Journal of Pediatric Surgery 50 (2015) 798–804

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Evaluating the introduction of extracorporeal life support technology to a tertiary-care pediatric institution: Smoothing the learning curve through interprofessional simulation training

Carlos Sanchez-Glanville [a], Mary E. Brindle [a], Tanya Spence [b], Jaime Blackwood [b], Tanya Drews [b], Steve Menzies [c], Steven R. Lopushinsky [a,*]

[a] Section of Pediatric Surgery, University of Calgary, Calgary, Alberta, Canada
[b] Division of Pediatrics Critical Care, University of Calgary, Calgary, Alberta, Canada
[c] Division of Cardiac Sciences, University of Calgary, Calgary, Alberta, Canada

ARTICLE INFO

Article history:
Received 28 January 2015
Accepted 13 February 2015

Key words:
Extracorporeal life support (ECLS)
Extracorporeal membrane oxygenation (ECMO)
Simulation
Curriculum
Training
Extracorporeal Life Support Organization (ELSO)
Pediatric cardiopulmonary failure
Learning curve

ABSTRACT

Background: Extracorporeal life support (ECLS) is a life-saving technology for the critically ill child. Our objective was to evaluate the outcomes of an educational curriculum designed to introduce an ECLS program to a noncardiac pediatric surgical center.

Methods: An interdisciplinary curriculum was developed consisting of didactic courses, animal labs, simulations, and debrief sessions.

We reviewed all patients requiring ECLS between October 2011 and December 2013. All health care practitioners involved in the ECLS training curriculum were surveyed to evaluate their perception of the educational program. Primary outcomes include successful cannulation and 30-day survival.

Results: The knowledge and confidence improved with statistical significance ($p < 0.0001$–0.0003) for all of the components of the training curriculum. The highest score was given to the simulations. Twenty-one patients underwent cannulation. All patients were successfully cannulated to bypass, including six (28.6%) ECPR. Median time from activation to cutting was 52 min (IQR 40–72), and from cutting to bypass 40 min (IQR 30–45). Sixteen patients (76.2%) were decannulated to a sustainable cardiac rhythm and survived 30-days.

Conclusion: An ECLS curriculum incorporating simulation and dedicated practice seems to have eliminated the potential learning curve associated with the introduction of a complex technology to a novice environment.

The introduction of new technology into the clinical environment is a challenging process. When that equipment is complex and used in high-intensity, high-risk situations, the potential risks are magnified. Extracorporeal life support (ECLS) or extracorporeal membrane oxygenation (ECMO) is a well-established life-saving technology for the critically ill pediatric patient. Overall survival is estimated to be 57% with variations seen for underlying diagnosis, age, and circulatory mode [1]. ECLS offloads intrinsic pulmonary and circulatory systems to provide forward flow of oxygenated blood by way of an extrinsic circuit. Clinical conditions requiring ECLS range from hypoxic congenital heart disease to florid sepsis with cardiac and respiratory failure. Survival to discharge with ECLS in the neonatal and pediatric populations is 41% and 50% respectively for cardiac etiologies and 74% and 57% respectively for respiratory etiologies (ELSO International Summary 2014) [2].

ECLS is a technically challenging procedure and requires extensive multidisciplinary coordination to initiate rapidly and effectively. Recently our institution developed an in-house ECLS-cannulation program rather than relying on preemptive patient transfer or mobilizing surgeons from the provincial ECLS referral center. Unique to this program was the universal deficiency of skills across medical specialties and health professions given the absence of a cardiac surgery program. To become clinically proficient, an educational curriculum was developed to train subspecialty physicians, nurses, respiratory therapists and perfusionists with minimal to no prior pediatric ECLS experience. The focus of this training was to provide opportunity for dedicated practice of individual skills and separately to build and improve performance across multiple domains of expertise.

The program development of an ECLS team and its results has not been previously described for a noncardiac tertiary-care pediatric hospital. We aim to describe our educational curriculum and clinical outcomes 2-years out from the initiation of this life-saving program.

The study consisted of two major objectives: first, to analyze the educational curriculum as perceived by all clinical stakeholders, and second, to examine the clinical outcomes of all ECLS patients

* Corresponding author at: Department of Pediatric Surgery, Alberta Children's Hospital, 2888 Shaganappi Trail NW, Calgary, Alberta T3B 6A8.
E-mail address: steven.lopushinsky@albertahealthservices.ca (S.R. Lopushinsky).

http://dx.doi.org/10.1016/j.jpedsurg.2015.02.037
0022-3468/

following program initiation. The primary questions of this study were two-fold: First, what is the confidence and knowledge of healthcare providers performing ECLS-specific skills compared to precurriculum delivery? Second, to evaluate clinical relevance, what is the 30-day mortality rate of patients undergoing ECLS cannulation following program initiation?

1. Materials and methods

1.1. Study design

Perception of the educational curriculum was assessed by survey of all healthcare providers taking part in ECLS (physicians – pediatric-intensivists, cardiologists, and surgeons; nurses, respiratory therapists and perfusionists). Survey questions were generated through a multiple iterative process (MB, SL) to identify key elements of educational inquiry. The survey included demographic factors such as respondent age, gender, specialty and ECLS experience, as well as questions regarding the perceived benefit of the ECLS educational program in terms of knowledge, procedural confidence, realism, and team functioning. The elements of the educational program evaluated included didactic sessions, animal labs, simulation sessions and debriefing. Scoring was done on a 5-point Likert scale from one (very poor) through five (excellent). Respondents were also asked to rank each of the curricular components with respect to overall contribution to learning and team functioning. These were analyzed using a weighted scoring system, where the highest ranked was given a 4 and the lowest ranked was given a 1 per response. Finally, participants were given the opportunity to provide open-ended comments and feedback. The survey was created using SurveyMonkey (SurveyMonkey Inc., Palo Alto, CA) and distributed through an email link. A follow-up reminder email was sent 2 weeks later to maximize response rate. Data were collected anonymously and stored on a secure, password-protected computer.

For the second aspect of the study, a retrospective review was performed on all patients undergoing attempted cannulation for ECLS between November 1, 2011 and December 31, 2013. Data were collected from a prospectively generated database of patients meeting criteria for ECLS. Missing data were sought through chart review when required. Ethics approval was obtained through the University of Calgary Ethics Board (Study ID: REB14-0275).

1.2. Educational program

The novel Alberta Children's Hospital ECLS curriculum consists of four main components: (1) an intensive didactic course to cover the physiology and fundamentals of ECLS provision; (2) dedicated animal labs to practice surgical cannulation, proper cannula positioning, and circuit set-up and function; (3) point-of-care simulation team exercises (pediatric intensive care, emergency department, and operating room); and (4) regular team debrief sessions to review cases.

(1) The didactic two-day course was tailored using the *ECMO Specialist Training Manual, Third Edition* [3], and consisted of lectures and practical sessions covering the fundamentals of ECLS. Educational materials and discussion were made health-profession specific and included two sessions by visiting content-experts (ECLS program director, ECLS coordinator, and pediatric cardiothoracic Surgeon). Two groups were created for the course: the intensivists and perfusionists in one, and the specialist (i.e. ECLS specific respiratory therapist and registered nurses) in the second group. Additionally, theoretical concepts of ECLS were covered including: cardiac and pulmonary physiology, indications for ECLS, and an introduction to ECLS equipment and techniques. Additionally, the specialists, two intensivists, and one perfusionist participated in a weeklong course at the Stollery Pediatric Hospital in Edmonton, Alberta. The specialist and perfusionist participate in a 2-day continuing education courses on an annual basis.

(2) Animal labs were set up using sheep and pig models. In May 2011, a one-day cannulation dry-lab was run for the pediatric general surgeons. Subsequently, two three-hour animal sessions were run prior to program initiation to train six staff pediatric general surgeons and one pediatric surgery fellow. Animal testing had ethics approval through the University of Calgary and its trauma program. The focus of the first two labs was to practice the different cannulation techniques (veno-arterial, veno-venous, and Seldinger technique), and management of the ECLS pump. A third animal lab one-year post program initiation was used to build and maintain skills in neck, femoral, cephalad, and Avalon® veno-veno cannulation. All sessions were made interprofessional to build team rapport and communication skills.

Mandatory dry labs were created to build a team of ECLS-specialists skilled in the priming of the ECLS pump as well as trouble-shooting problems within the circuit. Every specialist had to complete one dry lab and one wet lab to obtain certification; two labs per year are required for ongoing certification.

(3) Six ECLS process simulations were run in the PICU setting prior to program initiation. It was mandatory for all participating members to attend at least one simulation. The simulations aimed to acclimatize team members to the steps of placing a patient on ECLS, including: streamlining the ECLS activation process, room setup, patient positioning, surgical cannulation, and circuit functioning. The original planned program start date (September 2011) was pushed back approximately two-months owing to deficiencies identified in these simulations.

Multiple case simulations (i.e. cardiomyopathy, myocarditis, hypothermic rewarming) were run in the PICU during the first 6 months of the live-ECLS program. Simulation dolls capable of a low-fidelity vessel cannulation were utilized. Over the 2-years of live ECLS at ACH, additional simulation in the PICU addressed ECPR and hypothermic cases.

Non-PICU simulation was expanded to the operating room and emergency-department. These multidisciplinary sessions were performed to further capture and train personnel in areas deemed high-risk for children to have cardiorespiratory decompensation.

(4) Debrief discussions were held with each simulation exercise and dedicated time was set aside to examine and review each clinical ECLS case since inception. The objectives of these sessions were to reinforce positive team behaviors, as well as to critically review areas for improvement.

1.3. Clinical program

The ECLS program was made available to patients November 2011, and the program was expanded to include ECPR in May 2012. Inclusion/exclusion criteria were compatible with standard North American practices (Appendices A and B). The mission statement of the ECLS program was to provide “rescue” ECLS. Once stabilized on ECLS, patients were transferred to the province's ECLS referral center. Patient transfer generally occurred within 24-hours of cannulation.

1.4. Statistical analysis

Descriptive analyses were performed on all demographic features of survey participants. Continuous variables were reported as mean (and standard deviation) or median (and IQR). Categorical variables were reported as overall counts and percentages.

The educational primary outcome was the change between pretraining and posttraining self rated knowledge and confidence to perform ECLS within the appropriate clinical role of the participant. Secondary outcomes include technical proficiency and attitudes of team functioning. Each element of the educational program was evaluated separately to determine their respective impact on training. Paired t-tests were used to compare the precurriculum and postcurriculum data. The univariate analyses were performed using Fisher exact test for the categorical data and t-test or Wilcoxan rank-sum as appropriate for continuous data.