



# Should Extracorporeal Membrane Oxygenation Be Offered? An International Survey

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**Objectives** To assess the current attitudes of extracorporeal membrane oxygenation (ECMO) program directors regarding eligibility for ECMO among children with cardiopulmonary failure.

**Study design** Electronic cross-sectional survey of ECMO program directors at ECMO centers worldwide within the Extracorporeal Life Support Organization directory (October 2015-December 2015).

**Results** Of 733 eligible respondents, 226 (31%) completed the survey, 65% of whom routinely cared for pediatric patients. There was wide variability in whether respondents would offer ECMO to any of the 5 scenario patients, ranging from 31% who would offer ECMO to a child with trisomy 18 to 76% who would offer ECMO to a child with prolonged cardiac arrest and indeterminate neurologic status. Even physicians practicing the same specialty sometimes held widely divergent opinions, with 50% of pediatric intensivists stating they would offer ECMO to a child with severe developmental delay and 50% stating they would not. Factors such as quality of life and neurologic status influenced decision making and were used to support decisions for and against offering ECMO.

**Conclusions** ECMO program directors vary widely in whether they would offer ECMO to various children with cardiopulmonary failure. This heterogeneity in physician decision making underscores the need for more evidence that could eventually inform interinstitutional guidelines regarding patient selection for ECMO. (*J Pediatr* 2017;182:107-13).

Since its development >40 years ago, extracorporeal membrane oxygenation (ECMO) has been used to support patients with cardiopulmonary failure refractory to conventional therapy. Although potentially life saving, ECMO is highly invasive, associated with significant complications, and requires substantial resources.<sup>1</sup> Careful selection of patients who may benefit from ECMO is critical. Criteria that influence eligibility for ECMO include reversibility of the underlying disease process, the patient's risk of bleeding, and their overall prognosis. These criteria have also evolved over time.<sup>2</sup> Conditions such as pulmonary hemorrhage, malignancy, and burn injury were once considered contraindications to ECMO, but patients with these conditions have since been supported successfully with ECMO.<sup>3-5</sup>

The Extracorporeal Life Support Organization (ELSO) Registry serves as a repository for information regarding the use of ECMO, complications, and survival. It has recorded more than 78 000 ECMO cases worldwide, including more than 7900 cases in 2015 alone.<sup>6</sup> ELSO also publishes guidelines; its most recent guidelines for pediatric respiratory failure cite no absolute indications for ECMO.<sup>7</sup> Contraindications include recent intracranial bleeding or severe neurologic compromise. Nonetheless, these criteria are meant to serve only as a guide, with much left to the judgment of the treating physician. Furthermore, severity of illness scores have been developed recently for patients on ECMO; however, these scores are not intended for use in the care of individual patients.<sup>8,9</sup> Thus, there are limited data regarding which patients should be offered ECMO. Given this ambiguity and paucity of data, we sought to assess the current opinions and attitudes of ECMO program directors regarding the decision of whether to offer ECMO to a patient. We also sought to determine whether various respondent or institutional characteristics affected these attitudes and opinions.

## Methods

This study was a cross-sectional observational survey of ECMO program directors at ELSO member institutions internationally. The survey was sent electronically to all 774 individuals listed as program directors in the ELSO member directory. Of these, 41 failed to deliver owing to invalid email addresses, leaving 733 eligible respondents.

A 24-item questionnaire was developed by the authors after review of the published literature and based on their clinical experience. The survey instrument was

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ECMO Extracorporeal membrane oxygenation  
ELSO Extracorporeal Life Support Organization

developed and administered on the Qualtrics platform (Provo, Utah) and consisted of fixed choice questions, clinical vignettes, and free text response questions.

The survey focused on the decision of whether to offer ECMO support in each of the case scenarios and the rationale for this decision. It explicitly instructed respondents to assume that the patient and/or family were fully aware of the risks and benefits, and that ECMO was consistent with their goals and values. Each case was designed such that the degree of cardiopulmonary compromise could justify ECMO, but where the past medical history, comorbidities, and surrounding circumstances might affect that decision. Hence, we attempted to isolate factors beyond severity of illness that could affect the decision regarding ECMO eligibility.

Questionnaires were sent via electronic mail to all ECMO program directors within the ELSO registry. Two additional electronic mailings were sent to nonrespondents in 2-week intervals. The University of Michigan Institutional Review Board granted the study exemption from human subjects review.

### Analyses

Data were analyzed using Stata 14 (StataCorp, College Station, Texas). Categorical variables were analyzed using  $\chi^2$  tests and the Fisher exact test when the cell size was  $\leq 5$ . A 2-sided  $\alpha$  of 0.05 was used as the threshold for statistical significance. Because the case scenarios included only pediatric patients, for the purposes of analysis we combined respondents from adult specialties (critical care, anesthesiology, general surgery, surgical critical care, cardiothoracic surgery, other) into a single group regarding clinical field. Similarly, given their relatively small number of respondents, we combined Australia, New Zealand, the Middle East, and Africa into a single geographic group.

Free text comments were imported into ATLAS/ti (Berlin, Germany) software for content categorization. One investigator conducted open coding of data and subsequent sorting into meaningful categories. Categories were developed until every unit of content was categorized and the relationships between categories were established in an iterative process involving 3 of the study investigators.

## Results

There were 305 responses (42% of eligible respondents) received. We considered respondents' decision regarding ECMO the most important element of the survey, and therefore included only respondents who provided a response to all 5 case scenarios, resulting in 226 surveys that were considered complete. This represents an overall response rate of 31%. Nonrespondents did not differ significantly from respondents in terms of geographical location ( $P = .74$ ). Respondents represented more than 10 different specialties and 65% routinely cared for pediatric patients; 77% of respondents were from North America or Europe (Table I).

### Would You Offer ECMO?

Respondents varied widely in whether they would offer ECMO in each of the patient scenarios (Figure 1). Physician specialty

**Table I. Respondent characteristics**

	n (%)
Specialty	
Pediatric critical care medicine	86 (38)
Critical care medicine	63 (28)
Cardiothoracic surgery	36 (16)
Pediatric cardiothoracic surgery	26 (12)
Neonatology	22 (10)
Anesthesiology	20 (9)
Pediatric surgery	15 (7)
Surgical critical care	13 (6)
General surgery	2 (1)
Other	10 (4)
Experience managing ECMO (y)	
1-5	40 (18)
6-10	83 (37)
11-20	69 (31)
>20	34 (15)
Geographic region	
North America	123 (54)
Europe	52 (23)
Asia	20 (9)
South America	19 (8)
Australia/New Zealand	6 (3)
Middle East	4 (2)
Africa	1 (0.4)
Estimated annual ECMO volume at institution	
<6	24 (11)
6-14	65 (29)
15-30	69 (31)
>30	65 (29)
Maximum ECMO circuits capable of being maintained at institution	
1-2	70 (31)
3-4	90 (40)
5-6	41 (18)
>6	25 (11)

sometimes influenced these decisions (Figure 2). There were no differences in response based on estimated annual institutional ECMO volume or respondents' years of experience. Only 5 respondents stated they would offer ECMO in all 5 cases and only 1 respondent stated they would not offer ECMO in any of the cases.

Qualitative analysis revealed many factors, ranging from perceived reversibility of the acute condition to potential for harm, which influenced decisions. Of the 510 free text comments, 51 (10%) explicitly noted that parental desire was a motivating factor in their decision to offer ECMO. Only 6 of the 510 comments (1%) cited limited resources as an influence. Similar considerations (eg, baseline quality of life or expected prognosis) were used to justify decisions to offer or withhold ECMO (Table II).

Case 1 is an adolescent female with severe developmental delay, cerebral palsy, scoliosis, and acute respiratory failure. Citing concerns regarding the patient's severe developmental delay and potential technical challenges with cannulation due to significant scoliosis, 38% of respondents would not offer ECMO. In contrast, 62% of respondents would offer ECMO, emphasizing the patient's quality of life and the lack of recurrent hospitalizations. The decision to offer ECMO varied by respondent medical specialty ( $P = .024$ ): 50% of responding pediatric intensivists would offer ECMO and 80% of

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