New miniaturised life support system for mobile percutaneous cardiopulmonary bypass

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Conflict of interests

2006  Matthias Arlt and Alois Philipp were the originators of hand-held ECMO

2007-2009  consultancy of MAQUET Cardiopulmonary AG

since 2009  no conflicts of interest
Mobile patients

- Changes in medical systems
- Decreasing number of hospitals in rural areas
- Centralization of medical technology and experts
- Interhospital transfer in state of severe cardiopulmonary failure

**Increasing demand on interhospital transfer of critically ill patients**

“too ill to be moved”?

- Patients with severe cardiopulmonary failure have to be moved to specialised medical care centres.
- Interhospital transfer in state of cardiopulmonary failure is risk laden.
- Withholding transfer eliminates advanced treatment options.

The role of extracorporeal life support

...In patients with acute and severe respiratory failure who are failing all advanced modes of mechanical ventilation, the use of extracorporeal life support is an option...

Mark R. Hemmila Crit Care Med 2006 Vol. 34, No. 9
## Extracorporeal life support

### Principals

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECLS</td>
<td>Extracorporeal life support</td>
<td>Encompasses all extracorporeal technologies and life support components including oxygenation, carbon dioxide removal, and haemodynamic support; renal and liver support may also be incorporated</td>
</tr>
<tr>
<td>ECMO</td>
<td>Extracorporeal membrane oxygenation</td>
<td>Older traditional term for extracorporeal life support that omits reference to inherent additional life supports such as haemodynamic support and carbon dioxide removal</td>
</tr>
<tr>
<td>VV ECLS</td>
<td>Venous-venous extracorporeal life support</td>
<td><strong>Respiratory failure</strong></td>
</tr>
<tr>
<td>VA ECLS</td>
<td>Venous-arterial extracorporeal life support</td>
<td><strong>Cardiac- cardiopulmonary failure</strong></td>
</tr>
<tr>
<td>ECPR</td>
<td>Extracorporeal cardiopulmonary resuscitation</td>
<td>Extracorporeal life support instituted during, and as an adjunct to, conventional cardiopulmonary resuscitation</td>
</tr>
<tr>
<td>ECCO2R</td>
<td>Extracorporeal membrane carbon dioxide removal</td>
<td>Selective carbon dioxide removal</td>
</tr>
</tbody>
</table>
The main role of this complex technique (ECMO) is to prevent hypoxia by all means.

- Full heparinization
- Complexe technique
- Seize and weight

- Bleeding complications
- Heart surgery dependency
- No emergency use
Mobile percutaneous cardiopulmonary bypass 2007

Extended technical and personnel support

ECMO Transport Norwegen Riks Hospital 2007
Mobile percutaneous cardiopulmonary bypass 2007

Emergency use of ECMO „out-of-centre“ was impossible
Concept of hand-held ECMO (Mini-ECMO)

- Maximum oxygen transfer to the tissues
- CO₂ elimination
- Preserved bloodflow in all conditions
- Independent of the haemodynamics
- No full dose heparinisation
- Small size and portable weight
- Independent of wall connection points

using a **blood pump** and a **gas exchange modul**
First experiences with a new miniaturised life support system for mobile percutaneous cardiopulmonary bypass

Matthias Arlt a, *, Alois Philipp b, Markus Zimmermann a, Sabine Voelkel a, Michael Hilker b, Jonny Hobbhahn a, Christof Schmid b

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b Department of Cardiothoracic Surgery, University Hospital Regensburg, 93042 Regensburg, Germany

For the first time, using an extracorporeal circulation system is now possible without extended technical or personnel support...
Methods

veno-venous ECMO
pulmonary failure

veno-arterial ECMO
cardio±pulmonary failure
Methods

- Refractory cardiac, pulmonary, cardiopulmonary failure
  - Patients „out-of-centre“, „in-centre“
  - Standardised patient evaluation on scene
  - Standardised inclusion and exclusion criterias
  - Interdisciplinary decision making
  - Implantation of hand-held ECMO on scene (ICU, ED, OR, OH)
  - Patient transfer for specialised medical care
Bridging on ECMO

High frequency ventilation
Rotation therapy

Lung protective ventilation

Prone positioning
Respiratory setting on ECMO

Research

A new miniaturized system for extracorporeal membrane oxygenation in adult respiratory failure

Thomas Müller¹, Alois Philipp², Andreas Luchner¹, Christian Karagiannidis¹, Thomas Bein³, Michael Hilker², Leopold Rupprecht², Julia Langgarten⁴, Markus Zimmermann³, Matthias Arlt³, Jan Wenger¹, Christof Schmid², Günter AJ Riegger¹, Michael Pfeifer¹ and Matthias Lubnow¹

<table>
<thead>
<tr>
<th>Respiratory parameters before, during and after extracorporeal support</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td><em>FIO₂</em></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Minute Ventilation (L/min)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Tidal Volume (mL)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Tidal Volume per kg pred. BW (mL/kg)</td>
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<tr>
<td></td>
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<tr>
<td>Peak Inspiratory pressure (cm H₂O)</td>
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</tbody>
</table>
Bridging on ECMO

“in hospital”

ECMO “awake”

“out-of hospital”
It seems justified to implement the use of miniaturized ECMO systems in clinical practice. In particular, this technique offers practical advantages during transport of ARDS patients.
Hand-held ECMO trauma with cardiopulmonary failure

Clinical paper

Extracorporeal membrane oxygenation in severe trauma patients with bleeding shock

Matthias Arlt*, Alois Philipp, Sabine Voelkel, Leopold Rupprecht, Thomas Mueller, Michael Hilker, Bernhard M. Graf, Christof Schmid

University Hospital Regensburg, Germany

...ECMO in severe trauma patients with resistant pulmonary and/or cardiopulmonary failure can be first-time instituted alongside conventional management of bleeding shock and damage control surgery. Even trauma victims with disastrous injuries will have another chance at survival.
Emergency medical transport systems may need to take patients with complicated acute myocardial infarction to hospitals with the capability to perform urgent revascularization.

Hand-held ECMO

European Journal of Cardio-thoracic Surgery 40 (2011) 689–694

Hand-held minimised extracorporeal membrane oxygenation: a new bridge to recovery in patients with out-of-centre cardiogenic shock

Matthias Arlt *, Alois Philipp, Sabine Voelkel, Daniele Camboni, Leopold Rupprecht, Bernhard-Martin Graf, Christof Schmid, Michael Hilker

University Hospital Regensburg, Regensburg, Germany

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Rapid-onset extracorporeal life support independent from the patient’s location

Prevention of hypoxic damage and circulatory arrest in cardiogenic shock patients

Patient transfer on ECMO in re-established blood flow and oxygen delivery
### Results interhospital transfer on ECMO (2006-2011)

<table>
<thead>
<tr>
<th>Variable</th>
<th>V-a ECMO</th>
<th>V-v ECMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>33</td>
<td>75</td>
</tr>
<tr>
<td>Age, years</td>
<td>49 ± 13</td>
<td>44 ± 15</td>
</tr>
<tr>
<td>Sex, male/ female</td>
<td>25/7</td>
<td>49/23</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>25 (22-36)</td>
<td>30 (16-84)</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARDS post trauma</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>ARDS not trauma</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Pneumonia, Aspiration</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Septic shock</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

BMI, Body-Mass-Index; ARDS, acute respiratory distress symptom

### Table Outcome

<table>
<thead>
<tr>
<th>Variable</th>
<th>V-a ECMO</th>
<th>V-v ECMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time on Assist, days</td>
<td>4 (0-9)</td>
<td>12 (0-67)</td>
</tr>
<tr>
<td>Weaned, n (%)</td>
<td>26 (81)</td>
<td>66 (92)</td>
</tr>
<tr>
<td>Discharged from hospital, n (%)</td>
<td>16 (48)</td>
<td>53 (74)</td>
</tr>
</tbody>
</table>
Extracorporeal resuscitation is highly effective

Finishing PCI and TAVI procedures becomes possible on ECMO

Patient transfer on extracorporeal life support is first time easily possible
Hand-held ECMO

PROS

- Emergency treatment of resistant hypoxemia
- Emergency treatment of resistant shock
- ECMO independent of the current location
- Patient and „life-support“ one unit
- Transfer to specialised medical care centers
Percutaneous cannulation for extracorporeal life support

Thorac Cardiovasc Surg. 2011 Mar;59(2):103-7

complications:
- Bleeding
- limb ischemia
- (Air embolism)
- (Device failure)
Percutaneous cardiopulmonary bypass

- 365 days 24 hrs service
- Implementation „out-of-center“
- Need for „in-door“ cannula switch
- Patient selection
Chain of rescue in cardiopulmonary failure

- Small community hospitals
- Specialized medical care centres
- Patients with refractory cardiopulmonary failure
- Emergency Medical Service
Conclusions

- Miniaturised extracorporeal life support is safe and effective
- Proper patient selection is crucial
- Patients in severe cardiopulmonary failure will become „transportable“
- Extracorporeal life support is „bridging“ not „therapy“
- Interdisciplinary patient management is the key for success