

Implementing Nurse Extracorporeal Membrane Oxygenation Specialists to Maintain a Sustainable Program

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Extracorporeal membrane oxygenation (ECMO) offers hope for patients with acute respiratory distress syndrome when other treatment methods fail. However, ECMO requires continuous hourly management leading to extremely high operating costs. With the onset of the COVID-19 pandemic, the high number of patients on ECMO led to a significant increase in the costs when using perfusionists to manage ECMO. Switching to a nurse-driven model resulted in a 52% decrease in costs related to the hourly management. Changing to a nurse-driven program provided increased nursing support and sustainability, and with determination and support, other ECMO centers can also change to nurse-driven programs.

For patients with acute respiratory distress syndrome (ARDS) or severe cardiogenic shock, extracorporeal membrane oxygenation (ECMO) is a highly complex life-saving therapy that provides oxygen to their bodies, allowing their hearts and lungs to recover.¹ Though effective for the care of patients with ARDS secondary to COVID-19, ECMO therapy for more than 10 days often costs patients more than \$1,000,000 and requires close monitoring by highly skilled health care professionals.^{1,2} Over the last 2.5 years, nearly 80 million Americans contracted COVID-19, leading to high numbers of patients with ARDS needing ECMO.³⁻⁶ This manuscript explains the reasons for switching from a perfusionist-driven to a nurse-driven program, describes the experience, and includes a list of recommendations for nurse leaders to consider if switching to a nurse-driven program. This project's success relied heavily on the support from the executive team, collaboration with key stakeholders, review of ECMO devices' inventory and need, staffing model, nurse ECMO specialist's (NES) training, quality and outcome measures, and potential cost savings associated with using the NES.

BACKGROUND

The ECMO program at Providence Saint John's Health Center provides care for patients from the greater Los Angeles area. While many ways of managing ECMO exist, we initially managed our ECMO patients in the intensive care unit (ICU) with

perfusionists from a contracted vendor. These perfusionists are health care professionals who complete an intense 2-year certification course focused on fluid and gas exchanges and management of the ECMO device. They often manage patients on heart and lung bypass machines in the operating room during open-heart surgery, which is why many programs also lean on their expertise to manage ECMO in the ICU.¹ Having this team of perfusionists helped ensure the program's success until the onset of the COVID-19 pandemic when the need for more perfusionists became dire, and the nursing leadership team decided to change to a nurse-driven model. From March 2020

KEY POINTS

- Despite being an effective treatment, extracorporeal membrane oxygenation (ECMO) management comes with extremely high costs.
- Implementing nurse ECMO specialists brought holistic care, stability, and sustainability to this program, and other programs can do the same.
- Despite significant cost savings, switching to a nurse-driven ECMO program requires close collaboration with key stakeholders, extensive training, and the executive team's support.

through April 2022, the program had 78 patients with COVID-19 on ECMO. This high volume of patients requiring ECMO exceeded the number of local perfusionists available to provide adequate patient care and ECMO management. An outside contracted vendor provided perfusionists flown in from across the country to bridge this gap. However, this increased need for agency perfusionists led to much higher operating costs associated with managing patients on ECMO. The constant turnover of perfusionists made it nearly impossible to build consistency in staffing the ECMO program, and it limited the ability to standardize the processes. The risks these costs and staffing difficulties brought to this program led to a nurse-driven model.

SUPPORT OF THE CNO

Most projects that occur in health organizations require support and approval from the executive team, and the chief nursing officer (CNO) recognized the high costs and lack of consistency seen with using a contracted vendor managing patients on ECMO. However, moving to a nurse-driven ECMO program required an upfront cost of one million dollars and the commitment of the nursing leadership team to ensure the project's success. To address the costs associated, the CNO, in conjunction with the director of critical care services, developed a proposed return on investment, which gained acceptance from the rest of the executive team and board of trustees. The CNO also collaborated with the executive team of our contracted vendor to establish a plan to provide training and support to our staff as we developed our program. The ICU manager became the project manager for implementing this nurse-driven NES model.

KEY STAKEHOLDERS

In addition to the nursing leadership team, the identified key stakeholders included the contracted vendor perfusionists, cardiovascular (CV) surgeons, ICU physicians (intensivists), ICU clinical supervisors, and the CV surgery team. First, the ICU manager collaborated with the contracted vendor's ECMO program coordinator to establish the initial training plan. This collaboration helped build consistency for the program and provided the opportunity to build a trusting relationship with each other. The support of the CV surgeons and the ICU medical director was critical to helping move the program forward with implementing ECMO training and protocols. Finally, providing the current clinical supervisors with the vision to hire 5 additional clinical supervisors, for a total of 9, and train them as the NES helped establish the importance of this project. The support and acceptance of each of these stakeholders led to the early acceptance of this new nurse-driven program.

CURRENT EQUIPMENT

Several ECMO devices exist, and this program uses 2 different closed-circuit centrifugal pump systems, the Cardiohelp™ (Maquet Cardiopulmonary AG, Hirrlingen, Germany) and Rotoflow™ (Getinge, Gothenburg, Sweden). Both devices provide adequate support for patients. The Cardiohelp has several additional monitoring capabilities, and it remains the preferred device for interfacility transports. However, the Cardiohelp device costs \$100,000, and the disposable circuits required for each patient cost \$11,500. In comparison, the Rotoflow device costs \$50,000, and the disposable circuits cost \$1800. When renting the equipment, the Cardiohelp devices cost \$8000 per month, and the Rotoflow's cost is \$2800 per month. The circuits are not interchangeable, and one patient may require multiple circuits throughout their time of ECMO.

STAFFING MODEL

A review of the literature demonstrates that different staffing models exist for ECMO management. Some programs use one nurse to one patient for ECMO, where that nurse manages the patient's care and the ECMO device. Another model uses a perfusionist to manage the ECMO device and a nurse to manage patient care. A third model uses nurses or respiratory therapists to manage the ECMO devices independently of other responsibilities.^{5,7} This program adopted a model that uses one bedside nurse with a 1:1 ratio to care for all aspects of the patient's care while the NES manage the ECMO device. Our preferred ratio includes having each NES manage one or 2 ECMO devices, and our highest acceptable ratio is one NES to 4 ECMO devices. The ratio greatly depends on the stability and level of acuity of the patient on ECMO.^{8,9}

NURSE ECMO SPECIALISTS

One critical reason for switching to a nurse-driven program was to increase the nursing care for patients on ECMO. Our experience using perfusionists proved that while experts in their field, perfusionists typically focus strictly on managing the ECMO device. Using nurses in this role brought added value because the NES collaborates closely with the bedside nurses, intensivists, and other ancillary staff to provide the appropriate care. In addition to the clinical expertise in ECMO management, the NES provides mentorship for bedside nurses, oversight for the clinical care, and support and education for the patients and families. Having the NES at the bedside 24 hours per day has brought increased clinical support for patients, and the bedside nurses and clinical supervisors have voiced strong support for the NES. Switching to a nurse-driven program helped this program provide a higher level of care, maintain patient safety, and maximized our ability to provide holistic care.

ECMO SPECIALIST TRAINING

The current literature supports the implementation of a comprehensive training program to establish and maintain competencies for all concepts related to the initiation of ECMO on a patient, including initial cannulation on a patient, setting up and changing the ECMO circuit, daily care, and troubleshooting of the ECMO devices.^{1,2,10,11} The vendor we used for perfusionists has a well-established program for training NES at nurse-driven programs to provide this highly specialized specialty. The critical parts of the education included didactic training in conjunction with hands-on training and simulation (known as wet-lab training in the ECMO environment) to provide baseline knowledge and skills.

The ICU manager, educator, and 8 clinical supervisors completed two 8-hour days of didactic and hands-on training that 3 of the vendor's perfusionist educators provided. During this training, 17 different case studies related to ECMO emergencies and troubleshooting helped the nurses reinforce their knowledge learned throughout these classes. Each nurse demonstrated proficiency in priming and troubleshooting the Cardiohelp and Rotoflow circuits. On the last day of the class, all nurses completed and passed a 100-question test that covered various concepts from the class' learning objectives. After completing these classes, each NES received a certificate of completion. The NES were proctored for 40 hours in the ICU and used a skills competency checklist to track the skills they performed. During this proctored time, the ICU had 5 patients on ECMO per day, which provided the nurses with many opportunities to perform their required skills. They were able to assist with cannulation, set up ECMO circuits, and change out the ECMO's oxygenator (the artificial lung). These experiences established baseline competency and increased the NES's confidence in the duties of their new role. Ongoing training includes a mandatory four-hour wet-lab training every 2 months with case scenarios for the NES in collaboration with the intensivists. Each NES must demonstrate continued competency in setting up and troubleshooting the ECMO circuit.

STATISTICAL ANALYSIS

From July 2019 through April 2022, the program cared for 130 patients, with 78 of these cases due to COVID-19. The current survival rate for patients on ECMO with a COVID-19 diagnosis is 40% (Figure 1), which meets the survival rates described in the literature of 40% to 53%.^{3,5} From the start of the pandemic, despite receiving hundreds of referrals, the program reached total capacity with 8 patients on ECMO at one time. In addition, the program averaged 4 patients on ECMO for the entire year of 2021. Since January 2022, the program has averaged 3 patients on ECMO. Despite these high numbers of patients on ECMO through the

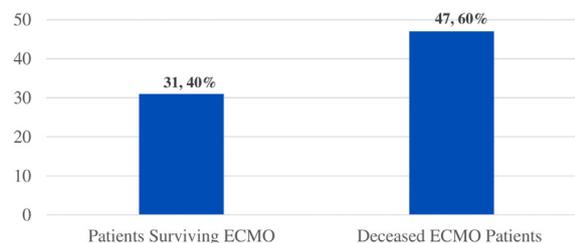


Figure 1. Total COVID ECMO Cases at Providence Saint John's Health Center From 2020 to 2022 (78)

height of the pandemic, it remains challenging to predict the future volumes, as it will most likely correlate with the future of the COVID-19 pandemic.

CONTINUOUS QUALITY IMPROVEMENT

The Plan Do Study Act model developed by Deming provides a pathway for continued evaluation and process improvement.¹² Embracing these principles helped ensure the timely identification and resolution of concerns related to the ECMO program. In addition, registering with the Extracorporeal Life Support Organization, which requires data input and oversight for each patient on ECMO, further helps ensure that the care provided is consistent with national and international standards and benchmarks.

PROGRAM SUSTAINABILITY

Even before calculating the costs of the 24 hours per day management required for each ECMO device, the complexity of ECMO makes it extremely costly. The cost for patients receiving ECMO therapy for more than 10 days often exceeds \$1,000,000.¹ Most of the operational costs, including the ECMO devices, the disposable circuits, and the oxygenators, are fixed costs,¹ so our most significant opportunity for cost savings included the costs of using the NES instead of perfusionists to provide ECMO management 24 hours per day.

A review of the available literature provided critical insight for a path forward for this program to achieve sustainability. One study compared the costs of a perfusionist-driven program versus a nurse-driven program. To demonstrate the cost savings, the researchers compared the costs related to the wages of perfusionists versus the wages of nurses. They reached a break-even point with ten patients on ECMO in one year.¹ Another study demonstrated a significant cost reduction after switching to a nurse-driven program.² For our program, the contracted rates with the vendor for the day-to-day ECMO management reached \$205 per hour for one patient, \$308 per hour for 2 patients, \$410 per hour for 3 patients, and \$461 per hour for 4 patients. These rates cost the program \$1,795,000 per year in perfusionist fees to manage one patient on ECMO and \$4,038,360 in perfusionist fees

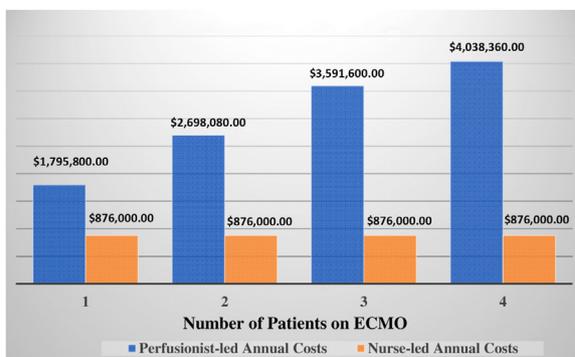


Figure 2. Cost Difference Based on Wages

to manage 4 patients. Using the NES costs \$100 per hour to manage up to 4 patients on ECMO, which costs \$876,000 in NES wages to manage one or 4 patients on ECMO for a year (see *Figure 2*). These numbers demonstrate \$919,000 per year in cost savings when managing one ECMO patient with the NES and cost savings of \$3,162,360 if managing 4 patients on ECMO. This analysis reflects the cost savings related only to the cost of NES versus perfusionists managing ECMO in the ICU.

The initial costs for the NES didactic training, wet lab, and precepting cost \$102,000, and these costs were seen as a one-time training cost as they would only occur again to replace one of NES if they resigned. To maintain competency, each NES must complete a four-hour wet lab every other month. The nursing leadership team estimated a cost of \$22,000 per year for ongoing training and competency. The 100-dollar per hour cost for using the NES includes the cost related to the continuing training for the NES. With the initial and ongoing training costs, the cost savings associated with managing our patients on ECMO with the NES remains significant, further justifying our decision to make this change.

RECOMMENDATIONS FOR NURSE LEADERS

While converting from a perfusionist-driven ECMO program to a nurse-driven ECMO program can produce significant cost savings, it remains critical to stay informed of the process to make a program successful. The following list of recommendations provides several essential concepts for nurse leaders to consider.

1. Having a clear understanding of the vision for the ECMO program is a critical component. In addition, the nursing leadership team's vision must align with the executive team's vision.
2. Determining the type of the ECMO device to use is dependent on the program's budget and CV surgeon preference. However, the Cardiohelp is seen as the most "nurse-friendly" device, and the Rotoflow is less expensive.

3. Training and supplying your own ECMO specialist will result in a more sustainable program, but you can start your program by contracting with a vendor to manage your patients on ECMO.
4. Using NESs brings added nursing support to the unit, and with their holistic approach, they provide expertise in ECMO management and all clinical care of the patients.
5. Providing training for your ECMO specialists should occur at a minimum of every 6 months, but we recommend wet labs every other month, depending on the program's volume.
6. Collecting data for the Extracorporeal Life Support Organization registry is labor-intensive. Therefore, you may want to do a cost-benefit analysis when deciding whether to outsource this to a company familiar with the registry.
7. Managing at least ten patients on ECMO per year justifies the use of NES.¹
8. Developing a nurse-driven ECMO program creates several opportunities for staff growth and empowerment, and it can help identify opportunities for quality improvement.

CONCLUSION

The increased number of patients requiring ECMO due to COVID-19 revealed an area of opportunity for our ECMO program. Initially, the program relied on a contracted vendor for perfusionists, which significantly increased the operating cost for patients on ECMO. However, the need to increase the number of patients managed on ECMO led to the realization of the critical need to build a sustainable program. The CNO and the ICU nursing leadership team opted to implement NES to address this need for ECMO management and ensure the program's cost-effectiveness. A collaboration with the key stakeholders led to the ultimate success of changing to a nurse-driven program. NES brought added value to the program by providing holistic care for both the patient and the ECMO devices. Other programs can follow these steps to develop a nurse-driven program, and this journey demonstrates the potential opportunities for growth and improvement.

REFERENCES

1. Dhamija A, Kakuturu J, Schauble D, et al. Outcome and cost of nurse-led vs perfusionist-led extracorporeal membrane oxygenation. *Annals Thorac Surg*. 2021;2021:1-8.
2. Cavarocchi N, Wallace S, Hong E. A cost-reducing extracorporeal membrane oxygenation (ECMO) program model: a single institution experience. *Perfusion*. 2015;30(2):148-153.
3. Garfield B, Bianchi P, Arachchilage D, et al. Six month mortality in patients with COVID-19 and non-COVID-19 viral pneumonia managed with veno-venous extracorporeal membrane oxygenation. *ASAIO J*. 2021;67(9):982-988.
4. Badulak J, Antonini MV, Stead CM, et al. Extracorporeal membrane oxygenation for COVID-19: Updated 2021

- guidelines from the extracorporeal life support organization. *ASA/O J.* 2021;67(5):485-495.
5. Supady A, Taccone F, Lepper P, et al. Survival after extracorporeal membrane oxygenation in severe COVID-19 ARDS: results from an international multicenter registry. *Crit Care.* 2021;25(90):1-4.
 6. Center for Disease and Control. Covid daily tracker. Available at: <https://covid.cdc.gov/covid-data-tracker/#datatracker-home>. Accessed March 19, 2022.
 7. Melnikov S, Furmanov A, Gololobov A, et al. Recommendations from the professional advisory committee on nursing practice in the care of ECMO-Supported patients. *Crit Care Nurse.* 2021;41(3):e1-e8. <https://doi.org/10.4037/ccn2021415>.
 8. Daly K, Camporota L, Barret N. An international survey: the role of specialist nurses in adult respiratory extracorporeal membrane oxygenation. *Br Assoc Crit Care Nurses.* 2016;22(5):5-311.
 9. Alshammari M, Velloikalam C, Alfeeli S. Perception of other healthcare professionals about the nurses' role and competencies in veno-venous extracorporeal membrane oxygenation care: a qualitative study. *Nurs Open.* 2022;(9):996-1004.
 10. Extracorporeal Life Support Organization. ELSO guidelines for training and continuing education of ECMO specialists. ELSO. 2010. Available at: <https://www.else.org/ecmo-resources/elseo-ecmo-guidelines.aspx>. Accessed March 19, 2022.
 11. Fouilloux V, Gran C, Guervilly C, Breaud J, El Louali F, Rostini P. Impact of education and training course for ECMO patients based on high-fidelity simulation: a pilot study dedicated to ICU nurses. *Perfusion.* 2019;34(1):29-34.
 12. Deming W. *The New Economics: for Industry, Government, Education.* Cambridge, MA: Massachusetts Institute of Technology, Center for Advanced Educational Services; 2000.

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