CASE REPORT

Extracorporeal Membrane Oxygenation (ECMO) in a newborn with respiratory distress due to Meconium Aspiration Syndrome: effect of the administration of exogenous surfactant

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Abstract

Objectives: to present the clinical outcome of a newborn with severe respiratory distress secondary to meconium aspiration syndrome and treated by extracorporeal membrane oxygenation (ECMO); and to present the effect of the use of exogenous surfactant in this case and the cost of the procedure.

Methods: case report of a newborn with meconium aspiration syndrome and treated at the neonatal ICU of the Instituto da Criança Prof. Pedro de Alcantara, Hospital das Clínicas of the Universidade de São Paulo.

Results: ECMO was carried out for 5 days with no clinical or mechanical complications. On the 4th day of ECMO, we administered porcine exogenous surfactant; a significant improvement in lung compliance was observed and the newborn was decannulated shortly after that. Treatment costs were compatible with the situation of healthcare in Brazil for treatment of critically ill newborn patients.

Conclusions: ECMO is indicated in cases of neonatal respiratory distress not responding to other treatments. The technique should be made available in neonatal Intensive Care Units (ICUs) of tertiary hospitals according to well-established protocols. The use of exogenous surfactant apparently allowed for earlier decannulation of the patient and should be considered in similar cases. The treatment costs do justify the organizing of ECMO teams in this type of ICUs.


Introduction

Extracorporeal membrane oxygenation (ECMO) or extracorporeal life support (ECLS) are used to describe prolonged extracorporeal life support for newborns who suffer from acute respiratory failure and are refractory to “conventional” treatments.1 More than one hundred pediatric centers employ this kind of technology as routine procedure, having treated over 19,000 children so far. In this study, we present the first case of a newborn treated with ECMO at the neonatal ICU of the Instituto da Criança Prof. Pedro de Alcantara, Hospital das Clínicas of the Universidade de São Paulo, and discuss the clinical and technical aspects involved.
Case report

Newborn, Caucasian, male, 4,950g, born of vaginal delivery, with gestational age of 39 weeks, presented with severe respiratory insufficiency due to meconium aspiration syndrome (MAS) on his second day of life, and was transferred to the neonatal ICU. The transfer required the introduction of a water-sealed tubular drain into the left hemithorax for treating pneumothorax. The initial treatment consisted of conventional mechanical ventilation with inspired oxygen fraction (FiO2) of 1.0, respiratory frequency (RF) of 60, positive end-expiratory pressure (PEEP) of 4mmHg, inspiratory pressure (IP) of 25mmHg. The investigation results of these parameters by arterial gas analysis were pH 7.6; PO2 45.4; PCO2 52.7; SatO2 86%. The echocardiogram showed severe pulmonary hypertension. Cranial ultrasound scanning and blood coagulation tests yielded normal results. Inotropic drugs (dopamine and dobutamine) were administered due to low blood pressure and impaired peripheral perfusion. After 4 hours of treatment, there was no improvement of respiratory parameters, and the administration of 20 p.p.m inhaled nitric oxide (iNO) was necessary; the dose was increased up to 30 p.p.m according to patient’s requirements. The results of arterial blood gas analysis after 18 hours of iNO were pH 7.5; PO2 125.9; PCO2 50.2; and SatO2 98%. Gasometric parameters progressively worsened despite high ventilation parameters and high concentration of iNO. Since no improvement in oxygenation was observed after this intensive treatment, we decided to use ECMO. The blood gas analysis performed immediately before ECMO initiation yielded the following results: pH 7.48; PO2 43.9; PCO2 58.9.

Evolution of ECMO

We carried out right carotid artery and right jugular vein cannulation through venoarterial bypass (Figure 1). A 12F arterial cannula and 14F venous cannula were used. Venoarterial ECMO was implemented according to the classical technique described in the literature. The ECMO circuit, pump, and heat exchanger were supplied by Braile Biomédica. The membrane oxygenator used was AVECOR 0800.

The ECMO flow was initially kept at 120 cc/kg, and reduced according to the child’s tolerance. Our objective was to maintain PO2 values between 70 and 90 mmHg and PCO2 between 40 and 50 mmHg. Mechanical ventilation was kept with minimal parameters, that is, FiO2= 0.3; RF= 12/min; PEEP= 5mmHg; and inspiratory pressure= 20mmHG. The activated clotting time (ACT) was kept between 180 and 220 seconds by means of heparin administration. Platelet count was kept above 100,000/mm³, and hematocrit, above 40%; blood transfusions were performed whenever necessary.

On the third day of ECMO, an exogenous surfactant (porcine) was administered at a dose of 100mg/kg, which was repeated after 12 hours, according to the institutional research protocol for the use of surfactant on MAS. Six hours after the administration of the first dose of surfactant, we observed significant resolution of pulmonary compliance, which was characterized by the light color of both lungs on x-ray, higher lung expansion under mechanical ventilation, and rapid reduction of ECMO flow (Figures 2 and 3). The newborn was decannulated on the fifth day of ECMO. The total time during which the newborn was submitted to ECMO was 116 hours.

Complications

No mechanical complications were observed. On the second day of ECMO, we observed that hemoglobinuria lightened spontaneously, and then ECMO flow was reduced. There were no hemorrhagic complications. A small-sized nodule measuring 1.5cm was detected on the right adrenal gland through an ultrasonography performed after decannulation, suggesting hemorrhage, but with no clinical consequences. During ECMO, Serratia marcescens was isolated in blood culture, and was successfully treated with cephalosporin. The newborn was extubated on the third day after ECMO, however required reintubation due to upper
tracheal obstruction caused by laryngitis. The newborn was finally submitted to tracheostomy due to severe laryngitis, remaining under ambient air conditions after that. The newborn was discharged without tracheostomy.

**Discussion**

ECMO has been recommended for the treatment of newborns with acute respiratory failure who are refractory to other available therapies, since 1986. ECMO is a complex technology that requires arduous work and appropriate previous training. In the last two decades, the use of ECMO has greatly increased, becoming a routine procedure at tertiary pediatric ICUs, providing a survival rate of 95% for children who supposedly have a mortality rate greater than 80%.

This technology has improved and become safer and more efficient. In typical respiratory diseases of the newborn, it is possible to use venovenous ECMO, since the necessity for cardiovascular support due to heart failure is rare. This technique consists of a double lumen catheter, which may be placed by puncturing or dissecting the inner jugular vein all the way through the right atrium for blood drainage or reinfusion during extracorporeal circulation. It is, indeed, a simpler technology that avoids the ligation of the carotid artery, in addition to offering efficiency and safety. Nowadays, it is the treatment of choice in several ICUs.

The benefits of using ECMO in selected cases are not limited to the increase in survival rate, especially during the neonatal period. It is common knowledge that newborns who are treated with ECMO have lower incidence of respiratory and cardiac sequelae, when compared to newborns treated with conventional methods. These newborns require less clinical follow-up, for shorter periods of time, and a reduced number of hospital readmissions.

ECMO complications may be grouped into types: mechanical complications, which occur in the extracorporeal circuit itself, and complications of patient’s clinical status. The longer the use of ECMO, the more complications will occur.

The incidence, severity, and consequences of the mechanical complications are directly related to the experience acquired by ECMO professionals. In ECMO reference centers, these complications are not frequent and do not have an impact on the final outcome.
ECMO mechanical complications such as blood clots in the circuit, gas embolism, cracks in circuit components, and oxygenator failure are more frequent in older children and adults than in newborns.

Most clinical complications result from three alterations that necessarily occur during ECMO: anticoagulation, blood interactions with the artificial circuit surfaces, and alterations in blood flow pattern. The most common clinical ECMO complications in newborns, according to cumulative data provided by ELSO (Extracorporeal Life Support Organization), are water retention requiring blood filtration, seizures, intracranial hemorrhage, hemolysis, high blood pressure, infection and increased serum creatinine level.

Except for intracerebral hemorrhage or infarction, most complications can be easily controlled and, usually, do not significantly interfere with the final outcome. Hemorrhage is the major complication of prolonged extracorporeal support, and, in newborns, intracerebral hemorrhage is the most severe complication.

ECMO referral criteria

ECMO referral criteria in our group are the same used by most ECMO centers:

a) general criteria: Newborn whose weight is greater than 2,500g or whose gestational age exceeds 35 weeks, with no coagulopathy, with no congenital cardiopathy, under mechanical ventilation for at least 15 days, without chromosomal or congenital anomalies that are incompatible with life.

b) specific criteria: oxygenation rate >40, acute deterioration of clinical status, heart arrest or failure, barotrauma, oxygen alveolo-arterial gradient >620 mmHg, and no response to all the other available treatments.

The latter outweighed the other ECMO referral criteria for this case.

Porcine surfactant was used as an attempt to reduce the duration of extracorporeal support. The use of surfactant for this purpose has been recommended by some authors with the aim of reducing the duration of ECMO.5-12 Stillerman et al. investigated the effect of bovine surfactant on newborns right after ECMO implementation, and found out a significant reduction in the duration of extracorporeal support.11

In a randomized controlled study, Lotze et al. observed that the use of multiple doses of bovine surfactant significantly improved pulmonary function in full-term newborns submitted to ECMO. These authors also reported improved pulmonary compliance, increased concentration of surfactant A protein in tracheal aspiration, and reduced need of extracorporeal support.9

The ideal moment for surfactant administration is not well-defined yet. We decided to administer the first dose only on the fourth day of ECMO, when the child presented no peripheral edema, and when the lung x-ray showed the outset of pulmonary reaeration. Actually, six hours after surfactant administration, we observed significant improvement of pulmonary function, allowing for rapid reduction of extracorporeal support (Figure 4).

As far as the complications originating from the use of surfactant were concerned, we did not find adverse effects that could interfere with the child’s status, which was in agreement with the results found in the literature.

The major setback for establishing and maintaining an ECMO program in Brazilian pediatric hospitals is the cost of such procedure. This is due to the advertisement of overestimated budgets that are not consonant with the Brazilian reality by international organizations, journals, and specialized books. These overestimated budgets wind up building an image that ECMO centers are impracticable or cost-prohibitive. Tables 1 and 2 show a comparison between the costs (in U.S. dollars) usually presented in publications and the costs at our institution.13

Table 1 - Comparison of ECMO costs between the USA and Brazil. (permanent material)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>USA U$</th>
<th>Instituto da Criança (Brazil) U$</th>
</tr>
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<tbody>
<tr>
<td>1. Pump</td>
<td>10,000.00</td>
<td>3,200.00</td>
</tr>
<tr>
<td>2. Pressure-sensitive gauge</td>
<td>1,000.00</td>
<td>150.00</td>
</tr>
<tr>
<td>3. Bladder box</td>
<td>3,000.00</td>
<td>Adapted</td>
</tr>
<tr>
<td>4. Heat exchanger</td>
<td>3,000.00</td>
<td>1,900.00</td>
</tr>
<tr>
<td>5. Battery-powered console</td>
<td>2,500.00</td>
<td>1,500.00</td>
</tr>
<tr>
<td>6. ACT machine</td>
<td>3,000.00</td>
<td>3,000.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>22,500.00</td>
<td>9,750.00</td>
</tr>
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One of the greatest challenges posed by the implementation of a new ECMO program is to provide ECMO professionals with qualification, since these professionals are a key element for a successful program. These professionals are in charge of continually maintaining the circuit, controlling heparinization, and membrane gas exchanges. At ECMO centers, nurses and perfusion specialists require special training and qualification so that they can do a good job. In our case, we initially decided to form an exclusive team of perfusion specialists, since these professionals are more familiar with the technique, and have more comprehensive knowledge about the physiology of extracorporeal circulation. On the other hand, perfusion specialists entail additional costs for the program, since they are usually unavailable at pediatric hospitals that perform heart surgeries. In spite of this, we recommend that other institutions that share similar characteristics to ours follow our example.14

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References