The Utility of Nurse-Managed Extracorporeal Life Support in an Adult Cardiac Intensive Care Unit

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Background. **The use of extracorporeal life support (ECLS) worldwide has increased exponentially since 2009. The patient requiring ECLS demands an investment of hospital resources, including personnel. Educating bedside nurses to manage ECLS circuits broadens the availability of trained providers.**

Methods. **Experienced cardiothoracic intensive care unit (CTICU) nurses underwent training to manage ECLS circuits, including volume assessment, treatment of arterial blood gas values, the physiology of ECLS, and recognition of common emergencies. In addition to lectures and a written examination, simulation using water circuits and an ICU model allowed assessment of skills and understanding of concepts. Performance assessments were completed regularly at the bedside, and skills revalidation occurred every 6 months. A sequential cohort of 40 patients was tracked over 1 year.**

Results. **Despite doubling the census of ECLS patients in 1 year, management by specially trained CTICU nurses has positively affected patient care and outcomes. At a single institution, 40 patients had a median of 6 days (interquartile range, 2 to 226 days) of support in 2014, leading to 767 patient-days of support. Survival to hospital discharge increased to 45% in 2014. Most survivors were weaned from support. Neurologic injury was the most common cause of death, followed by failure to qualify for advanced therapies.**

Conclusions. **With on-going education and assessment, including crisis training, physiology, and cannulation strategies, CTICU nurses can safely operate ECLS circuits and can increase the availability of appropriately trained providers to accommodate the exponential increase in ECLS occurrences without negatively affecting outcomes and generally at a lower cost.**

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Extracorporeal membrane oxygenation (ECMO) was initially used as an adjunctive therapy in the pediatric population for supportive measures in the face of cardiovascular and pulmonary failure related to congenital malformations [1, 2]. This technology was later extrapolated to use in adults with respiratory and cardiovascular compromise, with reservation, secondary to previously experienced dismal results. The H1N1 influenza pandemic of 2009 accentuated the need for this life-saving measure in adult respiratory failure [3]. The conventional ventilatory support versus ECMO for severe adult respiratory failure (CESAR) trial further went on to report the utility of this mode of patient care in a comparison against traditional ventilatory care in acute respiratory failure [4]. These experiences in addition to benchmark advances in technology, such as integration of the centrifugal pump and poly-methyl pentene oxygenators, revolutionized the capabilities of extended use ECMO circuitry.

In addition to the benefit of ECMO in respiratory failure, the H1N1 influenza pandemic also uncovered a need for further access to this resource and the key factors limiting this. One of the most prominent of which is personnel to manage the patients undergoing ECMO therapy. Traditionally at our hospital, these circuits were managed by perfusion specialists who use the same knowledge base and billing practices for the management of these bedside ECMO circuits as for intraoperative cardiopulmonary bypass. To allow the perfusionists to maximize their staffing of the operating room, our institution uses trained cardiothoracic intensive care unit (CTICU) nursing staff for the bedside management of these complex patients. The aim of this study is to report our institutional experience, outcomes, and potential cost

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saving analysis of the use of specially trained CTICU nursing in the care of ECMO patients.

Material and Methods

At our institution CTICU nurses with at least 1 year of critical care experience are eligible to train in the mechanical circulatory support program. Once mastery of implanted and temporary ventricular assist devices (VADs) has been demonstrated by completing the institutional courses and bedside care of these patients, a nurse is eligible to undergo ECMO training. Similar to the Extracorporeal Life Support Organization (ELSO) guidelines set forth for the training of ECMO specialist, our institution mandates that these individuals attend didactic sessions, participate in hands-on drills with water circuits, bedside training, and virtual ICU model simulation as part of their initial training [5]. Specifically, these individuals must attend an initial 6-hour course taught by an internal nurse educator. After this, these nurses must pass a written examination, covering physiology of ECLS and crisis scenarios. Then, they must also undergo a 24-hour preceptorship to be granted institutional certification as an ECMO nurse. Performance assessments are completed regularly at the bedside, and skills revalidation occurs every 6 months with a mandatory 6-hour review course. The bi-annual refresher course focuses on understanding complex physiology of various cannulation strategies and crisis scenarios with hands-on circuit management in a simulated ICU. The training algorithm is summarized in Figure 1.

In addition to the extensive training for the ECMO nurses, a simplified ECMO circuit has been developed to minimize management decisions in a nurse-managed model. A simplified ECLS circuit was constructed with the CentriMag Blood Pump (Thoratec Corp, Pleasanton, CA) and Quadrox-iD Oxygenator (Maquet Cardiovascular, Wayne, NJ) (Fig 2). Sweep gas is controlled with a standard blender. One pigtail is connected to each of the inflow and outflow ports of the oxygenator for blood gas monitoring. Oxygenator pressure monitoring is not used, and no additional connections are allowed in the circuit without physician approval.

We retrospectively reviewed the charts of 40 consecutive patients who underwent extracorporeal life support at our institution between January and December 2014. The charts of these 40 patients were reviewed under institutional review board-approved protocols. Data on modality, time on support, age, primary pathologic process, indicators of multisystem organ failure, and survival to discharge were collected. Risk factors for death while on ECLS were analyzed by Cox proportional hazard regression. Data were collected using an Excel spreadsheet (Microsoft Corp, Redmond WA) and further analyzed with STATA Version 14 (Statistical Software, College Station, TX).

Results

At our institution 40 patients had a median of 6 days (interquartile range [IQR]: 2 to 226 days) of support in 2014, with a total of 767 days of patient support that year. Modalities used included venovenous, venoarterial, venoarterial-venous, left VAD (LVAD), right VAD, and biventricular assist devices. Survival to discharge varied

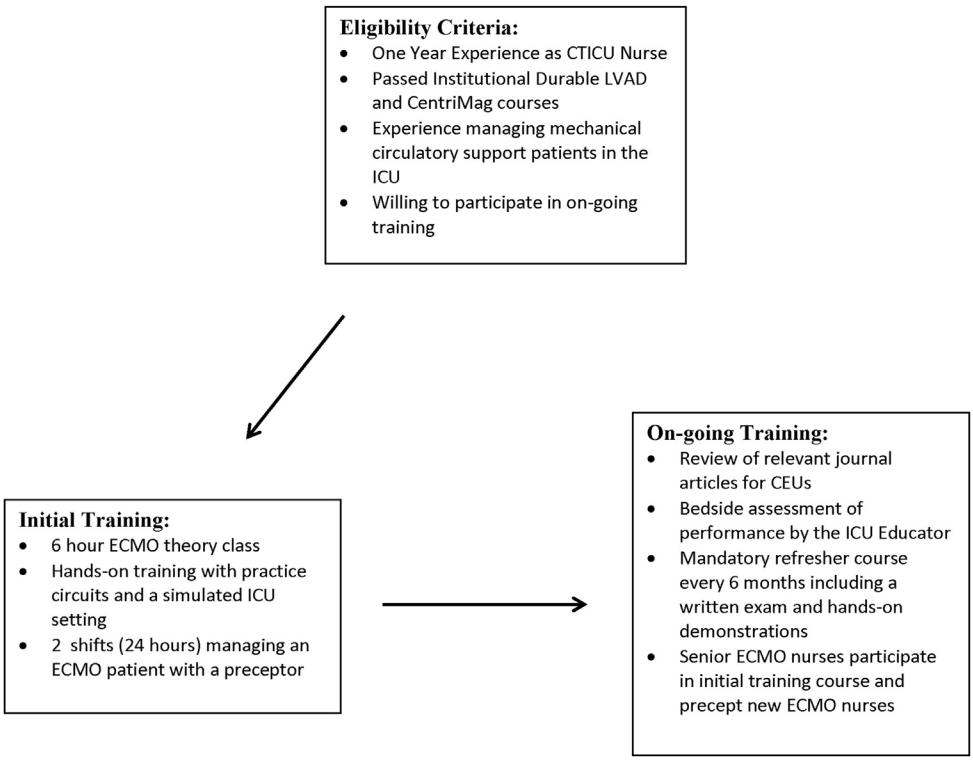

Fig 1. Nurse-managed extracorporeal life support (ECLS) training algorithm. (CEU = continuing education unit; CTICU = cardiothoracic intensive care unit; ECMO = extracorporeal membrane oxygenation; ICU = intensive care unit; LVAD = left ventricular assist device.)