Progressive Metabolic Derangement During Prolonged Resuscitation for Refractory VT/VF Cardiac Arrest and the Relationship to Neurologically Intact Survival with Extracorporeal Cardiopulmonary Resuscitation

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Disclosure Information

• Disclosure of Relevant Financial Relationships
  – I have no financial relationships to disclose.

• Disclosure of Off-Label and/or investigative Uses
  – I will discuss the following off label use and/or investigational use in my presentation:
    • ECMO in ECPR
Survival with Increasing Durations of CPR

Grunau et al, Resuscitation, 2016
Study Objectives:

1. Examine the effects of resuscitation duration on neurologically intact survival in the setting of ECPR

2. Describe the progressive metabolic derangement of prolonged resuscitation
Methods

• Standard CPR
  – Amiodarone arm of the ALPS trial
  – Shock-refractory VT/VF after ≥ 1 shock

• ECPR (MRC-ECMO)
  – Minnesota Resuscitation Consortium protocol
  – Refractory VT/VF cardiac arrest
  – Consecutive patients from December 1, 2015 to October 1, 2018
Amio Arm of ALPS

- 974 patients in the per-protocol population
  - 4 with unknown outcome
- 970 (99.6%) patients with outcome data
  - 211 patients > 75 years old
- 759 (78%) patients Aged 18-75
  - 105 patients missing CPR duration data
- 654 (67%) patients

Survival
- Survival to Discharge: mRS ≤ 3
  - 148/654 (23%)

MRC-ECMO

- 131 Patients Transported by EMS
  - 15/131 (11%) Excluded Not Meeting Resuscitation Criteria
    - 10 – ABG paO2 < 50
    - 5 – Lactic Acid > 18
  - 116/131 (89%) Patients Received Full CCL Treatment:
    - 12/131 (9%) Declared Dead with Failure to Achieve Sustained Organized Cardiac Rhythm after 90 Minutes
- 104/131 (79%) Patients Admitted to CICU

Survival
- Survival to Discharge: CPC 1-2
  - 44/116 (38%)
# Patient and Arrest Characteristics

<table>
<thead>
<tr>
<th>Patient and Arrest Characteristics</th>
<th>ALPS (n = 654)</th>
<th>MRC-ECMO (n = 131)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, SEM</td>
<td>59 ± 0.4</td>
<td>57 ± 1.1</td>
</tr>
<tr>
<td>Sex, No., (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>523 (80%)</td>
<td>103 (79%)</td>
</tr>
<tr>
<td>Female</td>
<td>131 (20%)</td>
<td>28 (21%)</td>
</tr>
<tr>
<td>Ethnicity, No., (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>464 (71%)</td>
<td>105 (80%)</td>
</tr>
<tr>
<td>Black</td>
<td>150 (23%)</td>
<td>16 (12%)</td>
</tr>
<tr>
<td>Other</td>
<td>40 (6%)</td>
<td>10 (8%)</td>
</tr>
<tr>
<td>Witnessed Arrest, No. (%)</td>
<td>491 (75%)</td>
<td>97 (84%)</td>
</tr>
<tr>
<td>Bystander CPR Performed, No. (%)</td>
<td>379 (58%)</td>
<td>85 (74%)</td>
</tr>
<tr>
<td>Arrest in Public Location, No. (%)</td>
<td>216 (33%)</td>
<td>47 (41%)</td>
</tr>
<tr>
<td>Duration of CPR, Time, SEM, min</td>
<td>34 ± 5</td>
<td>61 ± 2.1*</td>
</tr>
</tbody>
</table>

*Statistically significant compared to ALPS patients with p < 0.05
# Characteristics of Survivors of ECPR

<table>
<thead>
<tr>
<th>Arrest Characteristics and Initial Laboratory Results (n = 131)</th>
<th>Survivors with CPC 1 or 2 (n = 44)</th>
<th>Deaths or Survivors with CPC 3 or 4 (n = 72)</th>
<th>Excluded Due to Failed Resuscitation (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, SEM</td>
<td>55 ± 2.0</td>
<td>58 ± 1.3</td>
<td>56 ± 3.7</td>
</tr>
<tr>
<td>Witnessed Arrest, No. (%)</td>
<td>34 (77%)</td>
<td>51 (71%)</td>
<td>12 (80%)</td>
</tr>
<tr>
<td>Bystander CPR Performed, No. (%)</td>
<td>33 (75%)</td>
<td>46 (64%)</td>
<td>6 (40%)*</td>
</tr>
<tr>
<td>Arrest in Public Location, No. (%)</td>
<td>23 (52%)</td>
<td>20 (28%)*</td>
<td>4 (27%)</td>
</tr>
<tr>
<td>ETCO2 on arrival, SEM</td>
<td>37 ± 2.0</td>
<td>36 ± 1.9</td>
<td>35 ± 6.9</td>
</tr>
<tr>
<td>Lactic Acid on Opening ABG, SEM</td>
<td>11 ± 0.7</td>
<td>13 ± 0.4</td>
<td>17 ± 0.9</td>
</tr>
<tr>
<td>pH on Opening ABG, SEM</td>
<td>7.09 ± 0.03</td>
<td>7.06 ± 0.02</td>
<td>6.82 ± 0.04</td>
</tr>
<tr>
<td>paCO2 on opening ABG, SEM</td>
<td>54 ± 2.6</td>
<td>57 ± 2.5</td>
<td>96 ± 8.0*</td>
</tr>
<tr>
<td>paO2 on Opening ABG, SEM</td>
<td>146 ± 19</td>
<td>145 ± 15</td>
<td>49 ± 9.7*</td>
</tr>
<tr>
<td>911 to first responder, Time, SEM, min</td>
<td>6.0 ± 0.7</td>
<td>10 ± 1.4</td>
<td>14 ± 5.1</td>
</tr>
<tr>
<td>Duration of CPR, Time, SEM, min</td>
<td>51 ± 3.1</td>
<td>66 ± 1.7</td>
<td>65 ± 4.0</td>
</tr>
</tbody>
</table>

*Statistically significant compared to the survivors with p < 0.05
Relationship of Survival and Resuscitation Duration for Patients with Refractory VF

Survival with CPC 1 or 2 (%)

Duration of Professional CPR (min)

# at Risk

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>0-9</th>
<th>10-19</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
<th>70-79</th>
<th>80-89</th>
<th>90-99</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRC-ECPR</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>8</td>
<td>18</td>
<td>23</td>
<td>31</td>
<td>23</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>ALPS</td>
<td>70</td>
<td>151</td>
<td>102</td>
<td>95</td>
<td>99</td>
<td>69</td>
<td>29</td>
<td>11</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

MRC-ECPR
ALPS
Metabolic Derangement

**pH**

Time (min)

**Lactic Acid (mmol/L)**

Time (min)

**paCO2**

Time (min)

**paO2**

Time (min)
Porcine Model of Refractory VF
- ACD/ITD CPR with Epi Q5 min
- Invasive hemodynamics and Arterial Lactic Acid levels measured throughout
Conclusions

- Rapid deployment of ECPR is critical for survival.
  - Mortality increases 25% for every 10 min delay
- ECPR provides survival potential for patients with prolonged CPR
- Accruing metabolic derangement is associated with reduced likelihood of successful recovery
Thank you

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- All who have cared for these patients

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- Tom P. Aufderheide, MD