Title

ECMO in the Emergency Department in a Patient with Refractory Shock

Journal

Proceedings of UCLA Health, 25(1)

Authors

Moises Bravo
Celedon, Manuel A.
Darnsteadt, Derrick

Publication Date

2021-03-17

CLINICAL VIGNETTE

ECMO in the Emergency Department in a Patient with Refractory Shock

Moises Bravo, Manuel A. Celedon, MD and Derrick Darnsteadt, MD

Case Summary

A 28-year-old female (Gravida 1 Para 1) at 11 weeks of gestational age presented with abdominal cramps and heavy vaginal bleeding. She had taken misoprostol 4 days prior to her emergency department (ED) arrival. The patient reported waking up that morning feeling ill with a large amount of blood and tissue around her vagina. Associated symptoms included abdominal cramping, nausea, non-bloody non-bilious vomiting, shortness of breath, and fever.

Initial vitals on arrival were a temperature 97.2F, blood pressure 106/52 mmHg, heart rate 108/min, respiratory rate 18/min and oxygen saturation of 92% on room air. Evaluation by the Emergency Medicine Physician shortly after arrival revealed a patient in severe distress with mottled skin, hypotension (90/50 mmHg), and severe tachycardia (HR 170). Given concern for hemorrhagic shock, emergent intravenous access was placed via a "crash" right femoral central venous cordis catheter and transfusion of type O^- blood was initiated empirically. ED point-of-care ultrasound revealed a "flat" inferior vena cava (IVC), hyperdynamic cardiac function without evidence of pericardial effusion, and a negative Extended Focused Assessment with Sonography in Trauma (eFAST). During the resuscitation, the patient became progressively more hypoxemic and altered requiring emergent endotracheal intubation.

There was increasing difficultly oxygenating the patient despite maximum levels of inspired oxygen and positive end-expiratory pressure (PEEP). She also required multiple vasopressors to maintain her blood pressure. She became pulseless multiple times during the resuscitation and received cardiopulmonary resuscitation (CPR) of up to 6 minutes each episode to obtain return of spontaneous circulation. After discussion with the pulmonary critical care consultant, it was determined that the patient may benefit from Extracorporeal Membrane Oxygenation (ECMO).

Background

Utilization of ECMO has increased dramatically in recent years.[1] Its utilization is no longer isolated to the use as a support device in the operating room. It is now seen as a viable intervention for patients who present with either refractory acute cardiac or pulmonary failure. Studies of early ECMO initiation showed improved outcomes.[2] In the ED, it is important for providers to understand the indications, contraindications, and limitations of this therapy. As not all hospitals have the capability of providing ECMO, it is also important to recognize when to transfer patients. This case of undifferentiated shock resulted in activation of a mobile ECMO unit and initiation of ECMO prior to transfer to a hospital capable of managing ECMO patients.

Indications

ECMO provides sustained mechanical cardiopulmonary support. The system involves the use of a heat exchanger and mechanical pump to drain, circulate, and reintroduce blood into the vascular system. An oxygenator, or "artificial lung", is used to infuse hemoglobin with oxygen and remove carbon dioxide. ECMO can be administered in two different configurations, venovenous (VV) and venoarterial (VA).[3] The configurations differ by the location of deoxygenated blood extraction and oxygenated blood return. VV ECMO is used to provide respiratory support, typically by extracting blood from the right atrium, oxygenating it and returning it to the right atrium. Cannulas are placed either in the femoral or right jugular area(s). The use of VV ECMO is dependent on stable hemodynamics given dependence on the hearts' contractility to support the arterial system. VA ECMO is used when both respiratory and hemodynamic support are required. In VA ECMO, blood is extracted from the right atrium and returned to the arterial system. The former configuration essentially provides the function of the lungs outside of the body, and in the end, oxygenated blood still arrives at the heart to be pumped throughout the body. In the latter configuration, deoxygenated blood is extracted directly from the venous system and oxygenated blood is returned directly into the arterial system, essentially bypassing both the lungs and the heart.

Criteria

1. The best outcome in ECMO for adult respiratory failure occurs when ECMO is instituted early after onset (1-2 days):
    a. In hypoxic respiratory failure from any cause (primary or secondary) extracorporeal life support (ECLS) should be considered when the risk of mortality exceeds 50% and is indicated when the risk of mortality is 80% or greater.
        i. 50% mortality risk is associated with any of the following:
            1. $PaO_2/FiO_2 < 150$ on $FiO_2 > 90\%$

2. Murray score 2- 3
3. Age-adjusted Oxygenation Index (AOI) score 60
4. Age, PaO2/FiO2, plateau pressure score (APPS) 5-7[4]

ii. 80% mortality risk is associated with any of the following:
1. PaO2/FiO2 < 100 on FiO2> 90%
2. Murray score 3-4
3. AOI >80
4. APPS 8, despite optimal care for 6 hours or less.

b. CO2 retention on mechanical ventilation despite high plateau pressure (Pplat) (>30 cm H2O).
c. Severe air leak syndromes.
d. Need for intubation in a patient on lung transplant list.
e. Immediate cardiac or respiratory collapse (PE, blocked airway, unresponsive to optimal care).

Relative Contraindications

Each situation is considered individually, although the following are associated with poor outcomes despite ECMO:

1. Mechanical ventilation at high settings (FiO2 >0.9, Pplat >30) for 7 days or more. Although many centers do not consider extended time on a ventilator a contraindication.
2. Major pharmacologic immunosuppression (absolute neutrophil count <400/mm3).
3. CNS hemorrhage that is recent or expanding.
4. Nonrecoverable comorbidity such as major CNS damage or terminal malignancy.
5. Advanced Age; although there is no specific cut-off, risk increases with increasing age.

Outcomes

ECMO was traditionally utilized in the intensive care unit but has increasing interest in other settings, including the ED. ECMO in the emergent setting can be further distinguished based on specific indication and configuration. Utilization of ECMO in the ED can be divided into pulmonary versus cardiac system support. VV ECMO provides an alternative treatment of patients in acute respiratory failure, secondary to reversible causes, such as acute respiratory distress syndrome (ARDS). The Conventional Ventilatory Support vs ECMO for Severe Adult Respiratory Failure (CESAR) trial provided important data that increased interest in the use of ECMO.[5] The CESAR trial reported patients referred to ECMO centers had increased survival, without disability, six months post-intervention.[5] More recently, the ECMO for Severe ARDS (EOLIA) trial compared the use of VV ECMO vs conventional mechanical ventilation strategies in the treatment of severe ARDS.[6] Although the trial was stopped early due to no improvement in preliminary data for VV ECMO, final analysis did not show a significant difference, in 60-day mortality.[6] A meta-analysis examined 28 randomized controlled trials examining treatment for moderate to severe ARDS. Patients treated with prone positioning and VV ECMO had a lower 28-day mortality compared to conventional mechanical ventilation alone.[7] Patients on VV ECMO had improved oxygenation, increased period of time free of renal failure, and fewer incidents of ischemic stroke.[6]

Extracorporeal cardiopulmonary resuscitation (ECPR) refers to the use of VA ECMO as an intervention for cardiac arrest, after traditional resuscitative measures have been exhausted. The ultimate goal of ECPR is to prevent irreversible hypoxemic end-organ damage. Based on observational studies, the factor that determines positive outcomes is the time interval between initial cardiac arrest and initiation of ECPR.[2] This time interval is known as the low-flow time. Shorter low-flow times were associated with better outcomes, including a higher survival rate to discharge compared to long-flow times.[2] A meta-analysis compared the survival rate to discharge and long-term neurological outcomes in patients that underwent ECPR versus conventional cardiopulmonary resuscitation (CPR). Outcomes were analyzed at different intervals, including at the time discharge, at 3-6 months post event, and 1-year post event. Patients who underwent ECPR showed better overall outcomes.[8] Another meta-analysis showed a negative trend in survival in patients who had CPR administered >30 minutes without early ECPR initiation.[9] Other implementations of ECMO in the ED include extracorporeal life support (ECLS). This method describes the use of ECMO as a temporizing measure in critically ill patients.[10] ECLS is primarily used in patients who at first may not be stable enough to undergo other forms of cardiac support, such as placement of a left ventricular assist device (LVAD). An observational study found that patients who survived the ECLS bridge to LVAD placement had an 80% 1-year survival rate.[11] Observational studies in the use of VA ECMO in the treatment of refractory cardiogenic shock reported early support can rescue up to 40% of otherwise fatal cases.[12] Among the survivors of cardiogenic shock treated with ECMO, patients without sequelae reported a higher quality of life compared to patients on chronic hemodialysis or heart failure.[12]

Future Direction of this Procedure in the ED / and Medicine in General

Emergency medicine physicians are at the frontlines of patient resuscitation. Utilization of every treatment modality available is critical in providing an environment for success. Although not every medical facility can provide ECMO, all physicians should be aware of its capabilities and limitations. Providers should have this modality in mind as a possible intervention when conventional resuscitative efforts are unsuccessful. Recognizing appropriate candidates early in their hospital course will minimize delays in getting other specialties involved to initiate ECMO, activate a mobile ECMO team, or to initiate the transfer process to an ECMO-equipped facility. The procedure is not free of risks and should not be done without thorough assessment, however, earlier utilization is key when conventional treatments have failed. ECMO has come a long way since it was introduced and has now gained broader

adoption given positive outcomes. Further studies are needed to establish standardized criteria for patient selection in the ED, examining both survival and post-intervention quality of life.

Case Conclusion and Brief Discussion

VA ECMO was successfully started in the ED and the patient was transferred to an ECMO capable tertiary care hospital via the mobile ECMO team. While at the tertiary care center, the ECMO team was unable to maintain adequate flow and the patient required extensive vasopressor support. A family meeting was held to discuss goals of care and the family agreed not to escalate care and to transition toward palliative comfort care. The patient expired soon after and autopsy was declined. No etiology was determined for her decompensational.

VA ECMO was the ideal intervention for our patient given the need for both cardiac and pulmonary support. She had failed conventional management to maintain perfusion and was requiring multiple vasopressors and resuscitative adjuncts as well as intermittent CPR. She could not maintain oxygenation, despite maximum levels of FiO2 and PEEP. There were no contraindications to ECMO and early initiation of ECMO was an appropriate intervention given the patient grave condition.

REFERENCES

1. **Rush B, Wiskar K, Berger L, Griesdale D**. Trends in Extracorporeal Membrane Oxygenation for the Treatment of Acute Respiratory Distress Syndrome in the United States. *J Intensive Care Med*. 2017 Oct;32(9):535-539. doi: 10.1177/0885066616631956. Epub 2016 Feb 17. PMID: 26893318.
2. **Debaty G, Babaz V, Durand M, Gaide-Chevronnay L, Fournel E, Blancher M, Bouvaist H, Chavanon O, Maignan M, Bouzat P, Albaladejo P, Labarère J**. Prognostic factors for extracorporeal cardiopulmonary resuscitation recipients following out-of-hospital refractory cardiac arrest. A systematic review and meta-analysis. *Resuscitation*. 2017 Mar;112:1-10. doi: 10.1016/j.resuscitation.2016.12.011. Epub 2016 Dec 19. PMID: 28007504.
3. **Squiers JJ, Lima B, DiMaio JM**. Contemporary extracorporeal membrane oxygenation therapy in adults: Fundamental principles and systematic review of the evidence. *J Thorac Cardiovasc Surg*. 2016 Jul;152(1):20-32. doi: 10.1016/j.jtcvs.2016.02.067. Epub 2016 Mar 12. PMID: 27060027.
4. **Hwang H, Choi SM, Lee J, Park YS, Lee CH, Yoo CG, Kim YW, Han SK, Lee SM**. Validation of age, PaO_2/FlO_2 and plateau pressure score in Korean patients with acute respiratory distress syndrome: a retrospective cohort study. *Respir Res*. 2020 Apr 22;21(1):94. doi: 10.1186/s12931-020-01357-5. PMID: 32321513; PMCID: PMC7178575.
5. **Peek GJ, Clemens F, Elbourne D, Firmin R, Hardy P, Hibbert C, Killer H, Mugford M, Thalanany M, Tiruvoipati R, Truesdale A, Wilson A**. CESAR: conventional ventilatory support vs extracorporeal membrane oxygenation for severe adult respiratory failure. **BMC Health Serv Res.** 2006 Dec 23;6:163. doi: 10.1186/1472-6963-6-163. PMID: 17187683; PMCID: PMC1766357.
6. **Combes A, Hajage D, Capellier G, Demoule A, Lavoué S, Guervilly C, Da Silva D, Zafrani L, Tirot P, Veber B, Maury E, Levy B, Cohen Y, Richard C, Kalfon P, Bouadma L, Mehdaoui H, Beduneau G, Lebreton G, Brochard L, Ferguson ND, Fan E, Slutsky AS, Brodie D, Mercat A; EOLIA Trial Group, REVA, and ECMONet**. Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome. *N Engl J Med*. 2018 May 24;378(21):1965-1975. doi: 10.1056/NEJMoa1800385. PMID: 29791822.
7. **Aoyama H, Uchida K, Aoyama K, Pechlivanoglou P, Englesakis M, Yamada Y, Fan E**. Assessment of Therapeutic Interventions and Lung Protective Ventilation in Patients With Moderate to Severe Acute Respiratory Distress Syndrome: A Systematic Review and Network Meta-analysis. *JAMA Netw Open*. 2019 Jul 3;2(7): e198116. doi: 10.1001/jamanetworkopen.2019.8116. PMID: 31365111; PMCID: PMC6669780.
8. **Wang GN, Chen XF, Qiao L, Mei Y, Lv JR, Huang XH, Shen B, Zhang JS**. Comparison of extracorporeal and conventional cardiopulmonary resuscitation: A meta-analysis of 2 260 patients with cardiac arrest. *World J Emerg Med*. 2017;8(1):5-11. doi: 10.5847/wjem.j.1920-8642.2017.01.001. PMID: 28123613; PMCID: PMC5263037.
9. **Cardarelli MG, Young AJ, Griffith B**. Use of extracorporeal membrane oxygenation for adults in cardiac arrest (E-CPR): a meta-analysis of observational studies. *ASAIO J*. 2009 Nov-Dec;55(6):581-6. doi: 10.1097/MAT.0b013e3181bad907. PMID: 19770800.
10. **Mosier JM, Kelsey M, Raz Y, Gunnerson KJ, Meyer R, Hypes CD, Malo J, Whitmore SP, Spaite DW**. Extracorporeal membrane oxygenation (ECMO) for critically ill adults in the emergency department: history, current applications, and future directions. *Crit Care*. 2015 Dec 17;19:431. doi: 10.1186/s13054-015-1155-7. PMID: 26672979; PMCID: PMC4699333.
11. **Pagani FD, Aaronson KD, Swaniker F, Bartlett RH**. The use of extracorporeal life support in adult patients with primary cardiac failure as a bridge to implantable left ventricular assist device. *Ann Thorac Surg*. 2001 Mar;71(3 Suppl):S77-81; discussion S82-5. doi: 10.1016/s0003-4975(00)02620-5. PMID: 11265871.
12. **Combes A, Leprince P, Luyt CE, Bonnet N, Trouillet JL, Léger P, Pavie A, Chastre J**. Outcomes and long-term quality-of-life of patients supported by extracorporeal membrane oxygenation for refractory cardiogenic shock. *Crit Care Med*. 2008 May;36(5):1404-11. doi: 10.1097/CCM.0b013e31816f7cf7. PMID: 18434909.