Extracorporeal carbon dioxide removal in status asthmaticus: A case report

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This case report describes the use of extracorporeal carbon dioxide removal (ECCO₂R) in a 44-year-old man who presented to a regional public hospital's emergency department with status asthmaticus and subsequently failed conventional therapy. ECCO₂R with the Hemolung RAS was successfully utilized to stabilize the patient, correcting hypercapnia and permitting a de-escalation of invasive mechanical ventilation to facilitate lung recovery.

Introduction

Status asthmaticus, or acute severe asthma, is the term used to refer to an asthmatic exacerbation that does not respond to pharmacotherapy. Although precise epidemiology figures are lacking, it is estimated that about 30% of medical intensive care unit admissions for acute severe asthma require intubation and mechanical ventilation, with mortality of 8%. Ventilator strategies have been adopted to help minimize complications such as barotrauma, dynamic hyperinflation and auto-positive end expiratory pressure (auto-PEEP), but these strategies have not eliminated such complications. ECCO₂R as an adjunct to ventilation for status asthmaticus was first reported in 1981, and a number of subsequent reports have shown positive outcomes with this therapy.

Case Study

A 44 year-old male with a history of controlled asthma presented to his general practitioner with acute shortness of breath. The patient was immediately transferred to the Frankston Hospital emergency department (ED) via ambulance due to his severe breathlessness and low oxygen saturation. Upon admission to the ED, he suffered respiratory arrest. A brief period of resuscitation followed, including endotracheal intubation, invasive mechanical ventilation (IMV), and decompression of a tension pneumothorax via placement of a chest drain. Following a brief period of improvement, he again deteriorated and a second tension pneumothorax was identified in the patient’s other side, requiring placement of an additional chest drain. Admission to the intensive care unit (ICU) followed.

Over the next 48 hours in the ICU, the patient continued to deteriorate with the development of significant subcutaneous emphysema and ongoing air leaks. By the third day, he had become very difficult to ventilate with uncontrollable hypercapnia (arterial CO₂ tension, PaCO₂, was approximately 100 mmHg) despite optimal medical management. ECCO₂R was indicated to control the hypercapnia and facilitate de-escalation of invasive mechanical ventilation.

ECCO₂R was initiated using the Hemolung RAS (ALung Technologies, Pittsburgh, PA USA). The Hemolung 15.5 Fr Catheter was inserted percutaneously into the right internal jugular vein without complication. The Hemolung RAS circuit was then connected to the Catheter and ECCO₂R was initiated. Extracorporeal blood flow was established at 470 mL/min, and the sweep gas was gradually increased to 10 L/min to provide ECCO₂R of approximately 100 mL/min as measured by the Hemolung Controller. The
patient’s hypercapnia was quickly controlled with PaCO₂ falling from 80 to 53 mmHg within three hours of starting ECCO₂R. De-escalation of ventilatory support was achieved with peak inspiratory pressure reduced from 34 to 30 cmH₂O within 3 hours.

Over the next 48 hours, the patient showed signs of improvement. During the third day on ECCO₂R, the chest drain on the left side became blocked and was replaced to resolve another tension pneumothorax. Bleeding within the chest was noted during the drain replacement resulting in a reduction of systemic anticoagulation (Active Clotting Time [ACT] target reduced from 180 to 150 sec). ECCO₂R was continued for a total of seven days until respiratory function had substantially improved. No complications related to ECCO₂R were noted. Following the discontinuation of ECCO₂R, the patient had video-assisted thoracoscopic surgery (VATS) for evacuation of a hematoma in the left pleural cavity and a tracheostomy was placed to assist in weaning from IMV. He was transferred to a rehabilitation facility after 27 days in the hospital and ultimately discharged to home in good condition.

<table>
<thead>
<tr>
<th>Ventilation Mode</th>
<th>Pre-ECCO₂R</th>
<th>3 hr on ECCO₂R</th>
<th>24 hr on ECCO₂R</th>
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</thead>
<tbody>
<tr>
<td>Tidal Volume*</td>
<td>BiVent</td>
<td>BiVent</td>
<td>BiVent</td>
</tr>
<tr>
<td>485</td>
<td>385</td>
<td>500</td>
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<tr>
<td>Respiratory Rate (/min)</td>
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<td>12</td>
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<tr>
<td>Minute Volume (L/min)</td>
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<td>4.5</td>
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<tr>
<td>FiO₂ (%)</td>
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<td>40</td>
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<tr>
<td>Peak Inspiratory Pressure (cmH₂O)</td>
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<td>30</td>
</tr>
<tr>
<td>ECCO₂R (mL/min)</td>
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<td>105</td>
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<tr>
<td>ABG</td>
<td>pH</td>
<td>PaCO₂ (mmHg)</td>
<td>PaO₂ (mmHg)</td>
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<tr>
<td></td>
<td>7.32</td>
<td>54</td>
<td>89</td>
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</tbody>
</table>

*Tidal volumes may be inaccurate as the patient had bilateral chest drains with ongoing air leaks

Discussion with Dr. Tiruvoipati

Q: There is not a lot of literature on the use of ECCO₂R in asthma. What other options did you consider for this patient and why did you decide to use the Hemolung RAS?

A: A variety of methods for optimizing ventilation were attempted with this patient, including bronchodilators, corticosteroids and muscle relaxants for nearly 72 hours. The patient’s primary diagnosis was hypercapnic respiratory failure and while his oxygenation was good, his CO₂ levels were so high that they could not be controlled. The only alternative would have been to transfer the patient to a specialized ECMO center. Not only would this have required a risky transfer, it would not have been the optimal treatment since this patient’s primary problem was excess CO₂, and high blood flow rates used with ECMO are not necessary to remove CO₂. I believe, and the patient believes as well, that Respiratory Dialysis with the Hemolung RAS saved his life.
User Report

Q: For what other applications are you using the Hemolung RAS?

A: The Hemolung RAS is excellent for treating hypercapnic respiratory failure and is much less invasive than ECMO. I predict that the use of ECMO in similar situations will decrease significantly, as the Hemolung RAS will provide the needed therapy in 90% of cases.

Q: How has the Hemolung RAS been received by your ICU staff?

A: We are still in an initial trial period with the Hemolung RAS and as such, have specially trained physician consultants overseeing all use. However, the general perception of the device is very positive. The nursing staff is very receptive to the treatment and pleased with the ease of operation. There are not many adjustments when a patient is receiving Respiratory Dialysis, therefore, it is not a laborious process. Compared to ECMO, the Hemolung RAS does not require a multidisciplinary team to support, and it is much less invasive. It is similar to renal replacement therapy, with a slightly bigger catheter. Our center has investigated starting an ECMO program for two or three years, but the amount of support and knowledge required make that very difficult. The Hemolung RAS is a perfect alternative for centers like ours.

About the Author

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Ravi Tiruvoipati, MD is Director of Intensive Care at Peninsula Private Hospital and a Consultant Intensivist at Frankston Hospital in Melbourne, Australia. He is also an adjunct clinical associate professor at Monash University in Melbourne. He received no compensation in association with this case report and has no conflicts of interest to disclose. Dr. Tiruvoipati can be reached via email at travindranath@hotmail.com.

About the Hemolung RAS

The Hemolung RAS from ALung Technologies provides Respiratory Dialysis®, a simple, minimally-invasive form of extracorporeal carbon dioxide removal (ECCO₂R). The system utilizes patented technology to provide highly efficient CO₂ removal at dialysis-like blood flow rates which are achieved through a single 15.5 Fr venous catheter. For more information, please visit http://www.alung.com.