CASE REPORT

Pumpless Extracorporeal Lung Assist for the Treatment of Severe, Refractory Status Asthmaticus

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Background. Until recently, the only available lung-protective treatment option for carbon dioxide removal due to severe, refractory status asthmaticus has been extracorporeal pump-driven membrane oxygenation (ECMO). Pumpless extracorporeal lung assist (pECLA) may serve as an alternative therapy for these patients. Case Report. A 42-year-old woman presented with an acute exacerbation of asthma to our Emergency Department. Despite optimal pharmacological therapy, the patient developed respiratory failure requiring mechanical ventilation with elevated airway pressures. For severe ventilation-refractory hypercapnia and respiratory acidosis, ECMO was used initially and was later replaced by a pECLA device. The clinical condition continuously improved with sufficient pulmonary gas exchange. The pECLA was removed after 8 days, and the patient was successfully weaned from mechanical ventilation. Conclusions. This report suggests that pECLA is an alternative extracorporeal lung assist in patients with ventilation-refractory hypercapnia and respiratory acidosis due to severe, refractory status asthmaticus.

Keywords critical care, extracorporeal lung assist, extracorporeal membrane oxygenation, pECLA, status asthmaticus

BACKGROUND

Pharmacological therapy with bronchodilators and systemic corticosteroids is usually sufficient to reduce airflow obstruction and improve symptoms in patients with acute asthma. Severe attacks of asthma poorly responsive to therapy and associated with signs or symptoms of potential respiratory failure are often referred to as status asthmaticus. Approximately, 4% of all patients hospitalized for acute asthma require mechanical ventilation (1), which is associated with increased in-hospital mortality compared with patients who do not require mechanical ventilation (7 vs. 0.2%) (1). In patients with ventilation-refractory hypercapnia and respiratory acidosis, extracorporeal pump-driven membrane oxygenation (ECMO) may be a treatment alternative to allow for optimized lung-protective ventilation strategies. Nevertheless, clinical outcome studies for extracorporeal lung assist in patients with severe, refractory status asthmaticus have been lacking (2–5). Here we report our experience with a pumpless extracorporeal lung assist device (pECLA) for the treatment of respiratory failure in severe status asthmaticus refractory to pharmacological treatment.

CASE REPORT

A 42-year-old woman (height 175 cm, weight 56 kg), whose first onset of asthma occurred after exposure to animal hairs at the age of 22 years, presented to our Emergency Department (University Hospital) with symptoms of acute exacerbation of asthma. The symptoms began 1 hour before hospital admission with agitation, tachypnea, tachycardia, and shortness of breath. At home, the symptoms did not respond to therapy with inhaled formoterol, intravenous methylprednisolone, and theophylline given by an emergency response physician.

Later and in our Emergency Department, the patient was still gasping for air and wheezing was audible over all lung fields on physical examination. Initial treatment in our hands consisted of nebulized salbutamol and ipratropium bromide every 20 minutes for 1 hour in addition toropium given by an emergency response physician.

The patient was admitted to our intensive care unit due to persistence of the severe dyspnea after 1 hour of intensive therapy. The blood gas analysis of the patient revealed impending respiratory failure. Arterial blood gas evaluation showed an elevation of carbon dioxide (68 mmHg). Because of slowing of the respiratory rate and inability to maintain respiratory effort, intubation was necessary (8.0 mm endotracheal tube). Initially, a high inspiratory flow rate from 80 to 100 L/min, a minute ventilation less than 115 mL/kg, a tidal volume less than 8 mL/kg, an extrinsic positive end-expiratory pressure (extrinsic PEEP) less than 80% of the intrinsic PEEP, and a low respiratory rate from 10 to 14 breaths/min was used, allowing an inspiration/expiration ratio of 1:2 to 1:3 (6). To reduce bronchospasm, general anesthesia was induced (ketamine and sevoflurane). Furthermore, the medical therapy was extended to reprotol and methylprednisolone. A maintenance dose of theophylline was started under serum-level monitoring. In addition, the
We report a successful application of extracorporeal, pump-free interventional lung assist device in a patient with respiratory failure in refractory status asthmaticus. Mechanical ventilation in patients with respiratory failure secondary to obstructive pulmonary disease is complex. We report a successful application of extracorporeal, pump-free interventional lung assist device in a patient with respiratory failure in refractory status asthmaticus. Mechanical ventilation in patients with respiratory failure secondary to obstructive pulmonary disease is complex.

**DISCUSSION**

We report a successful application of extracorporeal, pump-free interventional lung assist device in a patient with respiratory failure in refractory status asthmaticus. Mechanical ventilation in patients with respiratory failure secondary to obstructive pulmonary disease is complex.

**TABLE 1.—Changes in Respiratory Variables Before and During Extracorporeal Lung Assist.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>8 hours after admission</th>
<th>8 hours after ECMO implantation (FiO2 50%, gas flow 4 L/min)</th>
<th>24 hours after ECMO implantation (FiO2 100%, gas flow 4 L/min)</th>
<th>8 hours after pECLA implantation (gas flow 8 L/min)</th>
<th>24 hours after pECLA implantation (gas flow 10 L/min)</th>
<th>48 hours after pECLA implantation (gas flow 12 L/min)</th>
<th>96 hours after pECLA implantation (gas flow 12 L/min)</th>
<th>24 hours after pECLA explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO2 (mmHg)</td>
<td>73</td>
<td>81</td>
<td>82</td>
<td>73</td>
<td>75</td>
<td>80</td>
<td>80</td>
<td>82</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>87</td>
<td>34</td>
<td>38</td>
<td>43</td>
<td>45</td>
<td>49</td>
<td>47</td>
<td>44</td>
</tr>
<tr>
<td>FiO2 (%)</td>
<td>40</td>
<td>30</td>
<td>30</td>
<td>46</td>
<td>80</td>
<td>70</td>
<td>62</td>
<td>50</td>
</tr>
<tr>
<td>Minute ventilation (L/min)</td>
<td>6.0</td>
<td>3.7</td>
<td>70</td>
<td>5.8</td>
<td>6.7</td>
<td>70</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Tidal volume (mL)</td>
<td>500</td>
<td>170</td>
<td>380</td>
<td>480</td>
<td>480</td>
<td>480</td>
<td>480</td>
<td>480</td>
</tr>
<tr>
<td>Peak VP (mmHg)</td>
<td>38</td>
<td>29</td>
<td>30</td>
<td>30</td>
<td>29</td>
<td>28</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>PEEP (mmHg)</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

*Note:* ECMO, extracorporeal membrane oxygenation; pECLA, pumpless extracorporeal lung assist; PaO2, arterial oxygen tension; PaCO2, arterial carbon dioxide tension; FiO2, fraction of inspired oxygen; VP, ventilatory pressure; PEEP, positive end-expiratory pressure.
because of the risk of causing barotraumas. One treatment option for these patients with severe, refractory status asthmaticus has been extracorporeal gas exchange and, until recently, ECMO was the only available treatment option (2, 3, 7).

But ECMO is expensive, has known side effects, and can only be applied reasonably for several days. Beyond that, the number of accompanying complications increases significantly. Hemmila and coworkers demonstrated that bleeding, hemolysis, culture-proven new infection, renal insufficiency, and deep venous thrombosis post-ECMO were associated with a significantly decreased survival in patients treated with ECMO for adult respiratory distress syndrome (ARDS) (8–11). Development of deep venous thrombosis and fatal pulmonary embolism has been the cause of late deaths following decannulation despite being on anticoagulation during ECMO (8).

The pECLA system is a low-resistance lung assist device designed for pulsatile blood flow with tight diffusion membranes and a protein matrix coating. It is driven by the arterial pressure and therefore does not need extracorporeal pump assistance (12). Therefore, it does not require a high degree of technical and staff support. On the contrary, the blood–gas exchange capacity of pECLA, particularly for oxygen, is limited in comparison with pump-driven ECMO for two reasons. First, the arteriovenous shunt limits oxygen transfer capacity. Second, pECLA is unable to achieve the flow rates of ECMO (4–6 L/min). Nevertheless, it was shown that pECLA exerts effective removal of carbon dioxide and a moderate increase in oxygenation (12–16).

Possible major complications using pECLA system are episodes of transient ischemia of a lower limb after arterial cannulation. Our patient did not show signs of malperfusion of the lower extremities. Other complications associated with pECLA included compartmental syndrome in a lower limb and cannula thrombosis, which were not observed in this patient. Also, hemolysis has been described as a side effect of pECLA (15). But in comparison to ECMO neither platelet count nor hemolysis measurements were affected by continuous pumpless pECLA therapy in our patient.

Conclusions
In conclusion, pECLA may represent a rescue therapy for patients with severe, refractory pulmonary failure in status asthmaticus. As an alternative extracorporeal lung assist to ECMO, it supports gas exchange, allowing for lung-protective mechanical ventilation with lower tidal volumes and reduced airway.

Declaration of Interest
The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

References