ECLS: A new frontier for refractory V.Fib and pulseless VT

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Cardiovascular Emergencies: An exploration into the expansion of time-critical diagnosis

Refractory V.fib/Pulseless VT

- > 350,000 patients have out-of-hospital cardiac arrest in the United States annually
  - Out of hospital arrest survival 2-11%
  - Neurologically intact survival in ~ 12%
- V.fib/pulseless VT is present in ~ 81,000 patients (23%) in the United States
  - The overwhelming majority of these patients have acute cardiac ischemia (STEMI/NSTEMI)
  - ~ 65,000 (80+%) of these patients die
  - If ROSC (20%), coronary revascularization is associated with survival and favorable neurologic outcomes
  - For patients in refractory cardiac arrest, strategies are needed to bridge them from the field to the cath lab/revascularization

Mozaffarian D. Circulation. 2016;133:e38-e360
Vyas A. Circ Cardiovasc Interventions. 2015;8
Soeholm, H. European Society of Cardiology presentation London, UK, 8/29/15
Goals and Methods of Care

- The ultimate goal of cardiopulmonary resuscitation is to improve long-term outcome in patients who suffering from cardiac arrest
- To reach this goal, however, there are various difficult problems:
  - cardiac resuscitation
  - cerebral resuscitation
  - urgent and intensive treatment of primary disease
  - rehabilitation and long-term treatment of primary disease
- Improvements in CPR with automated devices
  - Initial studies negative (Sayre, JAMA 2006)
  - Follow-up studies equivocal or positive
- Extracorporeal Life Support (ECLS) as an adjunct to cardiac resuscitation in the field has shown encouraging outcomes in patients with cardiac arrest

Refractory V.fib/Pulseless VT

Automated CPR: Bridge to the cardiac catheterization lab?

- Effective and efficient chest compression
- 100 compressions/minute
- Equal time for compression and decompression
- Full chest recoil
- Improved quality and increased consistency of compressions compared to manual CPR, both at the scene, during transport and in the cardiac cath lab
- LUCAS has shown to improve blood flow to the brain compared to manual CPR in prehospital patients (60% increase as measured by Doppler)

Wilk L, Resuscitation June 2014 Volume 85 Issue 6 Pages 741-748

Olaveanen TM, Resuscitation. 2008;70(2) 185-90
Methods of Care

- ECLS – extracorporeal life support (also known as ECMO)
- ECMO - extracorporeal membranous oxygenation

Defined:
- This is an extracorporeal (outside of body) technique that provides both cardiac and respiratory support to a patient whose heart and lungs are unable to provide an adequate amount of gas exchange to sustain life.
- Essentially a form of partial cardiopulmonary bypass used for long-term support of respiratory and/or cardiac function (developed in 1972)

Refractory V.fib/Pulseless VT


Survival

975 IH arrests, 2 years
18-75 yo
CPR > 10min
38% VT/VF
37% PEA
25% asystole
59 Extracorporeal CPR (ECPR)
113 Conventional CPR (CCPR)
1st Endpoint: Survival

Statistically significant survival benefit in ECPR discharge, 30 days and 1 year
**Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis**

### Neurologic Outcomes

<table>
<thead>
<tr>
<th>1 = good cerebral performance</th>
<th>5 = brain death or death</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 = moderate cerebral disability</td>
<td>4 = coma or vegetative state</td>
</tr>
<tr>
<td>3 = severe cerebral disability</td>
<td>3 = severe cerebral disability</td>
</tr>
</tbody>
</table>

**Table: Neurologic Outcomes**

<table>
<thead>
<tr>
<th>Extracorporeal CPR group</th>
<th>Conventional CPR group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>59</td>
</tr>
<tr>
<td>Duration of extracorporeal membrane oxygenation (h)</td>
<td>110 (128)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>69 (2–71)</td>
</tr>
<tr>
<td>Weaned off extracorporeal membrane oxygenation, n (%)</td>
<td>29 (49.2)</td>
</tr>
</tbody>
</table>

**CPC states at discharge**

1 or 2, n (%)
- Extracorporeal CPR: 14 (23.7)
- Conventional CPR: 12 (9.6)

**Odds ratio (95% CI, p value)**
- Extracorporeal CPR: 2.6 (95% CI 1.1–6.7, p=0.02*)
- Conventional CPR: 2.6 (95% CI 1.1–6.7, p=0.02*)

**CPC states at 1 year**

1 or 2, n (%)
- Extracorporeal CPR: 9 (15.3)
- Conventional CPR: 10 (8.9)

**Odds ratio (95% CI, p value)**
- Extracorporeal CPR: 1.9 (95% CI 0.6–5.4, p=0.20)
- Conventional CPR: 1.9 (95% CI 0.6–5.4, p=0.20)

**CPC=Cerebral-performance category score. *p<0.05.**

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**ECPR for Refractory Cardiac Arrest**

*Sydney ECMO Research Interest Group*

- Retrospective observation, prospective data collection at 2 centers, 2009 - 2016
- 37 patients: 25 (68%) in-hospital arrest, 12 (32%) out-of-hospital arrest were placed on ECMO
- Median age 54 yo (47-58)
- VF/PVT in 20 pts (54%), PEA in 14 (38%), asystole 3 (8%)
- 27 (73%) witnessed arrest, 30 (81%) bystander CPR
- conventional CPR was continued with no or minimal interruption either by the medical team or mechanical chest compression device (LUCAS™2 Physio-control Inc.)
ECPR for Refractory Cardiac Arrest
Sydney ECMO Research Interest Group

• Median time from arrest to ECMO 45 minutes (30-70 min)
  – Placed at bedside or in Emergency Department (TEE/Fluoro/ultrasound guided)

• Median time on ECMO 3 days (1-6)

• All therapeutically cooled to 33 °C x 24h post arrest
  – Post March 2014 target temperature management (core temperature of 36 °C) was employed

• Cardiac Catheterization in 20 (54%) of patients, 10 (27%) PCI

1. 13 (35%) survived to hospital discharge
   - no significant difference in survival between out of hospital cardiac arrest versus in hospital cardiac arrest (31% vs. 69% p=0.87)

2. All had favorable neurologic outcomes: Cerebral Perfusion Category 1 (11, 85%) or 2 (2, 15%)

### Variable Total (n=37) Survivors (n=13) Non-survivors (n=24) P value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Survivors</th>
<th>Non-survivors</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst pre-ECMO pH (median)</td>
<td>7.17 (6.94-7.24)</td>
<td>7.14 (6.92-7.27)</td>
<td>7.19 (6.94-7.24)</td>
<td>0.96</td>
</tr>
<tr>
<td>Worst pre-ECMO HC03 (mmol/L)</td>
<td>15 (12-19)</td>
<td>19 (14-21)</td>
<td>13 (9-16)</td>
<td>0.07</td>
</tr>
<tr>
<td>Worst pre-ECMO lactate (mmol/L)</td>
<td>9.4 (5.5-13)</td>
<td>5.2 (4.1-10.1)</td>
<td>11.2 (8.6-15)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Pre-ECMO lactate: predictive of mortality OR 1.35 (1.06–1.73, p = 0.016)
- IHCA/OHCA no different
- Witnessed/unwitnessed no different
- Arrest to ECMO < 60 min no different
ECPR for Refractory Out of Hospital Cardiac Arrest

Lyon France Group

- Retrospective observational analysis, prospectively collected database, 2010-2014, 68 patients
  - 1st Endpoint: Survival to hospital discharge with good neurological recovery after ECLS support

- Witnessed out of hospital arrest, 18-55 yo, EtCO₂ >10 mmHg, AutoPulse (Zoll Inc) automated CPR, taken to OR

- Patients were divided into a shockable rhythm (SH-R) and a non-shockable rhythm (NSH-R) group according to cardiac rhythm at ECLS implantation

- Mean age 43.7, +/- 11.4:
  - asystole 50%,
  - PEA 3%
  - V.fib/rVT 47%

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ECPR for Refractory Out of Hospital Cardiac Arrest

Out-of-hospital cardiac arrest
n = 68

- SH-R group
  - n = 32 (47.1%)
  - ACLS
    - SH-R group
      - n = 19 (27.9%)
    - ECLS
      - n = 19
        - Death on ECLS
          - n = 13 (68.5%)
        - Weaning
          - n = 6 (31.5%)
          - Survival to discharge 31.5%
          - CPC 1-2
            - n = 3 (15.8%)
          - CPC 3-4
            - n = 3 (15.8%)

- NSH-R group
  - n = 36 (52.9%)
  - ACLS
    - NSH-R group
      - n = 29 (72.1%)
    - ECLS
      - n = 49
        - Conversion failure
          - n = 4
        - Weaning
          - n = 3 (6.1%)
          - Death on ECLS
            - n = 42 (85.7%)
          - Survival to discharge 0%
          - CPC 1-2
            - n = 0 (0%)
          - CPC 3-4
            - n = 0 (0%)
ECPR for Refractory *Out of Hospital* Cardiac Arrest

*Lyon France Group*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n=68)</th>
<th>SH-R group (n=19)</th>
<th>NSH-R group (n=49)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival to discharge</td>
<td>8.8%</td>
<td>31.5% (6)</td>
<td>0%</td>
<td>0.001</td>
</tr>
<tr>
<td>Survival to discharge with CPC 1 or 2</td>
<td>4.4%</td>
<td>15.8% (3)</td>
<td>0%</td>
<td>0.001</td>
</tr>
<tr>
<td>Total Hospital Days</td>
<td>9.5 +/- 32.4</td>
<td>20.9 +/- 44.5</td>
<td>5.1 +/- 25.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Lactate mmol/L</td>
<td>9.8 +/- 6.9</td>
<td>7.4 +/- 6.2</td>
<td>11.4 +/- 7.1</td>
<td>0.08</td>
</tr>
</tbody>
</table>

- Six (8.8%) patients survived to discharge (SH-R=31.5% vs. NSH-R=0%, p=0.00)
  - NSH-R should be considered a contraindication to ECLS
  - In the SH-R group 50% of the survivors were discharged without neurological complications

### CFD Algorithm

**Refractory VT/VF after 3 unsuccessful shocks and patient is still in ventricular fibrillation**

- **ECPR Field Criteria**
  - Inclusion Criteria
  - 18-65yo
  - Witness arrest
  - Bystander CPR
  - Mechanical CPR device (Lucas or Autopulse) must be in place while transporting

- **Exclusion Criteria**
  - DNR

**CFD Ventricular Fibrillation protocol should be followed**

- Radio Call to OSU-ED stating "ECPR Alert"
- OSU-ED notifies Transfer Center, ECLS team activated
- Transport patient directly to cardiac cath lab
Summary

- Overall out-of-hospital cardiac arrest survival rates are dismal (<10%) and neurologic recovery is very poor.
- Approximately 80,000 people die in the US every year from refractory VF or pulseless VT.
- Extracorporeal Life Support (ECLS) as an adjunct to cardiac resuscitation in the field with an automated CPR device has shown encouraging outcomes in patients with cardiac arrest but data is limited.
- On August 15, 2017, Columbus Fire Department and the Ross Heart Hospital/Wexner Medical Center launched a collaborative ECLS program for refractory VF/pulseless VT.
Thank You

wexnermedical.osu.edu

<table>
<thead>
<tr>
<th>Author (Ref)</th>
<th>Patients</th>
<th>Age</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
<th>Survival at discharge (CD 1-2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kagawa et al.</td>
<td>30</td>
<td>56%</td>
<td>Age 18-75 years</td>
<td>Terminal illness</td>
<td>12.8%</td>
</tr>
<tr>
<td>Le Cao et al.</td>
<td>51</td>
<td>42</td>
<td>Low-flow time &lt; 15 min</td>
<td>Acute aortic dissection with pericardial effusion</td>
<td>3.9%</td>
</tr>
<tr>
<td>Avall et al.</td>
<td>18</td>
<td>46%</td>
<td>Low-flow time &lt; 30 min</td>
<td>Terminal malignancy</td>
<td>5.5%</td>
</tr>
<tr>
<td>Hegewisch et al.</td>
<td>26</td>
<td>8%</td>
<td>Non-paediatric patients</td>
<td>Terminal status of malignancy</td>
<td>15.3%</td>
</tr>
<tr>
<td>Martina et al.</td>
<td>55</td>
<td>64%</td>
<td>Age &gt; 10 years</td>
<td>Acute aortic dissection</td>
<td>15.1%</td>
</tr>
<tr>
<td>Leck et al.</td>
<td>28</td>
<td>8%</td>
<td>Terminal malignancy</td>
<td>Terminal malignancy</td>
<td>30.1%</td>
</tr>
<tr>
<td>Wang et al.</td>
<td>31</td>
<td>50%</td>
<td>Age &gt; 16-40 years</td>
<td>Terminal stage malignancy</td>
<td>30.7%</td>
</tr>
<tr>
<td>Johnson et al.</td>
<td>15</td>
<td>NR</td>
<td>Shockable rhythm</td>
<td>Pre-existing multi-organ dysfunction</td>
<td>6.6%</td>
</tr>
<tr>
<td>Sakamoto et al.</td>
<td>260</td>
<td>56%</td>
<td>Non-shockable rhythm</td>
<td>Severe brain injury</td>
<td>12.3%</td>
</tr>
<tr>
<td>Stol et al.</td>
<td>11</td>
<td>NR</td>
<td>Shockable rhythm</td>
<td>Major medical conditions</td>
<td>45.4%</td>
</tr>
</tbody>
</table>

M. Pozzi et al. / International Journal of Cardiology 204 (2016) 70–76