ECMO, A Bridge To Transplantation Or To Nowhere: Medical, Ethical, And Financial Perspectives

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Abstract

Extracorporeal membrane oxygenation (ECMO) has a tremendous potential for prolonging life in individuals with severe heart and/or lung damage. Since the Covid-19 pandemic, its uses are expanding. The focus of this analysis is for individuals with heart and lung damage so severe that they need ECMO to bridge the gap until they can receive a donor organ. The technology, although very effective at sustaining life, creates a variety of ethical considerations such as cases that question if a certain use of the machine is prolonging life or rather prolonging the dying process, as well as justice issues due to the expensive nature of the treatment. Though this paper, the authors will give an introductory background and historical overview of ECMO and its applications, a case study of an ECMO patients' final months, a brief financial analysis as compared to the conventional treatment methods, and series of recommendations for the most appropriate applications of ECMO that are based both theologically as well as Bioethically on the principles of autonomy, beneficence, nonmaleficence, and justice.

INTRODUCTION

Extra corporeal membrane oxygenation (ECMO) has seen a vast increase in applications and overall usage in recent years for its use in caring for patients with severe cardiac and pulmonary conditions that are resistant to standard methods of treatment. ECMO has the capability to provide partial or total support of both the heart and lungs, which allows for a period of time for the processes of consultation, diagnosis, treatment, and recovery from the primary disease which is causing the cardiac or pulmonary dysfunction in the first place to be carried out. With usage rates of ECMO increasing, it is vital that we analyze the technology for its potential uses and benefits as well as some drawbacks and potential ethical questions raised by its use. Although this technology is far from new, being first used successfully in 1972, it was brought into the public eye due to the Covid-19 pandemic for patients whose lungs were so impaired that they needed lung bypass in order to recover.[1] Since then, it has mostly been used for patients while waiting for heart and/or lung transplants, and for those with respiratory failure due to Covid-19, asthma, or pneumonia.

This paper will examine ECMO's uses from historical, medical, financial, and ethical perspectives. The main ethical focus of the paper will be the issue of informed consent and if individuals who are agreeing to be put on ECMO truly understand what they are signing up with all of the benefits, risks and alternatives weighed. The authors will argue that ECMO must be used with careful consideration of its ethical implications.

HISTORY

Extracorporeal bypass has been used since the 1950s for patients requiring pulmonary bypass when undergoing procedures. Starting at that time, the technology continued to progress in function and application and then in 1971, "Dr. Solomon Hill successfully treated a patient with acute respiratory failure utilizing an extracorporeal bypass circuit.[2] This finding spurred increased usage of ECMO as a therapeutic option for patients with significant isolated lung injury refractory to optimal medical management…".[2] After this success, it's uses continued to expand and in 1974 there was a famous case published about it saving the life of a neonate in California after maximum ventilation showed no hope of progressing the child's condition.[2] Following this over the next few years, several randomized control trials were ran to compare the effectiveness of ECMO compared to the standard method of care which is mechanical ventilation, finding that ECMO can be a beneficial viable option in certain patients with consideration to age, gender,

medical comorbidities, and etiology of respiratory failure.[2]

Since the outbreak of the Covid-19 pandemic in the spring of 2020, ECMO's uses have yet again expanded to a new realm of treatment potential for the acute respiratory distress that often accompanies a Covid-19 infection. One major issue that medical institutions faced during the height of the pandemic was a generalized shortage of resources, and availability of ECMO was no different, therefore specific guidelines were placed to assist clinicians in the triage of patients when deciding who to place on the machine. The new criteria reserved it for those who were 71 years old or younger and presented to the clinic with initially severe respiratory distress that was found to be unresponsive to mechanical ventilation.3 The pandemic has made this already scarce resource even more difficult to obtain, specifically for those in areas where the local hospital or clinic can not afford an ECMO machine.

CASE STUDY

The case that will serve as the centerpiece of this analysis of ECMOs uses is that of Francia Bolivar Henry who lived on the machine with sarcoidosis (an inflammatory disease that caused her lung to collapse) for her last few months alive. Ms. Henry was a bright and joyful 30 year old pastry chef and even while living in the ICU in the Brigham and Women's Hospital in Boston, hooked up to a machine that is mechanically breathing for her, she still found joy in each day. The physical condition of her lungs had gotten to a point where her doctors told her that a transplant was her only option and she agreed to be put on the transplant list, and so she did the only thing that she could: waited. As time passed, her condition continued to deteriorate until her only option to continue waiting was to be placed on ECMO, thus the catheters were inserted and her bridge to transplantation had begun. Although her struggling lungs are now out of the equation, life on ECMO is still filled with risks of complications which is why it is not suggested for long term use.[4]

One of the main ethical concerns regarding ECMO bridging is brought to light when the patient is no longer qualified or is unable to get a donor organ and now, the bridge to transplantation has become a bridge to nowhere, and must be terminated. Doctors attempt to make this potential issue clear when explaining ECMO and its uses but, in the heat of the moment, it seems plausible to say that many patients and proxies are not making a fully informed decision and are rather being swayed by the desperation of the moment without considering the future consequences.[4]

This is exactly what happened in the case of Ms. Henry, she appeared stable yet, she was living on a fine line, and as the complications continued, she was removed from the transplant list. Although her ferocious will to live was still unwavering as she continued to push herself to walk each day, keep her mind sharp, and keep her spirits up; one by one, transplantation programs denied her. It began to be quite clear to her and those around her that she was never going to get the transplant. This very scenario is a dilemma that the seemingly limitless scientific advancements into life prolonging treatments have made: she was awake, alert, and due to the ECMO machine, living on a mechanically stabilized and extremely costly bridge to nowhere. As more scientific advancements are made into technology similar to ECMO, scenarios like this one will become increasingly prevalent, challenging clinicians to question themselves as to what it truly means to do no harm.[4] Thus analyzing cases such as this one is an invaluable exercise that will help guide clinicians and patients though these situations that are inevitable in the future of medicine.

MEDICAL PERSPECTIVES

ECMO functions similarly to the heart-lung bypass machine that is used during an open heart surgery in the sense that it effectively oxygenates one's blood outside of the body in an artificial lung, allowing time for the actual heart and lungs to rest. The artificial cardiovascular circuit is capable of filling the blood with oxygen for bodily functions while ridding it of natural toxins such as carbon dioxide, finally the blood is warmed to body temperature and sent back through one's own cardiovascular system. Mechanical ventilation, commonly known as a breathing machine, has classically been used to treat lung failure. These devices apply positive pressure to surge airflow into the lungs and enhance gas exchange, supplying the body with the necessary oxygen and eliminating carbon dioxide. The caveat is that people usually breathe through a negative pressure system, which is opposite to how ventilation works. This rise in positive pressure can put strain on the lungs by raising the volume and pressure, leading to potential structural lung damage. Hence, ECMO is effective because it allows the lungs to rest and curtail the damage that mechanical ventilation or another lung injury may have caused.[5] There are two main types of ECMO, VA ECMO, in which the catheters are connected to one vein and one artery and is used when both the heart and the lungs are damaged, and VV ECMO, which is placed into two veins, which is used when just the lungs are damaged.[6]

The five main uses for ECMO are as follows according to the heart and lung specialists at University of California San Francisco (UCSF):

1. For patients recovering from heart failure, or lung failure or heart surgery.
2. As a bridge option to further treatment, when doctors want to assess the state of other organs such as the kidneys or brain before performing heart or lung surgery.
3. For support during high-risk procedures in the cardiac catheterization lab.
4. As a bridge to a heart assist device, such as the left ventricular assist device (LVAD).
5. As a bridge for patients awaiting lung transplant. The ECMO helps keep tissues well oxygenated, which makes the patient a better candidate for transplant.[6]

Conditions where ECMO is typically initiated include Cardiogenic Shock: After cardiac surgery, unable to wean off CPB, Acute myocardial infarction (when the ventricles of the heart do not function causing insufficient blood flow) and Heart failure after transplantation due to graft rejection, intractable arrhythmia. Further, Respiratory failure is another indication for ECMO: In pulmonary arterial hypertension of the neonate, Pulmonary embolism (when an artery in the lungs is blocked) Acute Respiratory Distress Syndrome (a type of respiratory failure that prevents adequate oxygen from getting to the lungs and blood), viral or bacterial pneumonia, aspiration pneumonia, respiratory burns. Situations where ECMO will not be indicated follow:

1. For more than seven days, mechanical ventilation has been used at high settings (FIO2 > 0.9, P-plat > 30).[7]
2. If total time of cardiac arrest is greater than 60 minutes.[7]
3. If chest compressions have not been started within ten minutes after arrest.
4. If severe neurological condition or damage present prior to arrest.
5. Patients with chronic irreversible conditions like Chronic pulmonary disease, Bleeding disorders, irreversible brain disease, progressively degenerative systemic disease etc.
6. There are no explicit age restrictions, although risk with rising age should be considered.[7]

In order to initiate and maintain ECMO, a surgical procedure is carried out and constant monitoring is required. The process consists of first sedating the patient, administering pain medication and then anticoagulants, followed by the insertion of the two catheters into either two veins or one vein and one artery depending on what the patient needs. Finally, an X-ray is used to verify that the tubes are in the correct placement and the machine should be started.[5] After the machine is properly set up and blood is being perfused through, the patient is monitored by specially trained nurses, respiratory therapists, and their surgeon. Further, since most of the time one is on the machine they will be sedated, supplemental nutrition and hydration are provided either intravenously or through a naso-gastric tube.[6] Furthermore, various medications are required to work against some of the common complications, "... heparin to prevent blood clots; antibiotics to prevent infections; sedatives to minimize movement and improve sleep; diuretics to help the kidney get rid of fluids; electrolytes to maintain the proper balance of salts and sugars; and blood products to replace blood loss".[6]

Since life on the machine is so full of danger, the decision to go on ECMO is a difficult one. Once connected, the patient could have "a life-threatening clot, a devastating hemorrhage or a stroke".[4] Another complication is that unlike those on dialysis or with a ventricular assistance device, patients on ECMO cannot live outside the I.C.U. since "they need constant monitoring, often daily blood transfusions, and the longer they wait, the more complications they face".[4] Although ECMO can be a very useful tool, it was not designed for long term use and rather was supposed to be used solely as a temporary solution to one's cardiopulmonary distress.

FINANCIAL IMPLICATIONS

Since ECMO bridging is known to be costly, it is vital to compare it to conventional treatment methods. In this study run by Dr. Kate Brown of University College London, the cost effectiveness of the two treatment options were measured in cost per quality adjusted life year (QALY).6 The study analyzed was a cost utility evaluation, which used 75 pediatric patients with end-stage heart failure who were offered ECMO as an option to bridge the gap until a potential transplantation as compared to a cohort who underwent the conventional method of treatment (mechanical ventilation). The study found that, although ECMO proved to be highly effective in bridging the gap, it was disproportionately more expensive, "Average life expectancy rose from 6.78 to 9.79 years and costs from £146,398 to £309,599 per patient with ECMO bridging".6 Brown et al offered three suggestions on how to maximize the cost-effectiveness of the technology to reach a greater population of individuals who could benefit, "1) increased availability of organ donors, 2) reduction in mechanical support costs possibly by alternate devices and 3) inclusion of patients most likely to benefit".6 Ultimately, ECMO bridging is effective and expensive, creating a potential

justice issue in that the most vulnerable uninsured and underinsured individuals will most likely not be given ECMO as a treatment option and it will be reserved for the well off in developed nations.

ETHICAL ANALYSIS OF ECMO

Extracorporeal Membrane Oxygenation (ECMO) is now being used as a bridge to cardiac and lung transplant and support for lung resections in unstable patients.[8] The use of ECMO has significantly increased in the last few years. "The Extracorporeal Life Support Organization registry has reported over 100,000 ECMO cases worldwide since 1987.[9] This increase in patients using ECMO has raised numerous ethical questions because of the uncertainty of the outcomes and the lack of clarity on the intended treatment direction. For some ECMO has become a "bridge to transplant," but for others it has become a "bridge to nowhere," when the patient becomes no longer a candidate for transplant and is unlikely to recover. Many ethical and medical questions arise about whether the patient is a candidate for ECMO. Questions such as: Does the patient or the proxy truly have informed consent about ECMO? Is ECMO in the patient's best interest? What is the survival rate for a patient on ECMO? For some, the main question is whether the goal of ECMO is quality of life or quality of life? To determine if this procedure is ethical, the principles of respect for persons, beneficence, nonmaleficence and justice will be applied to this procedure and its consequences.

Respect for persons

This principle incorporates two ethical convictions: first, that persons should be treated as autonomous agents; and second, that persons with diminished autonomy are entitled to protection. The principle of respect for persons thus divides into two separate moral requirements: the requirement to acknowledge autonomy and the requirement to protect those with diminished autonomy.[10] Respect for human persons refers to the right of a person to exercise self-determination and to be treated with dignity and respect. All people deserve autonomy and to be treated with dignity and respect. The major ethical issue is that when a patient is a possible candidate for ECMO most are often deemed noncompetent and it is during a crisis clinical situation. The patient's proxy must make this decision quickly, lacking certainty about the diagnosis and prognosis and not truly understanding the risks, benefits, alternatives and consequences. Many times, there is a limited amount of time to discuss all the elements of consent. These limitations are compounded by the fact, that often we do not know the wishes of the patient or the goals of care of the patient. This can limit the patient's autonomy.

Second, as an autonomous agent an individual has the right of informed consent. Patients/proxies have the right to know all information about their diagnosis, prognosis, treatment and care plan. The elements of informed consent include:

1. A fair explanation of the procedures to be followed, including an identification of those which are experimental;
2. A description of the attendant discomforts and risks;
3. A description of the benefits to be expected;
4. A disclosure of appropriate alternative procedures that would be advantageous for the subjects;
5. A offer to answer any inquiries concerning the procedures;
6. An instruction that the subject is free to discontinue participation in the project or activity at any time.[11]

"Most ECMO programs are led by cardiothoracic surgeons. Large database and public reporting of outcomes, such as The Society of Thoracic Surgeons national registry, have facilitated careful consideration of the risk-benefit profile for each patient and circumstance by physician leaders in charge of ECMO centers. These deliberations are more appropriate for semi elective or semi urgent situations in which an early referral has been made to the program on behalf of a patient whose condition has not improved despite maximal conventional therapy. In other emergency cases, there simply is not adequate time to explore every aspect of the decision at hand."[12] In a specific sense, the surgeons who want to utilize ECMO have an ethical obligation to give an objective, non-biased assessment of all materially relevant information pertaining to the success of ECMO, complications, limitations, risks/benefits, alternatives and consequences. In addition, the rates of success must be discussed with the patient/proxy and these rates must be presented in a realistic manner. The surgeons are also responsible to verify, to the best of their ability, that the patient/proxy can comprehend and has comprehended the information and has not engaged in "selective hearing." Under the circumstances, it is not uncommon for patients to engage in "selective hearing," that is, taking in all information about potential benefits and filtering out all information about potential risks. In addition to this, surgeons must be vigilant against their influence over subjects, who may unwarily treat the surgeon with the same deference as they treat their primary care physicians. Dr. Robert Levine, professor of Medicine at Yale University,

describes the surgeon/researcher's obligation as one of "forthright disclosure." This includes preliminary evidence and data from animal studies and previous human clinical trials that indicate the risks and benefits as well as the safety and efficacy of these controlled studies.[13] Patients/proxys need to have information that a prudent person would require to make well-reasoned decisions that will protect their personal interest.

The problem is determining what sort of knowledge translates to what degree of risk to patients. This is a value judgment that must be made by the surgeons. The concern is that the judgment of some surgeons may be biased by considerations of career self-interest and even financial gains.[14] "The potential for coercion can be difficult for surgeons. On the one hand, most accept that the final choice for surgery should be left to the patient. On the other hand, surgeons want what they believe to be best for their patients. Therefore, there is ample room for unintentional coercion through selecting information for disclosure that overtly reinforces the surgeon's beliefs."[15] There is also the problem of forming an "innovative alliance." Patients/proxies may encourage their surgeons to try any new and promising technique to improve their quality of life or prospects for survival and surgeons also may be eager to apply a promising new technique for the same reasons. It is the duty of the surgeons to decide whether responsible behavior lies in attempting an innovative technique or in concluding that the background research is not sufficient to warrant its use, even when the patient consents.[16] The surgeon has the responsibility to act in the best interest of the patient. The belief that ECMO will not cause too much harm to too many people or that society will benefit at the possible expense of particular individuals violates the duty of the surgeon/researcher to act in the best interest of the patient. To determine whether that duty has been breached, a surgeon/researcher's actions should be measured against the accepted practice as set by professional norms. Those surgeons/researchers whose treatments fall below the professional standards and cause harm to patients may be held civilly liable for that failure.[17] Various ways have been proposed that ensure individuals going into research and experimental protocols are giving informed consent, these include: written and oral forms of consent so that the patient/proxy has time to read and reflect on the risks and benefits; someone other than a member of the surgical team obtains the informed consent; obtaining second opinions from other knowledgeable physicians regarding the feasibility of such a procedure; and appointing an objective advocate who would accompany the patient during the decision-making process. These advocates would ensure that the patient is capable of understanding the information and comprehends all the information, that researchers do not overestimate potential benefits and underestimate potential risks, and that all viable options are given, even the option of no transplant. These are not only excellent safeguards; they should be implemented with every research protocol. These safeguards should also be used in regards to procedures like ECMO to verify that surgeon bias is not a factor and that the patient/proxy is giving informed consent and truly understand the full dimensions of this procedure.

Medical advances are necessary for society, and experimental surgeries and life-support therapies are important tools to bring about these advances. But these advances can never be at the expense of denying individuals their basic dignity and respect. If patients/proxies are made aware and comprehend the success data, short-term and long-term risks and benefits, alternatives and possible consequences and safeguards are put in place to avoid the potential for coercion, then informed consent can be obtained ethically for this procedure.

Beneficence/Nonmaleficence

Beneficence involves the obligation to prevent and remove harm and to promote the good of the person by minimizing the possible harms or risks and maximizing the potential benefits. Beneficence includes nonmaleficence, which prohibits the infliction of harm, injury, or death upon others. In medical ethics this principle has been closely associated with the maxim Primum non nocere: "Above all do no harm."

Proponents of ECMO argue that this therapy does what is "good" for the patient and is in the patient's best interest. "In some cases, this might mean allowing appropriate time for recovery without necessary escalation of maximal invasive therapy. Others, though, deteriorate in a predictably unpredictable fashion. A difficult and in many cases unresolved question is what constitutes an adequate or reasonable trial for ECMO. Ongoing therapy is fraught with the potential for imminent complications, and this in the end may, in fact, outweigh the benefits being provided."[18] To determine what is "good" for the patient or in their "best interest," the proxy needs to understand the patient's values, goals of care, advance directives, etc. in order to determine if the decision to use ECMO is within the value of beneficence/nonmaleficence.

Many critics of ECMO will argue that the unnecessary medical complications that could lead to death, outweigh any benefit to these patients. To determine if this procedure is beneficial for the patient or a "bridge to nowhere," there must be guidelines established that are clearly presented to patients/proxies. These guidelines should include the following: ECMO Weaning Guidelines, Guidelines for Indications and Contraindications for ECMO, Futility Criteria for ECMO Withdrawal, Guidelines for Physicians during a Code Event, Indications and Contraindications for ECMO in patients following burn and inhalation injury, etc. These guidelines for patient candidacy or patient use of ECMO should be vetted by a multidisciplinary group a priori as an important component for any ECMO program, as inappropriate use of the technology and subsequent harm, may be more likely avoided.19 This will help all parties concerned to discern whether ECMO meets the criteria of beneficence or nonmaleficence. Arguably, it appears that with the proper safeguards ECMO does not fail the test of beneficence or the test of nonmaleficence. No one will dispute that balancing the benefits and risks is difficult, especially with a highly technical intervention and usually in a crisis clinical situation. Some will continue to argue that the risks outweigh the benefits. However, if these patients/proxies truly have informed consent and understand the risk/benefits, alternatives and consequences of ECMO, then they have the right to agree to this procedure. For many patients, their desire to be a candidate for transplant clearly outweighs the possible medical risks to them that ECMO may present.

Justice

The principle of justice recognizes that each person should be treated fairly and equitably, and be given his or her due. The issue of ECMO also focuses on distributive justice: the fair, equitable, and appropriate distribution of medical resources in society. At a time when reforming healthcare in this country has become a high priority, failure to initiate preventative measures and clinical research that would save medical resources and possibly human lives in the long-run violates the principle of distributive justice.

The issue of justice pertains to ECMO specifically in regards to distributive justice, which concerns the fair and equitable allocation of medical resources. "Given that ECMO is very resource-intensive (and subsequently, expensive) determining what constitutes a fair distribution is challenging. When data are sparse, expert opinions tend to drive thinking and decisions."[20] Total cost of ECMO has been viewed as equivalent to the cost of major cardiac surgery. "This cost was estimated by including the expense of the circuit, cost of the use of the operating room or procedural suite, and any specific items that can only be associated with ECMO utilization (e.g., cannulas, guide wire). As a scarce resource, cost goes beyond the simple financial impact on the ever-changing health care industry, but many programs may have only a limited number of "ECMO circuits" or "ECMO beds," and if one is being utilized, that bed, by definition, cannot be for another patient."[21] There are selection criteria that could be implemented to ensure fair and equitable allocation of resources that would address the justice issue. The United Network of Organ Sharing, transplant centers and cardiac life support criteria have clearly defined criteria to ensure fair and equitable allocation of resources. Similar criteria could be implemented in regards to the use of ECMO. As a matter of social justice, who ECMO would benefit and whether it is a fair and equitable allocation of medical resources is an important ethical issue. Medical professionals have an ethical obligation to use available resources fairly and to distribute them equitably. However, critics have used and continue to use these arguments for all expensive experimental procedures. These are the same arguments that were used when organ transplants were proposed. Unless research and data are advanced, medicine will never meet the needs of individuals and society as a whole. Yes, ECMO is expensive, but as the procedures are perfected, and new data is advanced, it is inevitable that more and more people will benefit from this procedure with the addition of responsible safeguards and guidelines. One can argue that this is a fair and equitable use of medical resources and thus meets the test of the principle of justice. At the present time, if ECMO is being shown to be an effective way of treating severe cardiac and pulmonary dysfunction and the risk-benefit ratio is reasonable, and safeguards are put in place to assure patients have informed consent, then physicians have an ethical obligation to offer ECMO as a viable option, but with the stipulation that a criteria will be put in place that will be activated if the patient is no longer benefiting from the procedure. To have a patient continue on ECMO, when further treatment is medically futile, would violate the principle of justice.

CONCLUSION

In all, ECMO is a highly effective and expensive treatment for heart and lung failure which poses many questions regarding informed consent, just allocation, and the distinction between prolonging life and extending the dying

process. Some efforts that should be pushed forward to hospital systems to aid in the proper utilization of ECMO to maximize the good in each patient are "Preemptive ethics consultation, daily interdisciplinary rounds, and early advance care planning that addresses values, appropriate goals and fears, as well as support from spiritual and palliative care providers…."[8] As modern medicine continues to create issues of this nature with technological advancements, physicians should keep a keen eye on the ethical implications that accompany the proposed benefit.

ADDENDUM

For further information regarding the implementation of adequate futility policies to protect physicians from legal concerns and provide patients with the utmost dignity and respect please see "TIME FOR A FORMALIZED MEDICAL FUTILITY POLICY" by Peter Clark S.J. Ph.D. and Catherine M. Mikus ESQ:

Clark PA, Mikus CM. Time for a formalized medical futility policy. Mercy Health System's procedures will help free its physicians from legal concerns. Health Prog. 2000 Jul-Aug;81(4):24-32. PMID: 11183674.

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