It is only fitting that the first neonate to be supported by extracorporeal membrane oxygenation (ECMO) was named Esperanza, which when translated from Spanish means hope. Indeed, to the more than 50,000 patients who have survived because of ECMO, this revolutionary treatment has provided hope where there was none before. In the past 5 decades, the use of artificial oxygenation and perfusion has revolutionized the care of critically ill patients, both in the operating room and in the intensive care unit. Use of artificial oxygenation and perfusion has evolved from bypass during cardiac surgery to advanced life support, to complex extracorporeal cardiopulmonary resuscitation (ECPR). Within the past 20 years, ECPR has been initiated when traditional resuscitation methods have failed and has proven its effectiveness with a survival to discharge rate of approximately 40%. However, the appropriate use of this therapy and delineated criteria for initiating and withdrawing this therapy have yet to be defined. Furthermore, implementation of this therapy requires careful consideration of ethical concerns. Many ethical concerns arise with this advanced form of life support. More often than not, the dilemma is not whether to withhold ECMO, but rather when to withdraw it. Although clinicians must decide if ECMO is appropriate and when further intervention is futile, the ultimate burden of choice is left to the patient’s caregivers. Offering support and guidance to the patient’s family as well as the patient is essential. (Critical Care Nurse. 2015;35[1]:60-70)
extraordinary therapy introduces many ethical dilemmas concerning advanced life support. This article addresses the use of ECMO during CPR, as well as the ethical problems we face with the continued advancement of end-of-life care.

**Extracorporeal Cardiopulmonary Resuscitation**

ECPR is considered the initiation of ECMO, following refractory cardiac arrest unresponsive to conventional cardiopulmonary resuscitation (CPR). During the initiation of ECPR, traditional resuscitation measures are continued, including chest compressions and emergency administration of medication. Practitioners initiating this treatment should aim to maximize cardiac output and flow to optimize outcomes. While traditional resuscitation continues, surgeons place the ECMO cannulas in large arterial and venous vessels. Location of cannula placement is based on the type of ECMO that the patient will receive. There are 2 forms of ECMO, venovenous and venoarterial. During venovenous ECMO, blood is drained from the right atrium, oxygenated through the circuit, then perfused back into the right atrium where the heart pumps it to the rest of the body, bypassing only the lungs. However, this form of ECMO requires adequate cardiac function, which is always severely impaired or absent in ECPR patients. Therefore, venoarterial extracorporeal support is initiated for ECPR patients. In this technique, 1 cannula is placed for venous drainage, similar to venovenous ECMO, but the oxygenated blood is returned to the aorta, bypassing both the lungs and heart (see Figure). Placement of the cannulas is dependent on the ease of access and the size of the patient. If access to intracardiac placement is available, such as with postoperative cardiac patients, this method is usually preferable, with direct cannulation of the right atrium and aorta. Other methods include the cannulation of the femoral artery and vein. However, this use is restricted to adolescents and adults because the size of their vessels is large enough to support adequate drainage and reinfusion. Still, the most common method of cannulation is venous access through the internal jugular vein directly into the right atrium and arterial access through the right carotid artery into the aorta.

Once a patient is successfully cannulated, the patient is immediately connected to the ECMO circuit. For this reason, most centers have developed a “rapid deployment system,” in which a circuit is preprimed with a crystalloid solution or is able to be primed with blood products within a very short period, usually 10 to 20 minutes. Although a large immediate infusion of crystalloid solution can be tolerated by older children and adolescents, some centers are reluctant to administer such an infusion to a neonate because of the significant hemodilution. However, the...
benefits of immediate end-organ perfusion often outweigh the risks of low hematocrit, which can be resolved with blood transfusions once the circuit has been established.15

**The Benefits of ECPR**

The postresuscitation phase in pediatric patients remains a high-risk period, complicated by significant myocardial dysfunction, hyperthermia, hyperglycemia, impaired autoregulation of blood pressure, and ischemia/reperfusion response.14-16 Upon return of spontaneous circulation and reperfusion, a decrease in contractility of the heart, known as myocardial stunning, often occurs. Decreased function of the heart can lead to hypotensive shock, with further damage arising from increased production of inflammatory mediators and nitric oxide.16 Treatment of hypotension and myocardial dysfunction often requires aggressive hemodynamic support with fluid resuscitation and vasoactive agents including epinephrine, dobutamine, and dopamine.16

In contrast, mechanical circulation via ECMO allows the body a period of hemodynamic stability and the possibility of resolution of underlying disease processes.15,16 Perfusion of organs with fully oxygenated blood via the ECMO circuit allows decreased myocardial oxygen demand, generally without the use of high-dose vasoconstrictors and inotrophic agents.15 This stability in the postresuscitation period may further improve survival rates.17

Large, multi-institutional studies16-18 show that overall survival to discharge rates in pediatric patients resuscitated with conventional CPR remains at approximately 25% to 27%. However, survival statistics for ECPR are more encouraging, with a general rate of success of near 40% to 60%.2,5,19-21,27-32 Multi-institutional data obtained in 2012 from the Extracorporeal Life Support Organization (ELSO), an international registry and database of ECMO treatment, demonstrated that ECPR was successful for 934 out of 2236 neonatal and pediatric patients, with survival to discharge of 39% for neonates and 40% for children. Other retrospective, single-institution studies have shown survival rates as high as 72% to 80%.22-24 The Table provides more detailed information from the current studies of ECPR in pediatric patients. Critical analysis of this information is imperative when determining the utility of ECPR.

Most studies rate ECPR’s success solely on survival to discharge statistics; only a few studies address neurological outcome. A void remains in the literature as far as addressing quality of life after ECPR. Furthermore, “good neurological outcome” is often a subjective measure, with terminology varying among researchers. Some studies have shown that ECPR patients have an increased likelihood of central nervous system complications developing compared with patients treated with ECMO without CPR.4 Other studies examining ECPR patients have shown favorable neurological outcomes, as measured by the Pediatric Cerebral Performance Category Scale, with a score of 2 or less in most patients.4,8,9,20,34 Further investigation into long-term neurological sequelae is needed and should be included in future studies.

**When to Initiate Therapy?**

In 2005, the American Heart Association recommended the use of ECPR for in-hospital patients in cardiac arrest when the duration of no-flow arrest is brief and the condition leading to the cardiac arrest is reversible.15 This broad recommendation does not offer a definition of “brief,” nor does it differentiate between time of no-flow arrest and duration of traditional CPR. More recent recommendations from the 2010 International Consensus on Cardiopulmonary Resuscitation36 specifies that ECPR is appropriate for patients with heart disease that is “amenable to treatment or heart transplantation,” where the cardiac arrest occurs in the intensive care unit in a facility with the personnel, equipment, and training to provide ECPR. Use of ECPR is indicated in only 1 situation after out-of-hospital cardiac arrest, which is in cases of environmentally induced severe hypothermia (< 30°C), again, only if the appropriate equipment and expertise are available.36 Medical institutions providing ECPR should have established protocols for its implementation and use. Often centers lacking these resources are unable to offer ECPR at all.

The advantages of ECPR after prolonged conventional resuscitation remain a source of controversy. Despite the large number of studies performed regarding ECPR use, no criteria or guidelines for timing of initiation of this therapy have been clearly established. The International Consensus on Cardiopulmonary Resuscitation recognizes that evidence is insufficient for establishing
<table>
<thead>
<tr>
<th>Reference</th>
<th>Population of patients</th>
<th>No. of patients</th>
<th>No. (%) of survivors to discharge</th>
<th>Duration of cardiopulmonary resuscitation, min</th>
<th>Duration of ECMO therapy</th>
</tr>
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<tbody>
<tr>
<td>Aharon et al&lt;sup&gt;28&lt;/sup&gt;</td>
<td>Postoperative, cardiac</td>
<td>10</td>
<td>8 (80)</td>
<td>Mean (range), 42 (5-110) &gt; 30 min associated with poor survival</td>
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<td>Alsoufi et al&lt;sup&gt;21&lt;/sup&gt;</td>
<td>Postoperative, cardiac</td>
<td>48</td>
<td>23 (46)</td>
<td>Not reported</td>
<td>Not reported</td>
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<td>Alsoufi et al&lt;sup&gt;30&lt;/sup&gt;</td>
<td>ICU and cardiac</td>
<td>80</td>
<td>27 (34)</td>
<td>Median (range) Survivors: 46 (14-95) Nonsurvivors: 41 (19-110)</td>
<td>4 days for both survivors and nonsurvivors</td>
</tr>
<tr>
<td>Cengiz et al&lt;sup&gt;4&lt;/sup&gt;</td>
<td>ELSO registry</td>
<td>161</td>
<td>64 (40)</td>
<td>Not reported</td>
<td>Mean (SD) Survivors: 4.7 (3.5) days Nonsurvivors: 4.4 (6.4) days</td>
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<tr>
<td>Chan et al&lt;sup&gt;5&lt;/sup&gt;</td>
<td>ELSO registry of cardiac patients</td>
<td>492</td>
<td>208 (42)</td>
<td>Not reported</td>
<td>Median (IQR) Survivors: 87 (51-137) hours Nonsurvivors: 87 (37-171) hours</td>
</tr>
<tr>
<td>Chrysostomous et al&lt;sup&gt;29&lt;/sup&gt;</td>
<td>Cardiac</td>
<td>40</td>
<td>30 (75)</td>
<td>Median (IQR) Survivors: 40 (25-50) Nonsurvivors: 37 (35-50)</td>
<td>Median (IQR) Survivors: 53 (29-98) hours Nonsurvivors: 48 (28-102) hours</td>
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<tr>
<td>Conrad et al&lt;sup&gt;3&lt;/sup&gt;</td>
<td>ELSO registry</td>
<td>151</td>
<td>Neonatal: 65 (43) Pediatric: 111 (39)</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>de Mos et al&lt;sup&gt;10&lt;/sup&gt;</td>
<td>ICU</td>
<td>5</td>
<td>2 (40)</td>
<td>Range All: 31-77 Survivors: 35-48</td>
<td>Not reported</td>
</tr>
<tr>
<td>Del Nido&lt;sup&gt;23&lt;/sup&gt;</td>
<td>Cardiac</td>
<td>11</td>
<td>6 (55)</td>
<td>Mean (SD): 65 (9)</td>
<td>Mean (SD): 112 (18) hours</td>
</tr>
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<td>Delmo Walter et al&lt;sup&gt;11&lt;/sup&gt;</td>
<td>ICU</td>
<td>42</td>
<td>17 (40.4)</td>
<td>Mean (SD) Survivors: 35 (1.3) Nonsurvivors: 46 (4.2)</td>
<td>Mean (SD) Survivors: 4.0 (2.2) days Nonsurvivors: 6.0 (0.9) days</td>
</tr>
<tr>
<td>Duncan et al&lt;sup&gt;22&lt;/sup&gt;</td>
<td>Cardiac</td>
<td>11</td>
<td>6 (55)</td>
<td>Median (range) 55 (20-103)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Huang et al&lt;sup&gt;13&lt;/sup&gt;</td>
<td>Pediatric</td>
<td>54</td>
<td>25 (46)</td>
<td>Mean (SD) Survivors: 39 (17) Nonsurvivors: 52 (45)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Huang et al&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Pediatric</td>
<td>27</td>
<td>11 (41)</td>
<td>Median (IQR) Survivors: 45 (25-50) Nonsurvivors: 60 (37-81)</td>
<td>Median (IQR), range Survivors: 102 (68-135), 43-419 hours Nonsurvivors: 89.2 (26.9-221), 6-637 hours</td>
</tr>
<tr>
<td>Joffe et al&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Meta-analysis</td>
<td>762</td>
<td>361 (49)</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>Kane et al&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Cardiac</td>
<td>172</td>
<td>88 (51)</td>
<td>Median (interquartile range) Survivors: 32 (25-41) Nonsurvivors: 36 (21-45)</td>
<td>Median (interquartile range) Survivors: 84 (52-118) hours Nonsurvivors: 119 (57-183) hours</td>
</tr>
<tr>
<td>Kelly and Harrison&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Pediatric and cardiac</td>
<td>31</td>
<td>7 (23)</td>
<td>Median Survivors: 40 Nonsurvivors: 47</td>
<td>Mean Survivors: 4 days Nonsurvivors: 6 days</td>
</tr>
<tr>
<td>Kumar et al&lt;sup&gt;12&lt;/sup&gt;</td>
<td>Postoperative, cardiac</td>
<td>29</td>
<td>12 (41)</td>
<td>Mean (SD) Survivors: 42 (8) Nonsurvivors: 51 (10)</td>
<td>Not reported</td>
</tr>
</tbody>
</table>

Continued
any specific threshold for CPR duration beyond which survival is unlikely.36

A substantial amount of debate can be found in published reports about when ECPR should be initiated and when further intervention would be futile. Several pediatric studies have shown increased mortality rates for patients cannulated after 30 minutes of conventional CPR.7,11,28,34 However, other retrospective studies8-10,12,20,26,27,29,31,32 of pediatric patients have shown positive outcomes with median CPR duration of 30 to 50 minutes. Even more interesting are the multiple case reports24,27,30,32,37 of successful cannulation and survival to discharge in patients receiving CPR of up to 90 to 220 minutes.

Other research has focused on parameters that may act as predictors for positive outcome. ECPR patients with a preexisting diagnosis of cardiac illness have shown improved survival outcomes, when compared with patients with noncardiac illnesses.5,6,8,30,32 Perhaps patients with cardiac illness have less multiorgan dysfunction before cardiac arrest and therefore are more likely to

![Table](critical-care-nurse-table-continued.png)

**Table Continued**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population of patients</th>
<th>No. of patients</th>
<th>No. (% of survivors to discharge)</th>
<th>Duration of cardiopulmonary resuscitation, min</th>
<th>Duration of ECMO therapy</th>
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<tbody>
<tr>
<td>Morris et al32</td>
<td>ICU</td>
<td>64</td>
<td>21 (33)</td>
<td>Median (range) Survivors: 50 (5-105)</td>
<td>Median (range) Survivors: 55 (2-359) hours Nonsurvivors: 64 (1-506) hours</td>
</tr>
<tr>
<td>Paden et al2</td>
<td>ELSO registry</td>
<td>Neonatal: 784</td>
<td>Neonatal: 304 (39) Pediatric: 630 (40)</td>
<td>Not reported</td>
<td>Not reported in ECPR group</td>
</tr>
<tr>
<td>Polimenakos et al36</td>
<td>Cardiac single ventricle, neonates</td>
<td>14</td>
<td>8 (57)</td>
<td>Mean (SD) Survivors: 38.6 (6.3) Nonsurvivors: 42.1 (7.7)</td>
<td>Median (IQR) Survivors: 4 (3-6.5) days Nonsurvivors: 8 (5-11.5) days</td>
</tr>
<tr>
<td>Prodhon et al27</td>
<td>ICU, cardiac</td>
<td>32</td>
<td>24 (72)</td>
<td>Median (range) Survivors: 43 (15-142) Nonsurvivors: 60 (20-76)</td>
<td>Median (range) Survivors: 122 (41-816) hours Nonsurvivors: 59 (7-905) hours</td>
</tr>
<tr>
<td>Raymond et al8</td>
<td>AHA/NRCPR</td>
<td>199</td>
<td>87 (44)</td>
<td>Median (range) Survivors: 46 (26-68) Nonsurvivors: 57 (38-71)</td>
<td>Not reported</td>
</tr>
<tr>
<td>Shah et al32</td>
<td>Cardiac</td>
<td>27</td>
<td>9 (33)</td>
<td>Not reported</td>
<td>Mean (SD) Survivors: 79.3 (40.7) hours Nonsurvivors: 128.6 (193.3) hours</td>
</tr>
<tr>
<td>Sivarajan et al34</td>
<td>Cardiac</td>
<td>37</td>
<td>14 (38)</td>
<td>Median Survivors: 15 Nonsurvivors: 40</td>
<td>Not reported</td>
</tr>
<tr>
<td>Thiagarajan et al6</td>
<td>ELSO registry</td>
<td>682</td>
<td>261 (38)</td>
<td>Not reported</td>
<td>Median (interquartile range) Survivors: 88 (51-140) hours Nonsurvivors: 66 (26-157) hours</td>
</tr>
<tr>
<td>Tajik and Cardarelli7</td>
<td>Meta-analysis</td>
<td>288</td>
<td>114 (39.6)</td>
<td>Not reported</td>
<td>Median (range) 4.3 (0.03-90) days</td>
</tr>
<tr>
<td>Wolf et al34</td>
<td>Cardiac</td>
<td>90</td>
<td>50 (55.5)</td>
<td>Median (range) Survivors: 42 (16-98) Nonsurvivors: 43 (20-75)</td>
<td>Median (range) Survivors: 3 (1-20) days Nonsurvivors: 5 (1-21) days</td>
</tr>
<tr>
<td>Thourani et al31</td>
<td>Cardiac</td>
<td>15</td>
<td>11 (73.3)</td>
<td>Not reported</td>
<td>Median (range) 66 (18-179)</td>
</tr>
</tbody>
</table>

Abbreviations: AHA/NRCPR, American Heart Association/National Registry of Cardiopulmonary Resuscitation; ELSO, Extracorporeal Life Support Organization; ICU, intensive care unit; IQR, interquartile range.
survive after treatment with ECPR. Few published data support preexisting measurements as indicators for survival. Arterial blood gas values have been postulated to be predictive variables in several studies, with pH less than 7.2 associated with higher mortality. However, Thiagarajan et al noted that although pre-ECMO arterial pH less than 6.9 was strongly associated with negative outcome, 12% of children who survived after ECPR use had a pre-ECMO pH less than 6.9. Multiple studies have shown that preexisting renal insufficiency and metabolic electrolyte abnormalities are associated with worse survival to discharge.

This discordance in published results is of extreme importance to practitioners initiating ECPR in pediatric patients. The absence of clearly defined parameters and inconsistencies in published reports may lead some clinicians to initiate ECPR when attempts may be futile, but also may inhibit its use when there is the possibility of success.

When to Withdraw ECMO?

Transition from ECPR to standard ECMO care occurs once the child is cannulated and placed on the ECMO circuit. Further management of the patient focuses on treatment of underlying disease processes. The use of artificial oxygenation and perfusion in this time allows the child a period of hemodynamic stability and decreased myocardial oxygen demand, during which vital organ function may return. However, the precise amount of time it takes the organs to regain adequate function to support the body remains unknown. Several studies of duration of ECMO after CPR show similar amounts of time on the circuit for both survivors and nonsurvivors. Historically, data in pediatric patients indicate that ECMO for cardiac failure after cardiothoracic surgery continued beyond 3 to 6 days results in poor outcomes, and ECMO beyond 2 weeks may not improve respiratory failure. However, a recent review of ELSO data in cardiac ECMO patients shows no significant difference in survival to discharge between patients who receive ECMO for 14 to 20.9 days (25% survival) and patients who received ECMO for 21 to 27.9 days (23% survival); but, survival decreased significantly after 28 days to 13%. In pediatric patients receiving ECMO for acute respiratory failure, review of ELSO data showed survival rates were inversely related to duration of ECMO.

Patients receiving ECMO support for 3 weeks or longer had a survival to discharge rate of 38%, significantly decreased from the rate of survival of patients who received ECMO support for 2 weeks or less (61%).

If separation from the ECMO circuit is not possible because of ongoing cardiac or pulmonary failure, then transition to other modes of mechanical support may be an option. Patients with prolonged pulmonary failure but recovery of cardiac function may be transitioned to venovenous extracorporeal support, potentially decreasing the risk of oxygenator-associated thrombi. Patients with continued cardiac dysfunction may be converted to a ventricular assist device to act as a bridge for transplant. To date, only 2 ventricular assist devices are approved for pediatric use, the Berlin Heart and HeartWare. However, no current research supports the use of a ventricular assist device in children after cardiac arrest.

The only clear indicator for withdrawal of ECMO support is neurological devastation evidenced by brain death, in which termination of all life support is warranted. Other clear criteria for withdrawal of ECMO include hemorrhagic stroke or intraventricular hemorrhage in which anticoagulation must be discontinued to prevent worsening intracranial bleeding. Other indicators for termination of ECMO include worsening end-organ dysfunction. Renal insufficiency following ECPR is a poor prognostic factor. Acute renal injury can occur during cardiac arrest and resuscitation as a result of hypoperfusion of the kidneys. Again, the question of how long it will take for these organs to recover, or if recovery is possible at all, has yet to be answered.

Ethical Considerations

The judicious use of ECPR in pediatric critical care is complicated by a vast number of factors, including the high cost of care, questionable effectiveness, and intensified emotions of families and providers caring for a critically ill child. ECPR is an advanced form of life support, so its use in patient care must be in accordance with the principles of medical ethics. The first principle is beneficence, which requires that practitioners offer care that is beneficial to their patients. Unnecessary surgical
procedures and unauthorized research are common problems that arise when addressing beneficence. The second principle is nonmaleficence, meaning do no harm. This principle requires that the benefits of a treatment must outweigh the potential negative aspects such as overburdensome pain and unavoidable suffering. When discussing the continued use of ECMO, practitioners must decide if prolonged therapy to enhance the possibility of survival prevails over the risk of unnecessary discomfort and extended suffering of the child. The third ethical principle is autonomy, which refers to the patient’s right to decide what is appropriate in their care. In critically ill pediatric patients, a dependent child’s autonomy is delegated to the surrogate decision maker, most often the parents. Their values and judgments must be respected by practitioners and incorporated into decision making at every level.

The fourth principle is justice, which is often a source of controversy in modern medicine. This principle demands that therapies be provided equally to all patients despite differences in socioeconomic status, race, gender, and so on. However, medical resources are not limitless, and societies must strive to ensure appropriate distribution of health care. Median hospital charges of ECPR patients has been quoted at $310,824, which is significantly greater than charges for propensity-matched conventional CPR patients, which are $147,817.42 Financial burdens of ECMO support may far exceed reimbursement from insurance companies and may place the hospital at financial risk. Offering excess treatment in one patient may conceivably lead to a decrease in resources for another patient.

Taking into account the ethical principles of medicine, practitioners in the intensive care unit must be acutely aware of the potential for benefit and the medically futility of the therapies they provide. Most often, such awareness means that advanced life support is initiated and removed appropriately depending on the patient’s chance of survival and the desires of the patient’s family. These concepts are more commonly known as initiating, withholding, and withdrawing treatment.

Ethical guidelines have determined that, withholding and withdrawing life support are no different. However, many professionals recognize that a psychological difference clearly exists. Based on this assumption, the President’s Commission on Ethical Problems in Medicine concluded that, contrary to widespread feelings on the matter, withdrawing treatment was preferable to withholding treatment for 2 reasons. Primarily, withdrawing allows a time-limited trial of therapy in which the patient’s status can be reassessed and prognosis determined. Second, a traditional reluctance to withdraw treatment had led many practitioners to forgo lifesaving therapies altogether for fear of eventual “failure.” For this reason, most intensivists now offer advanced life support to their patients with the hope that therapies will be successful, or at the very least “buy some time.”

Withholding ECPR is often a debate between physicians involved in the patient’s care. Most families are not aware of ECPR and would not know to request that their child be treated with ECPR. Often ECPR is recommended by a physician, and therefore withholding ECPR may come to mean simply not offering it. Withholding ECPR often becomes an intraprofessional dilemma, where the effectiveness of treatment is controversial. As discussed previously, the lack of parameters to guide physicians is detrimental to evidence-based practice, and decisions in this scenario are often based on personal reasoning, experience, and values. In these difficult situations, practitioners most often decide to treat, possibly against their better judgment. Solomon et al examined perceptions of physicians and nurses caring for critically ill children and reported that 80% of critical care attending physicians agreed that “sometimes I feel we are saving children who should not be saved,” whereas only 8% agreed that “sometimes I feel we give up on children too soon.”

The ethical dilemma of ECPR is therefore most often not whether to withhold it, but when to withdraw it. Again, the literature does not support a definitive timetable for withdrawal of ECMO. Obviously, neurological devastation as evidenced by brain death is a definitive indicator for withdrawal of treatment. But no other parameters exist, and the decision to withdraw is often at the recommendation of the provider. Maintaining ethical principles at this time is essential for practitioners as they address the medical futility of further treatment. There must be a level of assurance that prolonged time on ECMO will enhance patients’ outcomes and that this possibility outweighs the risks of further suffering and discomfort for the child.
The Final Decision

Although clinicians must decide if ECMO is appropriate and when further intervention is futile, the ultimate burden of choice is left to the patient’s parents. As practitioners, we must be aware of, and respect, the tremendous responsibility of this decision. ECPR is initiated as the most advanced form of life support available to patients, when death without ECMO is most certainly imminent. Furthermore, many patients remain alive purely through the use of ECMO and cannot be supported with traditional medicine. Removal of the pump often equates to death.

In 2003, Curley and Meyer examined parental experiences with ECMO and reported that 61% of parents felt that they had no other choice but to consent to treatment, since death was the only other option. In the study, most parents understood that ECMO was an extraordinary intervention, even in the technologically dominant intensive care unit environment.

As practitioners, we must be aware of our communication with parents in this very difficult and anxious time. Honesty concerning the many complications and uncertainties of ECMO is paramount to effective discussions. Furthermore, when a decision is made to treat a child with ECMO, parents must be cautioned that its use involves a time-limited trial. Reasonable expectations of length of duration and outcome must be clear to parents. Finally, all members of the team must be prepared to answer questions and provide support throughout the use of ECMO. The importance of offering support and guidance can never be underestimated in this setting, where parents are very aware that every moment with their child may be their last.

Nursing Implications

The use of ECMO during CPR is a technologically advanced and complex treatment that requires extensive knowledge from every member of the healthcare team. Bedside nurses should be well educated on the physiology of the patient, as well as the mechanical aspects of the ECMO pump. Centers providing this treatment must offer educational programs to train nurses in rapid deployment of the ECMO circuit. Familiarity with the circuit and experience with the cannulation procedure will ensure a smooth transition from cardiopulmonary resuscitation to artificial circulation.

Once the patient is cannulated, highly skilled nurses are needed to manage daily treatment. Nursing care of ECMO patients is both physically and mentally demanding. These patients require frequent laboratory and physical assessments, as well as frequent neurological checks. Neurological injury is common in ECMO patients owing to the acuity of their illness and the risk of cerebral vascular injury from stroke or hemorrhage. Daily ultrasound imaging of the head are routine in most centers, and continuous electroencephalographic monitoring is also implemented with concerns for subclinical seizure activity. Because of the immense workload associated with ECMO patients, 2 nurses are generally needed to care for these acutely ill children. One nurse is tasked with the care of the patient, while the other nurse tends to the needs of the ECMO pump. Most centers have implemented the use of perfusionists and specially trained respiratory therapists to manage the ECMO circuit in an effort to reduce the strain on nursing staffing.

Furthermore, the bedside nurse is often depended on to provide support to patients’ families. This responsibility is difficult and challenging, and it requires a large amount of dedication. Most intensive care nurses are well versed in end-of-life care and must continue to use this skill during ECMO trials. Although the physical care of these patients can be burdensome, bedside nurses must strive to ensure that time is allocated for family support. When needed, nurses should be aware of the resources available for patients’ families, including palliative care teams, social workers, and chaplain services. These services can help by offering assistance to family members during periods of critical illness and end of life.

The Future of ECPR

Use of ECMO as a final therapy during CPR in the care of critically ill patients remains promising. As providers continue to broaden the boundaries of use of ECMO, it is imperative that judicious decision making be maintained in the clinical setting. Further data and research are needed to create guidelines and parameters for withholding and withdrawing ECMO. It is essential that clinicians providing this treatment be thoroughly educated and knowledgeable about the literature, so that decisions are based on evidence.
Finally, as with all end-of-life care, it is essential that all members of the health care team be aware of parental presence and concern. Support must be provided to patients’ families on a constant basis to ensure that their needs are met. It is very easy for physicians and nurses to become overwhelmed by the technical aspects of caring for these critically ill patients and focus solely on maintaining life. However, a holistic approach to care should remain a focus, with appropriate support of the patient as well as the patient’s family. CCN

Financial Disclosures
None reported.

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To learn more about extracorporeal membrane oxygenation, read “Discharge Outcome in Adults Treated With Extracorporeal Membrane Oxygenation” by Guttendorf et al in the American Journal of Critical Care, September 2014;23:365-377. Available at www.ajconline.org.

References


CNE Test  Test ID C151: Extracorporeal Membrane Oxygenation for Pediatric Cardiac Arrest

Learning objectives: 1. Determine the difference between venovenous and venoarterial extracorporeal membrane oxygenation (ECMO). 2. Describe the benefits of extracorporeal cardiopulmonary resuscitation. 3. Discuss the ethical considerations related to management of patients undergoing ECMO.

1. Venoarterial extracorporeal membrane oxygenation (ECMO) is the preferred extracorporeal support for extracorporeal cardiopulmonary resuscitation (ECPR) patients over venovenous ECMO because of which of the following?  
   a. Risk of hemodilution in neonates  
   b. Absence of adequate cardiac function  
   c. Impaired renal function  
   d. None of the above

2. Complications in the postresuscitation phase in pediatric patients include all except which of the following?  
   a. Impaired autoregulation of blood pressure  
   b. Myocardial dysfunction  
   c. Increased contractility of the heart  
   d. Hyperglycemia

3. Benefits of mechanical circulation via ECMO include which of the following?  
   a. Decreased risk of hypotensive shock  
   b. Decreased risk of aggressive vasoactive resuscitation  
   c. Promotion of autoregulation of blood pressure in the initial resuscitation period  
   d. Promotion of hemodynamic stability

4. ECPR is recommended for use in which of the following types of patient settings?  
   a. Heart transplant surgery  
   b. Brief no-flow cardiac arrest in the hospital setting  
   c. Severe hyperthermia  
   d. Prolonged cardiopulmonary resuscitation with spontaneous return of circulation

5. Which of the following preexisting measurements can help determine survival potential?  
   a. Preexisting diagnosis of cardiac illness has shown to improve survival outcomes  
   b. A pre-ECMO pH of less than 7.2 is associated with higher mortality  
   c. A pre-ECMO pH of less than 6.9% is associated with negative outcomes  
   d. All of the above

6. Which of the following is the only clear indicator for withdrawal of ECMO support?  
   a. Neurological deterioration  
   b. Ongoing cardiac dysfunction  
   c. Ongoing pulmonary failure  
   d. Oxygenator-associated thrombi

7. The use of ECPR in pediatric critical care is complicated by all except which of the following?  
   a. High cost of care  
   b. Questionable effectiveness  
   c. Intensified emotions of families and providers  
   d. Absence of standardized clinical guidelines for withdrawal

8. Which of the following terms is the term for the concept of initiating and removing advanced life support?  
   a. Initiating  
   b. Withholding  
   c. Withdrawing  
   d. All of the above

9. Nursing care of patients receiving ECMO include which of the following?  
   a. Neurologic assessment  
   b. Highly skilled nursing care  
   c. Early mobility  
   d. A and B

10. Which of the following can help nurses assist families with emotional support during hospitalization?  
    a. Child life specialists  
    b. Palliative care, social workers, and chaplain services  
    c. Physician support  
    d. Leadership support

11. Studies examining parents’ experiences with ECMO report which of the following?  
    a. Parents felt they had no other choice as death was the only other option.  
    b. ECMO is one of several treatments available to improve their child's condition.  
    c. Parents preferred optimistic reports on their child’s condition over reasonable prognosis.  
    d. Parents relied heavily on the physicians to guide them through the daily stressors of having a child undergoing supportive measures.

12. Which of the following statements is true regarding treatment of neonates with ECMO?  
    a. Large immediate infusion of crystalloids is a standard of care for neonates.  
    b. Immediate infusion with crystalloids is well tolerated by neonates.  
    c. Benefits of immediate end-organ perfusion often outweigh the risks of low hematocrit.  
    d. Hemodilution is not a significant risk with neonates.

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. a  2. a  3. a  4. a  5. a  6. a  7. a  8. a  9. a  10. a  11. a  12. a

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