Lung transplantation following 107 days of extracorporeal membrane oxygenation

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Abstract

Severe adult respiratory distress syndrome (ARDS) is associated with failure to maintain adequate gas exchange. There is increasing success using extracorporeal membrane oxygenation (ECMO) for respiratory failure; the longest reported surviving patient has been supported by ECMO for 57 days. At best about 50% wean from ECMO and should weaning fail their course is fatal. ECMO is generally considered to be a contraindication for successful lung transplantation. This report describes a patient maintained on ECMO for 107 days who underwent bilateral lung transplantation and weaned from organ-perfusion support. He survived for 351 days post-transplantation and died from Pseudomonas aeruginosa pneumonia. ECMO can be used for prolonged intervals to support patients with severe ARDS without complications that preclude lung transplantation. As ECMO use becomes more frequent, it becomes critical to determine criteria that would optimise patient selection for transplantation from ECMO.

Keywords: Pulmonary transplantation; ECMO; Respiratory failure; Adult respiratory distress syndrome

1. Case report

A 24-year-old male presented following an assault resulting in a parietal skull fracture and subdural and subarachnoid haemorrhage, necessitating a craniectomy and haematoma evacuation. The patient developed worsening respiratory function evidenced by hypoxaemia on airway pressure release ventilation (APRV). Because of persistent hypoxaemia, veno-venous extracorporeal membrane oxygenation (ECMO) was initiated on hospital day 18 using inferior vena cava inflow and superior vena cava outflow. Cannulation for ECMO was performed using a percutaneously placed 23 French femoral vein cannula (Medtronic, Inc., Minneapolis, MN, USA) and 21 French right internal jugular vein cannula. Bio-Medicus® heparin bonded cannulae, a closed, heparin bonded circuit and Bio-Medicus® perfusion system with the centrifugal pump and oxygenators (Medtronic, Inc., Minneapolis, MN, USA) were used. ACT was maintained between 160 and 200 s. Repeated chest roentgenograms revealed changes consistent with adult respiratory distress syndrome (ARDS). Tracheostomy was performed on hospital day 23. Sildenafil was administered to decrease pulmonary hypertension.

Because of failure to wean from ECMO, lung transplantation was offered as an option on ECMO day 45. Informed consent was obtained and on ECMO day 107, a suitable donor became available. Bilateral lung transplantation was performed via a ‘clamshell’ incision. ECMO was converted to conventional cardiopulmonary bypass. The operative procedure was complicated by proliferative visceral—parietal pleural adhesions. Following implantation and reperfusion of the lung allografts, bypass was successfully weaned. Pathologic examination showed severe interstitial fibrosis with pulmonary arteriopathy consistent with ARDS.

Postoperatively, a bronchial dehiscence was treated by stent placement. On post-transplant day 212, he was discharged to a physical rehabilitation facility and weaned from ventilatory support. He expired from recurrent pneumonia and respiratory failure 351 days post-transplantation.
2. Discussion

Because acute lung injury is a common problem having a poor prognosis, innovative efforts are currently needed to improve mortality. Although the largest randomised controlled trial of ECMO for respiratory failure published 30 years ago reported a survival of just 15% [1], there has been a renewed interest in the use of ECMO for this indication. Recent advances in ECMO systems including the introduction of centrifugal pumps, polymethylpentene oxygenators and heparin circuits have resulted in survival rates of approximately 50% for severe respiratory failure [2].

Our report describes a case of a man with ARDS who having failed mechanical ventilation was treated by ECMO support for 107 days until a donor organ became available. He survived 351 days after bilateral lung transplantation. Our case is of particular interest because the duration of ECMO support is nearly double the longest interval previously reported and also because lung transplantation was performed successfully after 107 days of ECMO. Although donor lung waiting times are typically long, ECMO may be used for prolonged intervals to support patients with catastrophic lung injury who would otherwise die while awaiting a suitable organ. A literature review describes 12 similar patients from Europe and Australia in whom ECMO had been used as a bridge to transplantation (Table 1). Four of these patients had ARDS. The maximum duration of ECMO support to transplantation for the entire cohort was 28 days while ARDS cases used ECMO for a mean of 9 days (range: 5—14 days).

The longest duration of any patient maintained by ECMO is 107 days. Among Michigan’s patients, the centre with the largest experience in the United States, the maximal duration of ECMO use was 57 days [2]. In another report, an infant was placed on ECMO for 48 days after suffering from viral cardiomyopathy and gradually recovered. At follow-up 18 months later, the patient was developmentally and neurologically intact [3]. A third report describes a patient with sepsis and ARDS after liver abscess. After antibiotics and surgical drainage, the patient was weaned from ECMO after 48 days [4].

ECMO can be used as a bridge to transplantation, but is rarely used. Available information is limited to a small number of case reports (Table 1). Of the 12 cases in the literature, the mean duration of ECMO as a bridge to transplant was only 11 days (range: 1—28 days). The first report involves a trauma patient who developed ARDS and then placed on ECMO. After 4 days of support, the patient was transplanted and was discharged 41 days later [5]. The same group used ECMO in three cases for 5, 6 and 13 days before lung transplantation. Two of the three cases were alive, 1 year after surgery [6]. In a retrospective review by the Medical University of Vienna evaluating ECMO, two cases are described in which ECMO was used as a bridge to lung transplantation. Both patients had cystic fibrosis with progressive respiratory failure. The first patient died 2 months after transplantation from sepsis, while the second patient was living at the time of their publication [7]. Most recently, a case series published in 2008 described three patients with respiratory failure who were bridged to transplant by ECMO for 28, 10 and 14 days and survived by 7 or more months [8].

Although ECMO is typically a contraindication to lung transplantation, our case demonstrates the feasibility of prolonged ECMO support leading to successful lung transplantation surgery. Nonetheless, the long-term outcome of our patient was not ideal arguably primarily because of evidence of physical deconditioning resulting from prolonged immobility prior to transplantation. Ongoing advancements of ECMO technology will probably lead to the future development of a compact artificial lung device rather than the traditional cumbersome ECMO circuit. A new portable ECMO system would ideally reduce conventional positive pressure ventilation requirements while optimising patient ambulation and pre-transplant physical strength and conditioning.

Table 1
Demographics and outcomes of published cases using ECMO for respiratory failure as a bridge for lung transplantation.

<table>
<thead>
<tr>
<th>Centre</th>
<th>Age</th>
<th>Year</th>
<th>Lung disease</th>
<th>ECMO duration (days)</th>
<th>Lung transplant</th>
<th>Weaned from ECMO</th>
<th>Weaned from ventilator</th>
<th>Status</th>
<th>Survival (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hannover Medical School, Germany [10]</td>
<td>32</td>
<td>1990</td>
<td>IPF</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Dead</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1990</td>
<td>IPF</td>
<td>8 h</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Alive</td>
<td>42</td>
</tr>
<tr>
<td>Hannover Medical School, Germany [6]</td>
<td>19</td>
<td>1993</td>
<td>ARDS</td>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Alive</td>
<td>30</td>
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<tr>
<td></td>
<td>32</td>
<td>1993</td>
<td>ARDS</td>
<td>6</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Dead</td>
<td>0</td>
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<tr>
<td></td>
<td>43</td>
<td>1993</td>
<td>ARDS</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Alive</td>
<td>12</td>
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<tr>
<td>University of Vienna, Vienna, Austria [9]</td>
<td>NA</td>
<td>2001</td>
<td>PH</td>
<td>7</td>
<td>Yes</td>
<td>NA</td>
<td>NA</td>
<td>Dead</td>
<td>5</td>
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<tr>
<td></td>
<td>NA</td>
<td>2001</td>
<td>PH</td>
<td>21</td>
<td>Yes</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>University of Vienna, Vienna, Austria [7]</td>
<td>NA</td>
<td>2006</td>
<td>CF</td>
<td>NA</td>
<td>Yes</td>
<td>Yes</td>
<td>NA</td>
<td>Died</td>
<td>2</td>
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<tr>
<td></td>
<td>NA</td>
<td>2006</td>
<td>CF</td>
<td>NA</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Alive</td>
<td>NA</td>
</tr>
<tr>
<td>St. Vincent’s Hospital, Australia [8]</td>
<td>15</td>
<td>2007</td>
<td>PNA</td>
<td>28</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Alive</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>2007</td>
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<td>Yes</td>
<td>Alive</td>
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<tr>
<td></td>
<td>26</td>
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<td>14</td>
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<td>Yes</td>
<td>Yes</td>
<td>Alive</td>
<td>7</td>
</tr>
</tbody>
</table>

The first two cases in 1990 were retransplant patients with pulmonary allograft failure. NA: not available; ARDS: acute respiratory distress syndrome; IPF: idiopathic pulmonary fibrosis; PH: pulmonary hypertension; CF: cystic fibrosis; PNA: pneumonia.
Acknowledgement

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References


