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Low Flow Veno-Venous ECMO Via Subclavian Dialysis Catheter for Severe Respiratory Failure

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ABSTRACT

Background: We present the case of a 12-year-old female with severe postoperative bacterial pneumonia unresponsive to conventional treatment following a failed renal transplant.

Case Repor t: The patient was placed on low flow veno-venous extracorporeal membrane oxygenation (ECMO) as an adjuvant treatment to antibiotic therapy and maximal ventilatory support. Venous ECMO resulted in rapid improvement and the patient was successfully weaned after 48 hours of circulatory assistance. Two days later, the patient was extubated and safely discharged from the intensive care unit. Eighteen months later, she remains stable on peritoneal dialysis and is awaiting a new donor kidney.

Conclusions: Low flow veno-venous ECMO represents a new therapeutic alternative for critically ill patients whose condition does not meet the conventional ECMO criteria. Further clinical experience is still needed.

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is a well-established treatment for severe unresponsive respiratory failure, with notable clinical success when used to support neonates suffering from pulmonary and cardiac disease [Meyer 1997]. ECMO was first examined in 1970 as an alternative to positive pressure ventilation in the management of patients with acute respiratory distress syndrome (ARDS). Initial studies failed to demonstrate an improvement in survival among patients treated with ECMO. Although several uncontrolled trials have since suggested that ECMO does improve outcome among ARDS patients, a 1994 study comparing survival between ARDS patients treated with ECMO and conventional ventilatory therapy showed no mortality difference [Morris 1994].

Despite the fact that extracorporeal life support (ECLS) techniques were originally designed and attempted in adults and older children with pulmonary disease, the techniques have not reached the same success rates obtained as a means of assistance for pure heart failure [Del Nido 1996]. Standard ECMO and CO_2 removal techniques aim to totally replace lung function by circulating the majority of the patient's blood volume through the system, with the inherent risks and complications of prolonged cardiopulmonary bypass. In previously published experimental research [Calderon 1994], the therapeutic effects of low-flow artificial gas exchange as adjuvant therapy for patients with severe respiratory failure who did not meet the criteria for standard ECLS procedures were demonstrated. We now present our first clinical experience.

CASE REPORT

We evaluated a 12-year-old female (weight, 45 kg; height, 150 cm; BS, 1.3m^2) who 30 days earlier underwent a living-related kidney transplant. During the sixteenth postoperative day, the child developed bilateral bacterial pneumonia. The medical team reduced immunosuppression, resulting in the loss of the graft, and peritoneal dialysis was restarted. On the twenty-fifth postoperative day, the pneumonia progressed, requiring mechanical ventilation.

Sputum cultures revealed multidrug-resistant *Pseudomonas aeruginosa* and a fourth-generation cephalosporin regimen was

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Table 1. Blood gases and Ventilation Settings

	RR	FiO2%	PEEP	PIP	PaO_2(aSat%)	mmHg	$DAaO_2$
Before ECMO	40	80	20	38	69	81	450
30 min After ECMO	34	65	20	34	72	88	380
Before Weaning	20	40	6	20	93	130	270

started. Immunosuppression therapy had already been weaned, and parenteral nutrition was started to treat her nutritional deficit resulting from longstanding renal disease and the recent surgical trauma. At the time of our consultation, the patient had been five days on mechanical ventilation with no signs of improvement.

After discussing the case and obtaining informed consent from the family, low flow veno-venous ECMO was instituted via a conventional 12 Fr double lumen temporary dialysis catheter inserted percutaneously into the right subclavian vein. The closed circuit consisted of a 1/4 inch inflow line, a pediatric membrane oxygenator (Jostra Medical, Germany), a roller pump (Cobe, Denver, Colorado, USA), a pediatric hemofilter (Minntech, Minneapolis, Minnesota, USA) and a 1/4 inch outflow line (see Figure 1). Flows during the procedure averaged 400cc/min and the ACT was maintained between 180 and 200 seconds by heparin infusion.

The patient showed progressive improvement and after 48 hours of circulatory support, a weaning trial was performed and was successful (see Table 1). The system was then removed. The child was extubated two days later and continued with an uneventful recovery. After eighteen months, she remains stable on peritoneal dialysis, awaiting kidney retransplantation.

DISCUSSION

Extracorporeal artificial gas exchange (ECMO-ECCO2R) has demonstrated its value in the treatment of critical respiratory failure. The best clinical results, however, have been in the neonatal population. This discrepancy can be explained when considering the pathophysiology of disease in different clinical settings. Neonatal ECMO is most commonly utilized for events in which the lung itself is not severely diseased, as in congenital diaphragmatic hernia or neonatal pulmonary hypertension. The older child and adult patient requiring extracorporeal membrane oxygenation, however, are frequently victims of critical pulmonary infections or ARDS. In the latter, ECLS therapy is targeted to temporarily replace respiratory function and maintain the patient alive while treating the pulmonary insult, which cannot always be reversed. Conventionally, this type of aggressive therapy is applied when all other therapeutic efforts have been exhausted because of the inherent risk and complications of the prolonged utilization of cardiopulmonary bypass. Sometimes though the underlying pulmonary disease will not reverse.

As mentioned before, clinical results of ECMO and ECCO2R in the adult patient population have not been as successful and reproducible as with the pediatric population. We believe that part of this is due to the fact that most adult trials have involved ARDS patients and most of them are offered the benefits of extracorporeal gas exchange late in the course of the disease. During our early experimental work, it was demonstrated that a low flow, less invasive veno-venous system was sufficient enough to improve gas exchange without major hemodynamic repercussions or the risks and complications of the formal high flow, large cannulae devices.

We consider, as in the previously described case, that this kind of therapy, when applied early, can assist in the overall treatment of patients suffering from severe respiratory failure outside of standard ECLS indicators, and will result in relatively minor morbidity. Also, analyzing the pathophysiology of severe pulmonary infections, even ARDS, fluid collection at the level of the alveolar-capillary membrane is a major contributor to gas exchange disruption. Placing a hemofilter as part of the extracorporeal circuit provides greatly accelerated fluid elimination in conjunction with medical treatment. It is our belief that low flow veno-venous ECMO deserves consideration as part of our therapeutic armamentarium. Further experimental and clinical research should be performed to define its precise indications.

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REVIEW AND COMMENT ARY

1. Editorial Board Member NS65 writes:

A method that we were discussing trying to use last week to help a struggling lung transplant patient, but had no data to support. Therefore, I think this is indeed relevant.

1) What were the gasses immediately after turning the system on? Were the hemodynamics adversely effected?

2) Were the clotting system and platelet function adversely affected? Was there clotting in the membrane post procedure?

3) Was the peritoneal dialysis continued, or was the pediatric filter hooked to a dialysis machine (this would be easy to do)? Was the patient mobile during this or able to get out of bed (that is, did the treatment inhibit mobilizing her which is important in the treatment of pneumonia)?

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4) Did a perfusionist or a nurse run the system (many programs cannot tie up a perfusionist for 48 hours).

Authors' Response by Moisés Calderón, MD, PhD:

1) The patient's progress was gradual; however, since the start, respiratory improvement was noticed. The blood gases and ventilation settings are presented in Table 1. There were no clots in the circuit. The patient was managed with heparin and we monitored ACT and platelet count. The patient was intubated during the procedure and was mobilized only by physical therapy technicians. We had perfusionist shifts all the time during the procedure.

2. Editorial Board Member TL41 writes:

The patient showed improvement over 2 days of the therapy, but had already been treated with antibiotics for 5 days. Was the improvement due to the intervention, or coincidental?

Little detail is given of other changes during the intervention. What gas transfer was achieved?

For example, a flow of 400 ml/min., with Hb of say 10 G/Dl and SvO_2 of 0.5 would transfer less than 30 ml O_2 per minute, if my mental arithmetic is correct. Did that small supplement permit changes in ventilator settings? Was the improvement rapid or gradual?

Authors' Response by Moisés Calderón, MD, PhD:

The system utilized by us in conjunction with the hemofilter were aimed to provide supplementary oxygenation and to increase the removal of extravascular water at the alveolar-capillary membrane, but as mentioned, there were no criteria for a formal ECMO. However, the patient got to a plateau with maximal conventional therapy; so with the institution of the low flow system, we aided conventional therapy.

The advantages of low flow ECMO are principally related to little or no hemodymic alteration, but the artificial exchange is not compared when utilizing high flow conventional devices. However, as demonstrated by all the experimental experience, when applied early in conjunction with all the conventional armamentarium, it could be of great benefit.