Introduction to Extracorporeal Membrane Oxygenation

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KEYWORDS

• ECMO • Multidisciplinary • Team building

KEY POINTS

- Extracorporeal membrane oxygenation (ECMO) has a long history of providing lifesaving support to patients.
- ECMO has evolved in application over time.
- Utility of ECMO requires a full team of trained professionals.
- Initiation of ECMO requires an organized, preplanned, coordinated effort.

INTRODUCTION

Suddenly there was a cardiac arrest on the hospital lobby floor and I recognized it was the hospital painter, a familiar face. The resuscitation process had begun. An unfamiliar voice from behind hollered out, "Secure the airway, lines in, and begin effective chest compressions! … the team will setup the heart-lung machine for extracorporeal membrane oxygenation" (ECMO). As a surgical intern, I blindly followed the orders, not having any idea about what we were planning to do next. Somehow over the next minutes I began my surgical career, cutting down on the groin and performing cannulation of the femoral vessels for cardiopulmonary bypass. I was overwhelmed at my success but not willing to ask the most important question: What is next? The chief calmly spoke out: "Now we have time to think." What a novel idea in the middle of the lobby on the floor with blood everywhere. I listened how he rationalized that the diagnosis was a pulmonary embolus. We proceeded to the operating room and performed the embolectomy. The diagnosis was correct; the procedure went well; our patient survived intact. It worked. I learned that day that ECMO provided respiratory and cardiac support but did not treat the underlying pathologic condition. It allowed us time to think.

It was 1979 and I was hooked on extracorporeal life support (ECLS).

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HISTORY

The question remains: Does ECMO really work? In 1979, the first randomized controlled data trial was published by Zapol and colleagues[1] in *The Journal of the American Medical Association* and concluded that there was no survival benefit to ECMO, with a high complication rate. From this article, ECMO sustained a significant setback but the enthusiasm continued through observational reports. In 1994 Morris and colleagues[2] published the second randomized trial, comparing pressure control inverse ratio ventilation versus extracorporeal carbon dioxide removal in adult respiratory distress syndrome (ARDS) and demonstrated survival of less than 10% with no significance differences. ECLS had suffered another major setback. These randomized trials are now recognized to have archaic ECMO technology, nonvetted treatment protocols, poor ventilator management, and high complication rates for infections and severe bleeding complications. Both the Zapol[1] and the Morris[2] trials have little relevance to current ECMO regimens.

Through the 1990s, there was particular interest by select groups in the United States and the United Kingdom in treating ARDS, pneumonias, and congenital disorders. The new era of the ECMO paradigm shift began at the turn of the millennia with the Conventional Ventilatory Support versus Extracorporeal Membrane Oxygenation for Severe Adult Respiratory Failure (CESAR) trial, the H1N1 influenza epidemic, new technology, and management protocols.[3,4] The CESAR trial was designed as an intent-to-treat trial comparing conventional ventilation with ECMO for severe ARDS at a referral center in the United Kigdom.[3] The primary outcome measures demonstrated a reduction in death or severe disability in the ECMO group (37% vs 53%); the secondary outcomes showed decreased ventilator time, length of intensive care unit (ICU) stay, blood usage, and cost of health care. The findings supported that lung rest via ECMO was feasible and that ARDS should be managed at tertiary care centers. The H1N1 epidemic, which began in Australia, showed the world that ECMO could be used by tertiary centers during high-volume crises. The Australian lead set the framework for the H1N1 epidemic as it spread across the hemispheres. They demonstrated a 71% survival in patients who failed conventional medical treatment of ARDS secondary to H1N1.[4] This sentinel article demonstrated advances in technology of blood oxygenators, circulatory pumps, and intravascular cannula design. This new ECMO technology allowed for longer circuit runs with fewer complications. Traditionally, prolonged ECMO runs were limited by hemolysis, bleeding, and infections. The advantages of centrifugal pumps were less hemolysis, heparin, and transfusions requirements resulting in fewer circuit-related complications. The advantages of new membrane oxygenators included increased longevity, less blood trauma, and improved gas exchange. It was too late for randomization; the door was open, and the interest was ongoing.

Management protocols and algorithms were nonexistence in 2005. The Extracorporeal Life Support Organization (ELSO) created guidelines for training, staffing, and equipment. Attempts were made to control costs and reduce labor requirements.[5] There was a practical recognition that bedside circuitry needed to be affordable, reliable, simple, and transportable. Monitoring patients on ECLS in the ICU required extension to a team approach not just trained surgical specialists. This requirement is especially true with multiple patients on prolonged support. The published 2005 ELSO data showed that historically, ECMO was primarily used for congenital and pediatric diseases.[5]

PROGRAM EVOLUTION

A decade later, there has been an increase in the number of adult ECMO cases due to the improvement in equipment, renewed interest, and growth of ECMO teams.[6] The