Mobile ECMO Team

PD Dr. Thomas Müller
UK Regensburg, Germany

no conflict of interest
Overview

1. rationale
2. which patient?
3. logistics:
   – organisation
   – equipment
   – team
4. risks - some practical aspects
5. outcome
6. summary
1. Rationale

- **who**: critically ill patients with either respiratory or circulatory failure, who may benefit from extracorporeal support

- **why**: conventional transport not possible: patient instable (hypoxia in supine position, high dose of vasopressors, NO, HFOV…):
  
  - **primary transport**: cannulation and ECMO start by mobile ECMO team in remote hospital
  
  - **secondary transport**: patient already supported by ECMO has to be transported
“We recommend that for most centers, an annual volume for the entire center should be at least 20 cases per year and that at minimum of 12 ECMO cases for ARF should be performed.

“Networks of hospitals at the local, regional or interregional level should be created around each ECMO center in tertiary referral hospitals.”

“Each ECMO network should ideally create mobile ECMO teams to retrieve patients and to deal with patients who have critical cardiopulmonary failure refractory to conventional therapy.”
"Conclusions: In this international, case-mix–adjusted analysis, higher annual hospital ECMO volume was associated with lower mortality in 1989–2013 for neonates and adults; the association among adults persisted in 2008–2013."
2. Indication for extracorporeal therapy?

1. **VV ECMO rescue**
   - vital gas exchange can not be secured by conventional means, and rapidly progressive hemodynamic instability
     - (P/F < 60 mm Hg, and pH < 7.2, and PIP > 35 cm H₂O, and Nor > 1.5 mg/h)

2. **VV ECMO semielective**
   - lung protective ventilation not possible to secure vital gas exchange; no improvement after 12-24 hours
     - (P/F < 85 mmHg, respiratory acidosis pH < 7.2)

3. **VA ECMO:**
   - cardiogenic shock refractory to conventional therapy, incipient or manifest organ failure (vasopressors, lactate, oliguria…)
   - resuscitation: ?

**remember:**
ECMO is a bridge: is there a potentially treatable cause?
Retrieval inquiry

- date, hospital, tel. number
- pat. characteristics: age, weight, height, pack years
- history
- microbiology, antibiotics
- ventilation
- hemodynamics
- organ function: renal, hepatic, cardiac, coagulation
- central lines
- accepted yes/no/time

<table>
<thead>
<tr>
<th>Externe Klinikdaten</th>
<th>Patientendaten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datum:</td>
<td>Patientenname:</td>
</tr>
<tr>
<td>Uhrzeit:</td>
<td></td>
</tr>
<tr>
<td>Klinik:</td>
<td>Geburtsdatum:</td>
</tr>
<tr>
<td>Station:</td>
<td>Größe:</td>
</tr>
<tr>
<td></td>
<td>Gewicht:</td>
</tr>
<tr>
<td>Anrufer:</td>
<td>Anamnese:</td>
</tr>
<tr>
<td>Rückrufnummer:</td>
<td>PackYears:</td>
</tr>
<tr>
<td>Anamnese</td>
<td></td>
</tr>
</tbody>
</table>

- Keimnachweis:
- Multiresistente Erreger:
- Antibiosen:
- Isolationspflichtig: ja/nein
- Neurologie:
- Dekubitus:

- Respiration
- Beatmungsbeginn:
- Noradrenalin (mg/h):
- FiO2: pH: Adrenalin (mg/h):
- AMV: TV: P_{aO_2}: Blutdruck:
- PEEP: PIP: P_{aCO_2}: ZVD:

- Labor
- Kreatinin:
- Bilirubin:
- CVVHF: ja/nein
- GOT:
- Hb:
- CT-Thorax:
- PTT:
- Leukozyten:
- ECHO/TEE:
- INR:
- Thrombozyten:
- IABP:

- Zugänge
- ZVK:
- Ort: Shaldon:
- Arterie:
- Ort:
- Gefäßprothesen in Leiste:

- Thoraxdrainagen:

- Informationen an
- Kardiotechniker:
- HTC OA (bei kardialem Versagen):

- Transport mit ECMO ja/nein
- Organversagen primär: kardial/ respiratorisch
- Aufnehmende Station im UKR:
- Übernahme zugesagt: ja/nein
- Uhrzeit:
- Bearbeiter:
Prediction of mortality in adult patients with severe acute lung failure receiving veno-venous extracorporeal membrane oxygenation: a prospective observational study


Table 4 Novel mortality prediction models for ALF patients receiving ECMO support

<table>
<thead>
<tr>
<th>Model 1 (pre-ECMO)</th>
<th>Coefficient</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per 5 years)</td>
<td>0.176</td>
<td>1.193</td>
<td>(1.148-1.239)</td>
</tr>
<tr>
<td>Immunocompromised state</td>
<td>0.958</td>
<td>2.605</td>
<td>(1.316-5.158)</td>
</tr>
<tr>
<td>Minute ventilation (L/min)</td>
<td>0.098</td>
<td>1.103</td>
<td>(1.014-1.199)</td>
</tr>
<tr>
<td>Pre-ECMO haemoglobin (g/dL)</td>
<td>-0.182</td>
<td>0.834</td>
<td>(0.728-0.954)</td>
</tr>
<tr>
<td>Pre-ECMO lactate (mmol/L)</td>
<td>0.013</td>
<td>1.013</td>
<td>(1.004-1.023)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.083</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Model 2 (day 1):

- age
- immunocompromised state
- minute ventilation
- pre ECMO Hb
- day 1 FiO₂
- day 1 fibrinogen
- day 1 norepi.
- day 1 CRP

TB Enger... T Müller, Crit Care 2014;18:R67
Table 4 Novel mortality prediction models for ALF patients receiving ECMO support

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**Model 1 (pre-ECMO):**

- age
- immunocompromised state
- minute ventilation
- pre ECMO Hb

**Model 2 (day 1):**

- day 1 FiO₂
- day 1 fibrinogen
- day 1 norepi.
- day 1 CRP

*nevertheless:* selection of patients is very challenging, the final decision is taken by the transporting physician.
3. Logistics of a Mobile ECMO Team

1. **Organisation:** telephone hot-line 24/7 with experienced intensivist

2. **Time matters:**
   - 1st responsibility: ECMO coordinator
   - rapid chain of decisions
   - pre-packed equipment/pre-primed ECMO

3. **Team:** depends on patient
   - adult VV: intensivist, nurse, perfusionist
   - adult VA: intensivist, nurse, perfusionist, (cardiac surgeon)
   - pediatric: pediatric intensivist, nurse, perfusionist, cardiac surgeon

4. **Equipment:** depends on patient and distance of retrieval

5. **Quality control:**
   - all patients have to be included in a data-base
   - regular M+M Conference
The Team

- always multidisciplinary
- on call 24/7 (pager)
- **Intensivist** experienced in
  - patient management: clinical assessment – alternatives?
  - ECMO: yes/no?
  - critical care medicine (ventilation, resuscitation, transport)
  - cannulation
  - ECMO management
- **Perfusionist** responsible for
  - equipment
  - ECMO management
  - cannulation support
- **Nurse** responsible for vital signs, drug administration, communication
Equipment: mobile versus portable ECMO

Linden V et al. Intensive Care Med 2001;27:1643-8

Arlt M et al, Resuscitation 2008;77: 345-50
Mobile ECMO today
ECMO pre hospital

- Car for ECMO-team
- Driver (if available)
- Intensivist and Perfusionist

- Primed ECMO System
- pre-packed equipment
- 2 L cold Ringer solution

Alert by the integrated command center Regensburg in case of probable OHCA parallel to the regular emergency medical service
# List of equipment

## Blue Bag: Cannula size [Fr.] length [cm]

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x</td>
<td>Venous HLS Cannula 21-38</td>
</tr>
<tr>
<td>1x</td>
<td>Venous HLS Cannula 23-38</td>
</tr>
<tr>
<td>1x</td>
<td>Venous HLS Cannula 21-55</td>
</tr>
<tr>
<td>1x</td>
<td>Venous HLS Cannula 23-55</td>
</tr>
<tr>
<td>2x</td>
<td>HLS Cannula 15-15 (small adults)</td>
</tr>
<tr>
<td>2x</td>
<td>HLS Cannula 17-23 (large adults)</td>
</tr>
<tr>
<td>2x</td>
<td>Freelite; Fem. Perfusion Set 7Fr</td>
</tr>
<tr>
<td>1x</td>
<td>Medos; Drive-Unit, DP3, Battery</td>
</tr>
<tr>
<td>1x</td>
<td>PVC Tube 3/8&quot; 2m</td>
</tr>
<tr>
<td>2x</td>
<td>Pressure monitoring line 120cm L-L</td>
</tr>
<tr>
<td>1x</td>
<td>Power cable</td>
</tr>
</tbody>
</table>

## Red backpack:

### Main pocket:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4x</td>
<td>Drape sheet 75x90</td>
</tr>
<tr>
<td>2x</td>
<td>Drape sheet 10x50</td>
</tr>
<tr>
<td>4x</td>
<td>Split sheet</td>
</tr>
<tr>
<td>3x</td>
<td>Surgical Gown</td>
</tr>
<tr>
<td>4x</td>
<td>Surgical cap + mask</td>
</tr>
<tr>
<td>8x</td>
<td>Surgical gloves</td>
</tr>
<tr>
<td>1x</td>
<td>Softasept® N disinfectant</td>
</tr>
<tr>
<td>4x</td>
<td>Pads</td>
</tr>
<tr>
<td>6x</td>
<td>Mersilene 1.0</td>
</tr>
<tr>
<td>3x</td>
<td>Stopcock max flow</td>
</tr>
<tr>
<td>4x</td>
<td>Tube attachment device</td>
</tr>
<tr>
<td>2x</td>
<td>Connector 3/8&quot;x3/8&quot;</td>
</tr>
<tr>
<td>2x</td>
<td>Blinde Tube 3/8&quot;</td>
</tr>
<tr>
<td>1x</td>
<td>Magnesium</td>
</tr>
<tr>
<td>2x</td>
<td>Potassium 14.9%</td>
</tr>
<tr>
<td>2x</td>
<td>Tris</td>
</tr>
<tr>
<td>1x</td>
<td>Protamine</td>
</tr>
<tr>
<td>2x</td>
<td>Heparin</td>
</tr>
<tr>
<td>1x</td>
<td>Gasfilter-line</td>
</tr>
<tr>
<td>2x</td>
<td>Scalpel</td>
</tr>
<tr>
<td>2x</td>
<td>Separat Needle to puncture</td>
</tr>
<tr>
<td>2x</td>
<td>Cook-Dilator 10; 14; 18; 20; 22 Fr</td>
</tr>
<tr>
<td>4x</td>
<td>Guidewire 70cm long (fem art)</td>
</tr>
<tr>
<td>2x</td>
<td>Guidewire .038i.; 150cm long</td>
</tr>
<tr>
<td>2x</td>
<td>Guidewire .025i.; 145cm long</td>
</tr>
<tr>
<td>2x</td>
<td>Guidewire Amplatz superstiff 145</td>
</tr>
<tr>
<td>1x</td>
<td>Y-connector 3/8&quot;x3/8&quot;x3/8&quot;</td>
</tr>
<tr>
<td>3x</td>
<td>Percutaneous insertion kit</td>
</tr>
<tr>
<td>4x</td>
<td>Holliste Tube fixation Plate</td>
</tr>
</tbody>
</table>

### Front pockets:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x</td>
<td>Clamps &amp; scissor set sterile</td>
</tr>
<tr>
<td>1x</td>
<td>Scissors sterile</td>
</tr>
<tr>
<td>1x</td>
<td>Headlight</td>
</tr>
</tbody>
</table>

### Side pockets:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x</td>
<td>Clamps &amp; scissor set sterile</td>
</tr>
<tr>
<td>1x</td>
<td>Scissors sterile</td>
</tr>
<tr>
<td>1x</td>
<td>Headlight</td>
</tr>
</tbody>
</table>

**2 bags cold Ringer's lactate solution 4°C [1000ml]**
Risk of Cannulation
4. Practical Aspects: Cannulation VV

- **1st choice: two cannulas**
  - right femoral vein (23 Fr, 35 cm) > right jugular vein (17 Fr, 15 cm)
    - best anatomical access
    - best for right-hander implantation
    - nursing care simplified

- **alternatives:**
  - left side: anatomically more difficult
  - fem – fem: risk of caval thrombosis (?)
  - fem > subclavian: dangerous, better not
  - jug > fem: less efficient (IVC sat < SVC sat; recirculation ↑)

- **important:** tip-to-tip distance, no incision, fixation, proper dressing
Double-Lumen Cannula?

- **pro:**
  - mobilization intended
  - possible in high BMI

- **con:**
  - difficult/time-consuming/complicated
  - fluoroscopy advisable
  - not in emergency situations

- preferably not in remote hospitals
Standard Cannulation for VA ECMO

- femoral vein > femoral artery
- jugular vein > femoral artery
Practical Aspects

1. have two RBCs ready
2. ask for central venous line in left jugular/subclavian vein
3. take care for sufficient power and oxygen supply
4. use check-lists
5. hand-held ultrasound/echocardiography is very helpful for evaluation of cardiac function and facilitates cannulation
6. importance of slow CO₂ removal: cave hypocapnia and alkalosis (possibly danger of cerebral vasospasm)
7. online SvO₂ measurement helps to monitor cardiac and ECMO function

385 requests accepted from 71 locations

370 bedside evaluation

25 conventional transport (3 failed cannulation)

V-a ECMO 110

V-v ECMO 227

Discharge 58 (53%)

Discharge 155 (68%)

† 14 patients

† 6 on system

† 2 on transport
University of Michigan 1990 – 2012:
221 patients transported on ECMO → 62 % survival to discharge

27 other case series reviewed:
643 patients transported on ECMO → 61 % survival to discharge

**conclusion:** transport on ECMO is

✓ feasible
✓ safe
✓ comparable outcome to in-house cannulation

## Summary

- A good retrieval service is a cornerstone of an ECMO center.
- Mobile ECMO is a multidisciplinary experience.
- Mobile ECMO is safe in experienced hands.
- Time is of highest importance travelling to the patient.
- Patient safety is of highest importance on return.
- Mobile ECMO can save lives.