Extracorporeal Membrane Oxygenation in Cardiac Arrest

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DECLARATION OF INTEREST

- I have nothing to declare
Overview

- Introduction
- Outcomes
- Prognostic factors
- Cannulation
- Post-resuscitation care
- Complications
Publications

Pubmed: extracorporeal and CPR
Definition

ECPR: Extracorporeal cardiopulmonary resuscitation
ECLS: Extracorporeal life support

The rapid deployment of extracorporeal membrane oxygenation (ECMO) to provide immediate cardiovascular support for patients who have cardiac arrest unresponsive to conventional CPR measures.

Veno–Arterial ECMO

V–A ECMO

Oxygenator
FiO₂ 40–60%

Pump
flow 3–4 l/min

Femoral access
cannulas 15–21F
ECLS
in-hospital and out-of-hospital

Image courtesy of Lamhaut L.
Extracorporeal Cardiopulmonary Resuscitation (eCPR)

Extracorporeal CPR (eCPR) should be considered as a rescue therapy for those patients in whom initial ALS measures are unsuccessful and, or to facilitate specific interventions (e.g. coronary angiography and percutaneous coronary intervention (PCI) or pulmonary thrombectomy for massive pulmonary embolism). There is an urgent need for randomised studies of eCPR and large eCPR registries to identify the circumstances in which it works best, establish guidelines for its use and identify the benefits, costs and risks of eCPR.
2015 Recommendation—New

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest. In settings where it can be rapidly implemented, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support (Class IIb, LOE C-LD). Published series have used rigorous inclusion and exclusion criteria to select patients for ECPR. Although these inclusion criteria are highly variable, most included only patients aged 18 to 75 years, with arrest of cardiac origin, after conventional CPR for more than 10 minutes without ROSC. Such inclusion criteria should be considered in a provider’s selection of potential candidates for ECPR.
Outcomes Meta-analysis

Venoarterial Extracorporeal Membrane Oxygenation for Cardiogenic Shock and Cardiac Arrest: A Meta-Analysis

Ashleigh Xie,*† Kevin Phan, BSc,*¶ Yi-Chin Tsai MBBS,‡ Tristan D. Yan, MD, MS, PhD, FRACS,*§‖ and Paul Forrest, MBChB, FANZCA‖

- 8 observational studies after 2000
- 343 patients with cardiac arrest
- Survival to discharge 35.9%

Xie A, J Cardiothorac Vasc Anesth. 2015 Jun;29(3) 637-45
Outcomes
Vienna 1993–2010

- 3621 patients with cardiac arrest at the ED
- 55 patients treated with ECPR (2%)
- 60% out-of-hospital cardiac arrest
- Time till start of canulation 52 min
- Cannulation time 33 min
# Outcomes

## Vienna 1993–2010

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>19</td>
<td>35%</td>
</tr>
<tr>
<td>Hypothermic</td>
<td>14</td>
<td>25%</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>11</td>
<td>20%</td>
</tr>
<tr>
<td>Intoxication</td>
<td>8</td>
<td>15%</td>
</tr>
<tr>
<td>Diabetic coma</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Weaning from ECMO</td>
<td>14</td>
<td>25%</td>
</tr>
<tr>
<td>6 month survival</td>
<td>8</td>
<td>15%</td>
</tr>
<tr>
<td>CPC–Score 1 or 2</td>
<td>8</td>
<td>15%</td>
</tr>
</tbody>
</table>
Outcomes
In–hospital cardiac arrest

- 3–year prospective observational study
- ECMO for 59 patients
- Age 18–75 years
- Witnessed in–hospital cardiac arrest of cardiac origin
- Undergoing CPR for >10 minutes
- Propensity–score matched with conventional CPR

Outcomes
In-hospital cardiac arrest


Conventional CPR
ECPR

p=0.003

Number at risk
Extracorporeal CPR-M 46
Conventional CPR-M 46

Time (days)
Cumulative survival

Outcomes
In–hospital cardiac arrest

- Weaning from ECMO: ECPR 49%, CCPR
- Survival to discharge: ECPR 29%, CCPR 12%
- CPC 1 or 2 at discharge: ECPR 24%, CCPR
- CPC 1 or 2 at one year: ECPR 9%

Outcomes
Cardiac origin

- 7–year retrospective study
- ECMO for 86 patients
- Age 18–74 years
- Cardiac arrest of cardiac origin, 49% out–of–hospital
- VF on ECG during CPR
- Undergoing ALS for >20 minutes

Outcomes
Cardiac origin

- Weaning from ECMO 50%
- 30–days survival
- CPC 1 or 2 at discharge 24%
- Survivors 28% out-of-hospital cardiac arrest
- Non-survivors 57% out-of-hospital cardiac arrest

Outcomes

Out-of-hospital cardiac arrest

- 3 year prospective study
- 26 hospitals ECPR
- 20 hospitals non-ECPR
- VF/VT initial ECG, 20–70 years
- Hospital arrival within 45min after EMS call

## Outcomes

### Out-of-hospital cardiac arrest

<table>
<thead>
<tr>
<th></th>
<th>ECPR</th>
<th>non-ECPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>260</td>
<td>194</td>
</tr>
<tr>
<td>Time from EMS call to arrival</td>
<td>29min</td>
<td>30min</td>
</tr>
<tr>
<td>CPC 1 or 2 at 6 months</td>
<td>12.4%</td>
<td>3.1%</td>
</tr>
</tbody>
</table>

Outcomes

CHEER trial

- Prospective study
- Age 18–65 years
- Cardiac arrest of cardiac origin
- Initial rhythm ventricular fibrillation
- CPR > 30min
- 26 patients, 11 OHCA, 15 IHCA
Outcomes
CHEER trial

• Mechanical chest compression (Autopulse®)
• 2 liter ice-cold saline
• Transfer to the ED, immediate ECMO

• Cardiac arrest to ECMO: 56min (40–85min)
• Arrival to ECMO flow: 20min (15–30min)
• Weaning from ECMO: 54%
• Hospital discharge: 54% (IHCA 60%, OHCA 45%)
• CPC 1 of survivors: 100%

Stub D, Resuscitation. 2015 Jan;86:88-94
Patient selection

Accidental Hypothermia

ECPR associated with 6.6-fold survival

Intoxication

Beta-blockers
Calcium-antagonists
Antiarrhythmics
Tricyclic antidepressants
Benzodiazepines

Case reports with good outcome
Prognostic factors
No flow time

51 consecutive patients witnessed OHCA, 2 survivors

Causes of death after ECPR
- Multi organ failure 47%
- Brain death 20%
- Hemorrhagic shock 14%

Le Guen M, Crit Care. 2011;15(1)
Prognostic factors
Time until ECMO-flow

Prognostic factors
Time of CPR

Prognostic factors

Serum lactate

117 patients: multivariate analysis only serum lactate

Prognostic factors

- No flow time
- VF/VT at initial ECG
- Cardiac origin
- Signs of live movement, respiration, pupillary response
- Time to ECMO flow
  no differences IHCA/OHCA when adjusted for time
- E\textsubscript{T}CO\textsubscript{2} > 10 mmHg
- Lactate levels
Cannulation

- Surgeon
- Emergency physician
- Cardiologist
- Intensivist

Arterial 15–19F
Venous 19–21F
Cannulation Technique

Percutaneous

- Seldinger technique
- Ultrasound or fluoroscopy to locate wire in V. cava inf. and Ao. desc.
- Risk of failure
- Distal limb perfusion catheter
Cannulation Technique

Open

- Needs a Surgeon
- Time consuming
- Not for out of hospital ECMO
- Lowest risk of failure
Cannulation Technique

Mixed

- Incision in the groin
- Insertion of guidewire, dilator and cannula under vision with Seldinger
- Increased bleeding
- Best for out-of-hospital ECMO
Post-resuscitation care

- MAP 60–70 mmHg
- Normoxia, normocapnia
- Ice-cold saline for volume loading and mild hypothermia
- Immediate coronary angiography or CT scan for pulmonary embolism
Post-resuscitation care
no flow – pulmonary oedema

24 hours after ECMO
Post-resuscitation care
no flow – watershed phenomenon

No contrast in coronaries and Ao. ascendens

Hoeper MM, Circulation. 2014 Sep 2;130(10):864-5
Post-resuscitation care
no flow – myocardial ischemia

- Decrease afterload as much as possible
  low ECMO flow
  MAP 60–70 mmHg

- Use inotropic agents
  dobutamine, levosimendan

- Increase FiO₂ and PEEP
  at respirator
Post–resuscitation care
no flow – pulmonary oedema

4 days after ECMO
Post-resuscitation care
no flow – pulmonary oedema

IABP
Impella
LV-vent
Complications
Acute setting

- Wrong cannulation venous–venous or arterial–arterial
- Bleeding
- Accidental decannulation
- „Harlequin” syndrome
# Complications in the ICU

- renal failure requiring haemofiltration 52%
- bacterial pneumonia 33%
- any bleeding 33%
- sepsis 26%
- haemolysis 18%
- central nervous system complications 15%
- liver dysfunction 16%
- leg ischaemia 10%
- venous thrombosis 10%
- gastrointestinal bleeding 7%
- aspiration pneumonia 5%
- disseminated intravascular coagulation 5%
Patient selection
Load & Go Criteria Vienna

- Age < 75 years
- Witnessed OHCA
- Basic life support
- Ventricular fibrillation/ventricular tachycardia
- No ROSC within 15 min of advanced-life-support

Patient selection
Load & Go Criteria Vienna
Population 1.8 Million
VICAR Study:
August 1, 2013 to July 31, 2014

<table>
<thead>
<tr>
<th>load &amp; go criteria, n (%)</th>
<th>Total</th>
<th>ROSC at Ongoing CPR</th>
<th>Died on transport</th>
<th>Died on the scene</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count (%)</td>
<td>864 (100)</td>
<td>257 (29.7)</td>
<td>96 (11.1)</td>
<td>511 (59.1)</td>
<td></td>
</tr>
<tr>
<td>VF/VT</td>
<td>215 (24.9)</td>
<td>118 (45.9)</td>
<td>37 (38.5)</td>
<td>60 (11.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Basic life support</td>
<td>514 (59.5)</td>
<td>169 (65.8)</td>
<td>69 (71.9)</td>
<td>276 (54.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Witnessed collapse</td>
<td>482 (55.8)</td>
<td>172 (66.9)</td>
<td>68 (70.8)</td>
<td>242 (47.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt;75 year</td>
<td>574 (66.4)</td>
<td>198 (77.0)</td>
<td>72 (75.0)</td>
<td>304 (59.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CPR &gt;15 min of ALS</td>
<td>400 (46.3)</td>
<td>94 (36.6)</td>
<td>–</td>
<td>306 (59.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>All “load &amp; go” criteria fulfilled, n (%)</td>
<td>55 (6.4)</td>
<td>17 (6.6)</td>
<td>16 (16.7)</td>
<td>22 (4.3)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Summary

- Only small non-randomized studies
- Survival in ECPR ranges from 4% to 54%
- Decision for ECMO after 15–20 min
- ECMO should start within 60 min
- Need for efficient ECMO rescue teams for IHCA and OHCA
Thank you!

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