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Review Article

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Advanced nurse specialist-managed pediatric extracorporeal membrane oxygenation: A 35-year single center experience

Abstract

Aim: To investigate the feasibility, safety, and clinical outcomes of a solely registered nurse (RN)-managed extracorporeal membrane oxygenation (ECMO) program in a community hospital over a 35-year period.

Material and Methods: A retrospective single-center review was conducted on all patients who received at least 24 hours of ECMO support in our pediatric intensive care unit (PICU) between August 1987 and August 2021. An integrated study of ECMO support type, ECMO duration, and patient survival to discharge was systematically performed.

Results: 321 ECMO runs were initiated on 319 patients. 273 (85.0%) runs were for elective pulmonary support, 34 (10.6%) were for elective cardiac support, and 14 (4.36%) were for emergent cardiac support in extracorporeal cardiopulmonary resuscitation (ECPR). Of the 321 ECMO runs, 279 (86.9%) were performed on neonatal patients, 37 (11.5%) on pediatric patients, and 5 (1.56%) on adult patients (excluded from analysis). The median duration of ECMO was 120 hours for neonatal patients and 134 hours for pediatric patients. 69.5% of all patients on ECMO survived to discharge. ECPR was an independent predictor of poor outcomes, in which 28.6% of the 14 patients survived to discharge.

Conclusion: A pediatric ECMO program fully managed by advanced nurse specialists was successfully implemented, maintained, and expanded. This model produced safe and efficacious outcomes that were comparable to data from the Extracorporeal Life Support Organization (ELSO) registry. Such an ECMO model is feasible even in a resource-limited setting like a community hospital. Nevertheless, for the most critical patients, the support of neonatologists, intensivists, and surgeons is imperative for enhancing favorable outcomes.

Keywords: ECMO, advanced nursing, review

INTRODUCTION

The use of the extracorporeal membrane oxygenation (ECMO) has expanded from its introduction in 1974 to include mechanical cardiac support in any patient with low cardiac output syndrome (LCOS) and variety of other critical illness conditions regardless of age (1, 2) ECMO guidelines include the use of readily available dedicated skilled personnel to safely deploy and manage patients on ECMO. Many hospitals still struggle with containing associated with ECMO high health care costs. Thus, new models have recently proposed (3,4). Some institutions use the advanced care nurses either to prime or maintain the EMCO circuit (5,6). We report our single-center experience with a cost-reducing ECMO model in neonates and children. The goal is to evaluate the feasibility effectiveness, and outcomes of this model of care.

MATERIAL AND METHODS

A retrospective single-center review was conducted on all patients younger than 18 years of age who received at least 24 hours of ECMO support in our pediatric intensive care unit (PICU) between August 1987 and August 2021. An integrated study of ECMO support type, ECMO duration, and patient survival to discharge was systematically performed. Review of medical records was approved by our hospital's committee on clinical investigation. Individual patients were not identified, and the need for patient consent was waived. The study was approved

by ethics committee. We included all patients supported with ECMO for a minimum of 24 h.

Primary outcomes were successful weaning from ECMO and post-ECMO survival to discharge. Secondary outcomes were occurrence of major complications: bleeding requiring surgical revision; cerebrovascular accident (CVA), either ischemic or hemorrhagic; blood culture-proven infections; pulmonary or gastrointestinal hemorrhage or peripheral thromboembolism (i.e., gastrointestinal or limb ischemia); mechanical failure or incidents (i.e. minor clotting, oxygenator failure requiring ECMO change, accidental cannula dislocation); a second ECMO run during the same hospitalization. Data was analyzed utilizing Fisher exact test on STATA software.

Ecmo Model

Every ECMO run was supported by 2 providers be assigned to 1 ECMO patient: an ECMO specialist, to manage the circuit and a dedicated bedside nurse (nurse:patient=1:1).

A respiratory therapist is readily available and always present on the unit. A typical full optional ECMO circuit includes a roller pump and a bladder, though since expanding the program to provide adult services, the nurses are trained on centrifugal pumps as well.

The ECMO program is based on personnel on call and regular shift ICU nurses sharing care of the patient; the nurses assigned to ECMO have had at least 1 ECMO training course or are tutored by a senior nurse. All surgeons involved in ECMO deployment and management have significant clinical experience with ECMO initiation and management. The intensivist on call conducts daily rounds to ensure proper clinical treatment of patients. The ECMO specialist on call is responsible for priming the circuit and providing support during the initial ECMO run. Nursing program leader and chief perfusionist are always available to troubleshoot any circuit-related issues. All other specialists (cardiologists, surgeons, and anesthesiologists) are required to be available for consult.

Treatment algorithms were developed initially by a neonatologist who founded the program and subsequently modified by multidisciplinary team and included nutrition and ventilation management protocols, guidelines for ECMO transport, anticoagulation and weaning from ECMO by a bridge technique (Figure 1). An ECMO training program was developed and

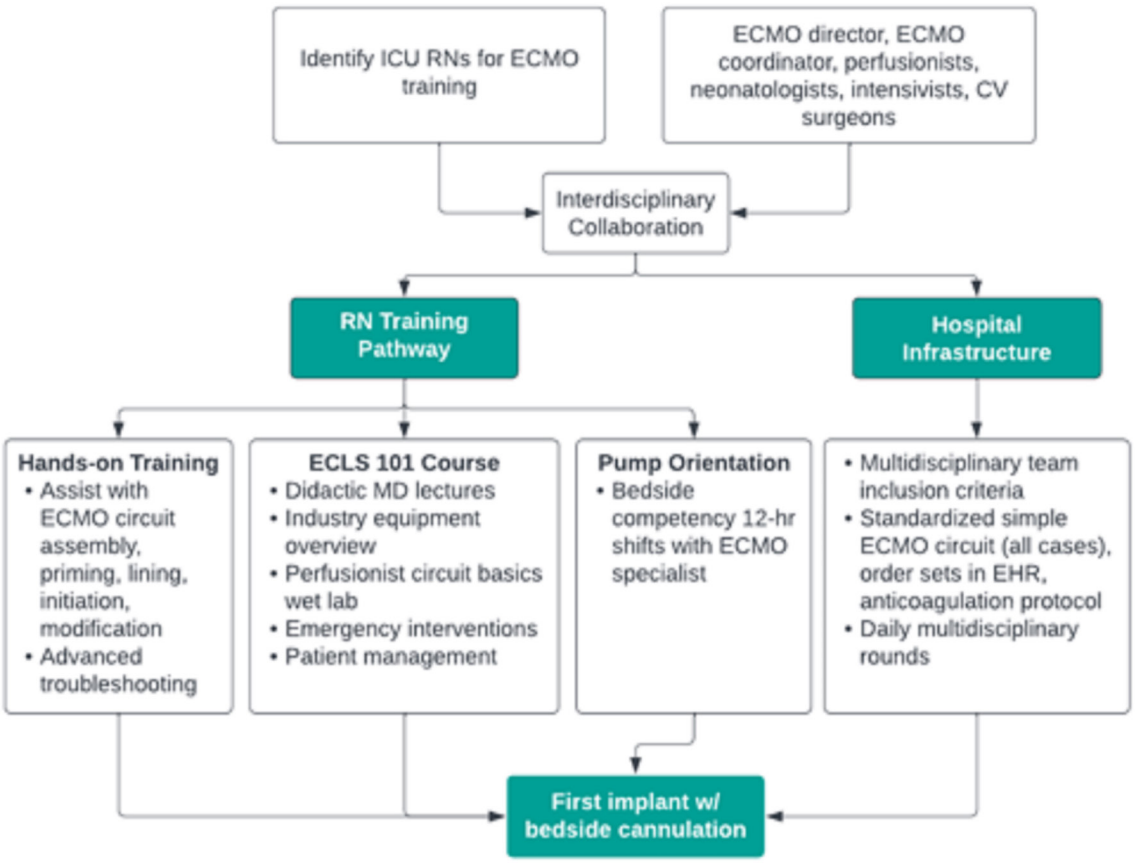

Figure 1. Algorithms of advanced nursing ECMO specialist training pathway

updated annually by senior ECMO specialists, neonatologists, intensivists, perfusionists and surgeons were provided periodically to all ECMO providers.

RESULT

321 ECMO runs were initiated on 319 patients. 273 (85.0%) runs were for elective pulmonary support, 34 (10.6%) were for elective cardiac support, and 14 (4.36%) were for emergent cardiac support in extracorporeal cardiopulmonary resuscitation (ECPR). Of the 321 ECMO runs, 279 (86.9%) were performed on neonatal patients, 37 (11.5%) on pediatric patients, and 5 (1.56%) on adult patients (excluded from analysis). The median duration of ECMO was 120 hours for neonatal patients and 134 hours for pediatric patients. 69.5% of all patients on ECMO survived to discharge. ECPR was an independent predictor of poor outcomes, in which 28.6% of the 14 patients survived to discharge.

COMMENTS

The goal of this study was to evaluate feasibility, safety, and clinical outcomes of our 35 years advance nurse ECMO specialist support model. Our analysis indicates that our ECMO model is sustainable, effective, and safe. ECMO support is a fundamental rescue tool with ECMO team models report improved weaning and survival. Finally, the use of ECMO was demonstrated to be an independent predictor of increased hospitalization costs. It is evident that the primary cost reduction comes mainly from reducing ECMO personnel and general costs. Our ECMO had clinical outcomes, i.e., rates of weaning and of discharge survival that were not significantly different from those associated with Extracorporeal Life Support Organization (ELSO).

Table 1. ECMO related major complications

Major Complications	N	% of All Patient Complications
Cardiovascular: CRP required	13	2.12%
Cardiovascular: Tamponde (blood)	7	1.14%
Neourologic: Brain death	7	1.14%
Neorologic: CNS diffuse ischemia (CT/MRI	3	0.49%
Neurologic: CNS Infraction (US or CT or MRI)	33	5.37%
Neurologic: Intra/extra parenchymal CNS Hemorrage (US or CT or MRI)	1	0.16%
Neurologic: Intraventrivular CNS hemorrhage (US or CT or MRI)	1	0.16%
Pulmonary: Pulmonary hemorrhage	18	2.93%
Total Major Patient Complications	83	13.52
Total Patient Complications	614	

The rate of occurrence of neurological complications during ECMO is still consistent in most series. Despite simplification of the circuit and reduction in the use of human resources, the overall occurrence of CVAs in our series was still significant and not different from that in other reports (Table 1).

LIMITATIONS

The inherent limitations of this study are its retrospective nature. In addition, a comparison to hypothetical ELSO ECMO models is a theoretical analysis because the recommended ELSO model is rarely used in common practice.

CONCLUSION

In conclusion, the ECMO program fully managed by advance nurse specialists can be successfully initiated, built, maintained, and expanded. This model has been safe and effective and produced excellent results in neonatal and pediatric patients over the period of the last 35 years. Such an ECMO model is reproducible even in a resource-limited setting such as a community hospital. Additionally, this model can be reproduced in other countries worldwide were availability of in-house and on-call perfusionists is limited. However, support of neonatologists, intensivists, and surgeons is crucial to enhance improved outcomes in the most critical patients.

Conflict of Interests: The author declares that there are no conflict of interests.

Financial Disclosure: There are no financial supports.

Ethics committee approval: Institutional IRB approval was obtained for this review.

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