Case Report

Bloodless Extracorporeal Membrane Oxygenation in the Jehovah’s Witness Patient

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Abstract: The successful use of prolonged extracorporeal life support with a heart-lung machine was first performed in 1972, as described by Hill et al., on a young man with post-traumatic respiratory failure. The first successful use of extracorporeal membrane oxygenation (ECMO) was 1976 by Bartlett et al. Since this time, the use of ECMO for neonatal and pediatric pulmonary support has become a standard of care in many children’s hospitals. The use of ECMO, being a very invasive procedure, is not without risk. In our experience, most patients require multiple transfusions of the different blood components (packed red blood cells, plasma, platelets, and cryoprecipitate). Exposure to one or more blood products often occurs with connection to the ECMO circuit, as the circuit is generally primed with blood products or whole blood. Jehovah's Witnesses (JWs) are known best in the medical community for their refusal of blood products, even at the risk of death, which presents challenges for health care providers. This belief stems from the biblical passages that have been quoted as forbidding transfusion: Genesis 9:3–4, Leviticus 17:13–14, and Acts 15:19–21. This refusal of blood poses even greater challenges when treating the pediatric JW population. When a blood product is deemed medically necessary for the JW patient, the healthcare provider must either seek legal intervention, or support the patient’s/family’s wishes and associated outcome. This ethical dilemma may be further complicated in the setting of therapies, which may pose additional risks and potentially less clear benefit such as with ECMO. Bloodless cardiac surgery with cardiopulmonary bypass has been reported in the JW population in adults and pediatrics, including neonates. After a thorough search of the literature, no published report of a JW patient being supported on ECMO without blood or blood component utilization was identified. This case report will present our experience with multiple day, bloodless ECMO support of a 17-year-old male patient of the JW faith. Keywords: extracorporeal membrane oxygenation, extracorporeal life support, Jehovah's Witness, erythropoietin, bloodless.

DESCRIPTION

Institutional Review Board granted approval for this investigation (#IRB06–00270). A 104 Kg, 17-year-old male of the JW faith was transferred to Nationwide Children’s Hospital from an outside hospital after a two-day history of fever, myalgias, headache, and dry cough, with progressive hypoxia and worsening airspace disease on chest radiographs. He was reportedly a healthy adolescent with a history notable for recent initiation of smoking and occupational exposure to pigeon droppings. On admission to the pediatric intensive care unit (PICU) the patient was tachypneic (rate 30 breaths/min), tachycardic (rate 104 beats/min), and febrile (37.6°C) with an arterial blood gas of pH 7.46, partial pressure of carbon dioxide (pCO₂) 33 mmHg, partial pressure of oxygen (pO₂) 61 mmHg, and base excess –1.2 mEq/L. During the first 24 hours in the PICU the patient was resuscitated with multiple fluid boluses, appropriate inotropic support, and increasing non-invasive bi-level positive airway pressure with peak inspiratory pressure of 20 cm H₂O and positive end
The patient developed rapidly progressive hypoxemic respiratory failure, with bilateral diffuse infiltrates on chest radiograph, was intubated and support was rapidly escalated. Once intubated, the patient was placed on conventional mechanical ventilation with a peak inspiratory pressure of 42 cm H₂O, positive end expiratory pressure 16 cm H₂O, and a set respiratory rate of 14 breaths per minute. The patient was transitioned to high frequency oscillatory ventilation and settings consisted of amplitude 60 cm H₂O, mean airway pressure 40 cm H₂O, and respiratory frequency of 4 Hertz. Nitric oxide was added at a concentration of 20 ppm without resolution of the patient’s hypoxia (pH 7.29, pCO₂ 45 mmHg, pO₂ 50 mmHg, and BE –5.1 mEq/L).

As it became apparent the patient’s condition was deteriorating, discussions of escalating support and ECMO were broached with the family. The family initially refused both ECMO and the administration of blood components (1,2). After continued discussion, education, and further explanation of techniques, the family consented to ECMO, but maintained refusal of blood and blood components. A court order was therefore secured for blood product administration should it be deemed medically necessary during the ECMO course. Our institution routinely conducts bloodless pediatric cardiac surgery and the cardiovascular perfusion staff had experience in circuit miniaturization (3). As this would be a deviation, however, from our standard ECMO practice, there were extensive discussions among the intensive care staff regarding the appropriateness of attempting bloodless ECMO with a customized circuit. Despite the inability to generate a consensus among the PICU attendings, after weighing the risks and benefits, the PICU attending physician of record and family agreed to attempt bloodless ECMO via the modified circuit.

The “standard” ECMO circuit was modified and replaced with a custom miniaturized circuit. The customized circuit included a Rotaflow centrifugal pump (Maquet, Hirrlingen, Germany), Quadrox-D oxygenator (Maquet Hirrlingen, Germany), CX-HCO5S ultra-filter (Terumo Cardiovascular, Ann Arbor, MI), and 3/16” x 3/32” Carmeda coated tubing (Medtronic, Ann Arbor, MI) venous drain line and arterialized return lines. Two Medtronic, DLP 66,000 pressure display boxes (Medtronic, Ann Arbor, MI) were used to monitor inlet pressure into the centrifugal pump and the pre-oxygenator pressure. A Spectrum Medical M3 monitor (Spectrum Medical Cheltenham, UK) was incorporated for blood flow rate, arterial and venous saturation, and hemoglobin/hematocrit monitoring (Figure 1). It was also decided at the onset of ECMO to significantly reduce the “standard” ECMO labs to minimize blood loss due to lab sampling.

The patient was cannulated for veno-venous ECMO with the right internal jugular vein serving as the arterialized blood return site and the right femoral vein serving as the venous drainage site. Once cannulated, the ECMO circuit was connected to the cannulas. The crystalloid ECMO prime was then displaced with the patient’s blood by first leaving the ECMO circuits return line clamped and slowly withdrawing crystalloid fluid at the pressure monitoring port on the Quadrox-D until blood filled the venous drain line and oxygenator. Following this, the venous drainage line was clamped, the return line was unclamped, and again crystalloid was slowly withdrawn at the pressure monitoring port in a retrograde fashion until the patient’s blood filled the arterialized return line. This technique is referred to as retrograde autologous prime.

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Placement on ECMO allowed for stability and enabled completion of a diagnostic bronchoscopy with bronchoalveolar lavage. This revealed a white blood cell count of 4543 mm³ of which 51% were eosinophils. No organisms were identified on multiple cultures. The patient met diagnostic criteria for acute eosinophilic pneumonia (AEP) and was subsequently started on steroid therapy. Originally described in 1989, AEP comprises a clinical diagnosis of acute febrile respiratory illness associated with hypoxemia (pO₂ < 60 mmHg or SaO₂ < 90% on room air), bilateral diffuse infiltrates on chest radiograph, and absence of known causes of pulmonary eosinophilia (5). Finally, the finding of bronchoalveolar lavage fluid with ≥25% eosinophils is required (9). AEP remains a relatively uncommon cause of hypoxic respiratory failure, especially in children, but one that dramatically alters management in its responsiveness to steroid therapy.

From a hematologic standpoint, the hemoglobin (Hgb) was 14.3 gm/dL upon admission, 12.2 gm/dL prior to ECMO initiation, and fell to 11.3 gm/dL after initiation.
To maximize red cell production, Epogen® (Amgen, Thousand Oaks, CA), 50 units/kg, was administered after the initiation of ECMO and increased after the first dose to 125 units/kg every Monday-Wednesday-Friday. It must be noted that this was an off label use of Epogen® and a manufacturers dosing recommendation was therefore not available. Iron supplementation is commonly administered with Epogen® to maximize red cell production, but was not used during this patients ECMO course. Figure 2 shows the patients hemoglobin and platelet counts versus time. No blood or blood components were given during the ECMO run.

After 14 days of ECMO, the patient was weaned, the oxygenator gas was clamped out, and the patient was trialed off ECMO. When it was decided to decannulate, a cell salvage (Fresenius C.A.T.S.; Terumo Cardiovascular, Ann Arbor, MI) device was brought to the bedside, setup, and maintained in a continuous circuit with the patient. The cell saver was used prophylactically for any potential blood loss during the decannulation. Additionally, the entire ECMO circuit was flushed with 1000 mL of Normosol® (Hospira, Inc., Lake Forest, IL) into the C.A.T.S. system, processed, and returned to the patient, further preserving red blood cell mass. Five hundred milliliters of processed blood was returned during the decannulation process that included the ECMO circuit with a resultant Hgb of 12.4 gm/dL post decannulation. The patient was subsequently discharged home with no blood products received at any time during the admission.

**COMMENT**

While there is legal precedent for superseding parental decisions in medical situations, this creates a contentious and difficult situation. Blood component administration is at times unavoidable; however, it is always difficult to go against the wishes of a parent who is trying to make a choice of religious belief over that which may be medically necessary or potentially life saving. This decision can be more challenging when it involves an adolescent, who is near adulthood, but who is medically anesthetized and paralyzed and whose wishes are unknown. It is not unreasonable, however, to do one’s best in trying to achieve the wishes of both the patient and parent/guardian, while still providing necessary care.

Jehovah’s Witness patients present unique challenges to the entire healthcare team. These challenges surround the refusal of blood and blood components, even at the risk of death. The American Academy of Pediatrics Committee on Bioethics recommended that the physicians work with...
the families regarding the care of the child and also suggest that the physicians should exercise caution in seeking legal approval to treat against the parental wishes (7). It is important to note that the discussion among the healthcare clinicians involved in this case was around attempting to perform veno-venous ECMO without blood product administration. There were no promises made to the family that we would, or could, accomplish an ECMO run without blood product administration. The discussion focused on attempting to respect the family’s wishes of not using blood products while providing the needed care for their child.

It is common practice in medicine to treat every patient the same including “standard” therapies to decrease practice variation and potential errors. This often translates into regimented laboratory tests, which can amount to a significant blood loss. This can be most apparent in the ECMO patient whose iatrogenic blood loss through laboratory testing often leads to transfusion of blood products. These transfusions are frequently based solely on the patients' laboratory results and the crossing of a clinician determined threshold, despite the lack of outward clinical signs or symptoms of needing the specific blood products.

To minimize previously mentioned iatrogenic blood loss and after discussion with the entire care team, we decreased the number and frequency of laboratory values. Daily labs included Hgb/Hematocrit, unfractionated anti-factor Xa, Anti-Thrombin III level, arterial blood gas, prothrombin time, partial thromboplastin time, and fibrinogen. Laboratory values obtained more frequently included the platelet count, which was run twice per day and the activated clotting time, which was run hourly. This was a considerable reduction from our normal laboratory technique for an ECMO patient.

There were several factors that contributed to our success with this JW patient. The patient weighed 104 Kg and had a reasonable pre-ECMO hematocrit. Surgical hemostasis was maintained during cannulation and decannulation. There were no bleeding or clotting complications throughout the ECMO course. Nationwide Children’s Hospital has extensive experience performing bloodless cardiopulmonary bypass in the cardiac operating theatre. This familiarity with circuit miniaturization, laboratory sample consolidation, and micro-testing where possible, increased the odds of a safe, successful ECMO course for this patient. It was this experience that also gave the team confidence in attempting this bloodless novel approach.

Bloodless ECMO is possible, but not without a considerable commitment from the entire team caring for the patient. While it would be easy to tell the patient/family that bloodless ECMO is not possible, the success in this patient reinforces that every effort should be made to meet the patients’ needs while respecting religious preferences if possible. Given the right team composition, the right attitude, the right patient, and the right set of circumstances, bloodless ECMO is possible if attempted.

REFERENCES