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Update on Extracorporeal Life Support 2004

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Since its beginnings in 1989, the Extracorporeal Life Support Organization (ELSO) Registry has collated and reported data on over 30,000 patients. The majority of patients entered into the Registry have been neonates with respiratory failure from meconium aspiration, persistent pulmonary hypertension, or congenital diaphragmatic hernia. These patients suffer from refractory hypoxemia; thus, this supportive technique came to be called "Extracorporeal Membrane Oxygenation (ECMO)" for its ability to provide excellent gas exchange. With advances in prevention, diagnosis, and treatment measures for neonatal respiratory failure, need for ECMO support has fallen from the peak of 1500 cases in the early 1990s to 800 cases annually. Sixty-six percent (over 19,000) of patients in the Registry are under the category of neonatal respiratory failure, with a 77% overall survival reported to discharge. The success of neonatal ECMO has led to expansion of the field to pediatric, cardiac, and adult patients. An average of 200 pediatric patients receive ECMO for respiratory failure per year with an overall survival of 55%. Adult respiratory failure patients form a smaller group, with less than 100 cases reported to the ELSO registry per year. Survival mirrors that noted in the pediatric ECMO population. The application of ECMO or related techniques continues to increase for cardiac failure across all age groups. Overall survival in cardiac patients ranges from 33% to 43%. A novel form of extracorporeal support is "ECPR" or ECMO during cardiac arrest. Bypass circuits and equipment can be set up and instituted within a very short period of time in this circumstance, thus the name "rapid deployment ECMO" has become associated with this form of support. Overall survival in the near-600 patients placed on ECMO during resuscitation is 40%.
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In September of 2004, the Extracorporeal Life Support Organization (ELSO) celebrated its 15th anniversary by honoring Dr. Bob Bartlett, the founding father of extracorporeal membrane oxygenation. One of the highlights of this anniversary gathering was the personal testimony offered by individuals who have benefited from extracorporeal life support. Chief among these was a woman named Esperanza. Esperanza, who is now a grown woman with children of her own, was the first neonate to receive extracorporeal membrane oxygenation for respiratory failure. Esperanza, which means "hope," was an abandoned infant with newborn respiratory failure failing conventional therapy. Dr. Bob Bartlett

and others were involved with laboratory modification of intraoperative cardiopulmonary bypass into a mode that could be used to support children with severe respiratory failure for several days while their underlying disease was resolving. This technique was called "Extracorporeal Membrane Oxygenation" and was abbreviated as "ECMO."¹ When consulted about this neonate who was dying from respiratory failure, work from the laboratory was rapidly transformed into a "bench to bedside" effort. The rest, as they say, is history.

The first few successes with ECMO support were tempered by equal numbers of failures and complications. As a forum to discuss these events and the early experiences with extracorporeal support, informal meetings were held with surgeons, neonatologists, intensivists, biomedical engineers, nurses, and perfusion personnel with interest in the field. To facilitate inclusion of all patients who received extracorporeal support, the term "ECMO" became interchangeable with "ECLS," which stands for extracorporeal life support. From these informal gatherings, a database for tracking in whom

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Table 1 Total Numbers of ECLS Cases Reported by the ELSO Registry International Summary, July 2004

Group	Total Cases	Survive to DC (no.)	Transfer (%)
Neonatal			
Respiratory	19,061	14,681	77
Cardiac	2,215	841	38
ECPR	151	65	43
Pediatric			
Respiratory	2,762	1,536	56
Cardiac	2,936	1,256	43
ECPR	282	111	39
Adult			
Respiratory	972	515	53
Cardiac	474	156	33
ECPR	132	50	38
Total	28,985	19,211	66

and how extracorporeal life support was delivered was developed. From its beginning forum of about 30 individuals, ELSO has grown to several hundred participants that represent over 100 international centers. Members get together at the annual ELSO conference to share experiences and provide networking opportunities. Vendors and representatives from research and development companies related to bypass and extracorporeal support also interact directly with participants to hear concerns over equipment and plan future research endeavors. Through interactions between business personnel and practitioners in the field, advances in the circuitry for ECLS have been made.

One of the most vital activities of ELSO is to maintain and share data from the Registry. To date, over 30,000 patients have been entered into the ELSO database. Periodic reports from the ELSO Registry are provided to member centers which give both global and center-specific data. Annual fees from the member centers help maintain the database and information delivery systems, although much of the leadership roles and other activities of the organization remain largely volunteer efforts. Members have also worked to create, edit, and distribute educational material such as the Extracorporeal Life Support Specialists manual and the Extracorporeal Life Support textbook. These informative texts are written, produced, and distributed by ELSO. Guidelines for training and application of ECMO techniques have also been developed and published from ELSO and its participants.

Data reported to ELSO include basic patient descriptive information, perinatal information (for neonates), pre-ECLS physiologic data, ECLS equipment and implementation data, complications (mechanical and patient related), and basic outcome information. With the continuing increase in the application of ECLS techniques to children with cardiac disease, an addendum that tracks more specific data on cardiac failure patients was created in 2001. From this addendum, more specific information regarding experiences with ECLS support in these complex children will be available. It is hoped that these data will facilitate determination of outcome predictors for this patient population. In a similar manner, an

addendum for patients placed on ECMO during cardiac arrest has also been recently created to more specifically track the occurrence and outcomes associated with this novel use of extracorporeal resuscitation.

The following overview of ELSO registry data represents a look at the history of extracorporeal support to date and illustrates the changing environment that is the current state of ECLS. The data provided were obtained from the July 2004 ELSO International Summary. The overall experience with ECLS across age and support category is shown in Table 1 and Fig. 1.

Neonatal Registry Summary

The majority (66%) of patients are neonatal, with an overall survival of 77% (Table 1). Neonatal ECLS has shown a progressive decline in the number of patients treated per year. Peaking at about 1500 cases in the early 1990s, recent years have seen an average of 800 patients treated per year (Fig. 2). These changes may reflect better prenatal care and perinatal preventive medicine as well as the availability of alternative therapies for support of neonatal respiratory failure, such as high frequency ventilation, inhaled nitric oxide, and surfactant. In particular, randomized studies of inhaled nitric oxide in neonatal respiratory failure and pulmonary hypertension noted that response to inhaled nitric oxide obviated the need for ECMO support in about one-third of patients.^{2,3} There has been concern that the availability of alternative therapies leads to a delay in ECMO institution and may be responsible in part for the poorer outcome noted in recent years of neonatal ECMO. Survival between 1995 and 2003 has fallen from 76% in 1995 to 62% in 2003 ($P = 0.0002$ with 8 *df* by Chi Square). Limited comparison data on severity of illness between patients treated in 1995 or 2003 are available from within the Registry, and comparison data to track equally ill patients treated with other methods than ECMO are unavailable. Thus, there is little "hard evidence" to show that the

Runs by Year

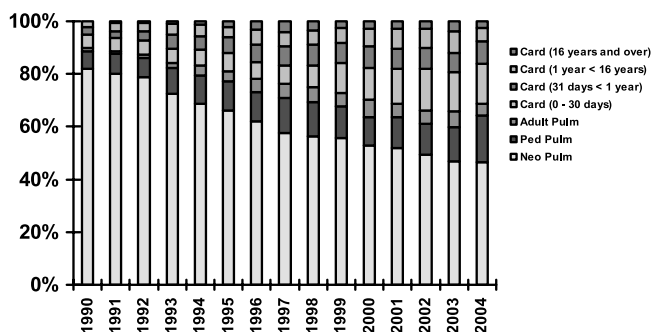


Figure 1 ECLS cases reported to the ELSO Registry as of July 2004. The bar graph represents the number of cases reported on an annual basis, while the line graph represents the cumulative cases reported as of the end of each year. A steady decrease in the number of cases reported annually has been occurring since 1992.

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