ECMO to Rescue Refractory Cardiac Arrest

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Conflict of interest

• Principal Investigator: EOLIA trial
  • VV ECMO in ARDS
  • NCT01470703
  • Sponsored by MAQUET, Getinge Group

• Received honoraria from
  • MAQUET, XENIOS, GAMBRO, ALUNG
FACTS...
Methods and Results—Retrospective cohort study of a cardiac arrest database at a single site. We included 1014 adult (≥18 years) patients experiencing nontraumatic out-of-hospital cardiac arrest between 2005 and 2011, defined as receiving cardiopulmonary resuscitation or defibrillation from a professional provider. We stratified by functional outcome at hospital discharge (modified Rankin scale). Survival to hospital discharge was 11%, but only 6% had a modified Rankin scale of 0 to 3.
Within 16 min of CPR, 90% of patients with good functional outcome had achieved ROSC…

After 16 min of CPR <1% of good functional recovery
# Duration of Resuscitation Efforts and Functional Outcome After Out-of-Hospital Cardiac Arrest

**When Should We Change to Novel Therapies?**

Joshua C. Reynolds, MD, MS; Adam Frisch, MD, MS; Jon C. Rittenberger, MD, MS; Clifton W. Callaway, MD, PhD

*Circulation. 2013;128:2488-2494*

## Prehospital adjusted model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR duration, min</td>
<td>0.84 (0.75–0.95)</td>
<td>0.004</td>
</tr>
<tr>
<td>Age, y</td>
<td>0.94 (0.91–0.99)</td>
<td>0.007</td>
</tr>
<tr>
<td>Male sex</td>
<td>0.58 (0.19–1.78)</td>
<td>0.34</td>
</tr>
<tr>
<td>Witnessed arrest</td>
<td>4.91 (1.29–18.67)</td>
<td>0.02</td>
</tr>
<tr>
<td>Absence perfectly predicts failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>911 call to EMS arrival, min</td>
<td>1.00 (0.85–1.18)</td>
<td>0.99</td>
</tr>
<tr>
<td>Shockable initial rhythm</td>
<td>10.31 (2.79–38.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chest compression fraction, %</td>
<td>0.03 (0.01–1.13)</td>
<td>0.06</td>
</tr>
<tr>
<td>Advanced airway attempted</td>
<td>2.68 (0.57–12.57)</td>
<td>0.21</td>
</tr>
<tr>
<td>Epinephrine administered</td>
<td>0.46 (0.11–1.91)</td>
<td>0.29</td>
</tr>
</tbody>
</table>
### Duration of Resuscitation Efforts and Functional Outcome After Out-of-Hospital Cardiac Arrest

**When Should We Change to Novel Therapies?**

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*Circulation. 2013;128:2488-2494*

#### Inpatient adjusted model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted OR (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR duration, min</td>
<td>0.84 (0.72–0.98)</td>
<td>0.02</td>
</tr>
<tr>
<td>Age, y</td>
<td>0.93 (0.89–0.97)</td>
<td>0.002</td>
</tr>
<tr>
<td>Male sex</td>
<td>0.71 (0.20–2.54)</td>
<td>0.61</td>
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<tr>
<td>Witnessed arrest</td>
<td>4.38 (1.07–18.03)</td>
<td>0.04</td>
</tr>
<tr>
<td>AED shock delivered</td>
<td>Absence perfectly predicts failure</td>
<td></td>
</tr>
<tr>
<td>911 call to EMS arrival, min</td>
<td>0.97 (0.82–1.16)</td>
<td>0.76</td>
</tr>
<tr>
<td>Shockable initial rhythm</td>
<td>3.35 (0.78–14.34)</td>
<td>0.10</td>
</tr>
<tr>
<td>Chest compression fraction, %</td>
<td>0.06 (0.01–2.84)</td>
<td>0.15</td>
</tr>
<tr>
<td>Advanced airway attempted</td>
<td>1.17 (0.25–5.43)</td>
<td>0.84</td>
</tr>
<tr>
<td>Epinephrine administered</td>
<td>0.37 (0.08–1.71)</td>
<td>0.20</td>
</tr>
<tr>
<td>Therapeutic hypothermia</td>
<td>0.40 (0.12–1.35)</td>
<td>0.14</td>
</tr>
<tr>
<td>Cardiac catheterization</td>
<td>5.85 (1.58–21.64)</td>
<td>0.008</td>
</tr>
</tbody>
</table>
Conclusions

Most CPR efforts fail to produce sustained ROSC after OHCA. Despite some increase in the total number of patients with ROSC when CPR is prolonged, the proportion of OHCA cases that survive to hospital discharge with favorable functional status declines with each minute of CPR. Alternative strategies to traditional resuscitation should be tested immediately after cardiac arrest rather than after the failure of traditional CPR.
BLS vs. ALS...
Outcomes After Out-of-Hospital Cardiac Arrest Treated by Basic vs Advanced Life Support

Prachi Sanghavi, BS; Anupam B. Jena, MD, PhD; Joseph P. Newhouse, PhD; Alan M. Zaslavsky, PhD

ORIGINAL INVESTIGATION | LESS IS MORE

Importance Most out-of-hospital cardiac arrests receiving emergency medical services in the United States are treated by ambulance service providers trained in advanced life support (ALS), but supporting evidence for the use of ALS over basic life support (BLS) is limited.

Objective To compare the effects of BLS and ALS on outcomes after out-of-hospital cardiac arrest.

Design, Setting, and Participants Observational cohort study of a nationally representative sample of traditional Medicare beneficiaries from nonrural counties who experienced out-of-hospital cardiac arrest between January 1, 2009, and October 2, 2011, and for whom ALS or BLS ambulance services were billed to Medicare (31,292 ALS cases and 16,443 BLS cases). Propensity score methods were used to compare the effects of ALS and BLS on patient survival, neurological performance, and medical spending after cardiac arrest.

Main Outcomes and Measures Survival to hospital discharge, to 30 days, and to 90 days; neurological performance; and incremental medical spending per additional survivor to 1 year.
Outcomes After Out-of-Hospital Cardiac Arrest Treated by Basic vs Advanced Life Support

Prachi Sanghavi, BS; Anupam B. Jena, MD, PhD; Joseph P. Newhouse, PhD; Alan M. Zaslavsky, PhD

JAMA Internal Medicine  Published online November 24, 2014

Original Investigation | LESS IS MORE

38004 Nontraumatic cardiac arrests

428 Individuals with multiple rides, death date >2 d before ride, inconsistent coding, or missing data

3448 Rural counties

32935 Final sample

31292 ALS

1020 States with distinctive ambulance billing practices

173 States with no nonrural BLS claims

1643 BLS
Outcomes After Out-of-Hospital Cardiac Arrest Treated by Basic vs Advanced Life Support

Prachi Sanghavi, BS; Anupam B. Jena, MD, PhD; Joseph P. Newhouse, PhD; Alan M. Zaslavsky, PhD
RESULTS  Survival to hospital discharge was greater among patients receiving BLS (13.1% vs 9.2% for ALS; 4.0 [95% CI, 2.3-5.7] percentage point difference), as was survival to 90 days (8.0% vs 5.4% for ALS; 2.6 [95% CI, 1.2-4.0] percentage point difference). Basic life support was associated with better neurological functioning among hospitalized patients (21.8% vs 44.8% with poor neurological functioning for ALS; 23.0 [95% CI, 18.6-27.4] percentage point difference). Incremental medical spending per additional survivor to 1 year for BLS relative to ALS was $154 333.

CONCLUSIONS AND RELEVANCE  Patients with out-of-hospital cardiac arrest who received BLS had higher survival at hospital discharge and at 90 days compared with those who received ALS and were less likely to experience poor neurological functioning.
Results of ECPR...

For out-of-hospital cardiac arrest
Utstein style study of cardiopulmonary bypass after cardiac arrest
Katsutoshi Tanno MD, Yasushi Itoh MD, PhD, Yoshihiro Takeyama MD, Satoshi Nara MD, Kazuhisa Mori MD, PhD, Yasufumi Asai MD, PhD

Cardiac etiology
n = 919

CPE
n = 398

Not witnessed
n = 141/66 (21%)

Witnessed
n = 521/66 (79%)

Initial rhythm VF/VT
n = 30

Admitted
n = 30

Discharged
n = 10

CPC1
n = 4

Nonshockable
n = 22

Admitted
n = 22

Discharged
n = 4

CPC1
n = 3

Initial rhythm VF/VT
n = 40

Admitted
n = 29

Discharged
n = 16

CPC1
n = 12

Nonshockable
n = 97

Admitted
n = 33

Discharged
n = 9

CPC1
n = 4

Non CPE
n = 332

Not witnessed
n = 194/332 (58%)

Witnessed
n = 138/332 (42%)

CPC1
n = 3

Sapporo, Japan
Utstein style study of cardiopulmonary bypass after cardiac arrest
Katsutoshi Tanno MD, Yasushi Itoh MD, PhD, Yoshihiro Takeyama MD, Satoshi Nara MD, Kazuhisa Mori MD, PhD, Yasufumi Asai MD, PhD

- Out-of-Hospital CA, Emergent transfer to the ED
- ECMO after only 20 min of unsuccessful CPR
- 66 ECMO VS 332 standard
  - Better survival
  - Cerebral performance unchanged

Sapporo, Japan

<table>
<thead>
<tr>
<th>Witnessed</th>
<th>Not witnessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 62 / 66 (79%)</td>
<td>n = 194 / 332 (58%)</td>
</tr>
<tr>
<td>CPC1 n = 2</td>
<td>Witnessed n = 138 / 332 (42%)</td>
</tr>
</tbody>
</table>

Survival and functional outcomes

<table>
<thead>
<tr>
<th>Survival after 3 months</th>
<th>CPB, n (%)</th>
<th>Standard, n (%)</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 (22.7)</td>
<td>33 (9.9)</td>
<td>2.66 (1.35-5.25)</td>
<td>&lt;.00</td>
<td></td>
</tr>
</tbody>
</table>

| Survivors' cerebral performance category, level 1a | 7 (10.6) | 19 (5.7) | 1.95 (0.79-4.86) | .14 |
Assessment of outcomes and differences between in- and out-of-hospital cardiac arrest patients treated with cardiopulmonary resuscitation using extracorporeal life support

Hiroshima, Japan

Eisuke Kagawa *, Ichiro Inoue, Takuji Kawagoe, Masaharu Ishihara, Yuji Shimatani,

Resuscitation 81 (2010) 968–973
Assessment of outcomes and differences between in- and out-of-hospital cardiac arrest patients treated with cardiopulmonary resuscitation using extracorporeal life support

Eisuke Kagawa *, Ichiro Inoue, Takuji Kawagoe, Masaharu Ishihara, Yuji Shimatani,

*Correspondence: alain.combes@aphp.fr

Aim: Cardiopulmonary resuscitation (CPR) using extracorporeal life support (ECLS) for in-hospital cardiac arrest (IHCA) patients has been assigned a low-grade recommendation in current resuscitation guidelines. This study compared the outcomes of IHCA and out-of-hospital cardiac arrest (OHCA) patients treated with ECLS.

Methods: A total of 77 patients were treated with ECLS. Baselines characteristics and outcomes were compared for 38 IHCA and 39 OCHA patients.

Results: The time interval between collapse and starting ECLS was significantly shorter after IHCA than after OHCA (25 [21–43] min versus 59 [45–65] min, p < 0.001). The weaning rate from ECLS (61% versus 36%, p = 0.03) and 30-day survival (34% versus 13%, p = 0.03) were higher for IHCA compared with OHCA patients. IHCA patients had a higher rate of favourable neurological outcome compared to OHCA patients, but the difference was not statistically significant (26% versus 10%, p = 0.07). Kaplan–Meier analysis showed improved 30-day and 1-year survival for IHCA patients treated with ECLS compared to OHCA patients who had ECLS. However, multivariate stepwise Cox regression model analysis indicated no difference in 30-day (odds ratio 0.94 [95% confidence interval 0.68–1.27], p = 0.67) and 1-year survival (0.99 (0.73–1.33), p = 0.95).

Conclusion: CPR with ECLS led to more favourable patient outcomes after IHCA compared with OHCA in our patient group. The difference in outcomes for ECLS after IHCA and OHCA disappeared after adjusting for patient factors and the time delay in starting ECLS.
Assessment of outcomes and differences between in- and out-of-hospital cardiac arrest patients treated with cardiopulmonary resuscitation using extracorporeal life support

Eisuke Kagawa *, Ichiro Inoue, Takuji Kawagoe, Masaharu Ishihara, Yuji Shimatani,

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio</th>
<th>95% confidence</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>30-day survival</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-hospital cardiac arrest</td>
<td>0.94</td>
<td>0.68–1.27</td>
<td>0.67</td>
</tr>
<tr>
<td>Time interval from collapse to start of extracorporeal life support (every 1 min)</td>
<td>0.98</td>
<td>0.96–0.99</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Initial rhythm of ventricular fibrillation</td>
<td>1.32</td>
<td>1.00–1.78</td>
<td>0.048</td>
</tr>
<tr>
<td><strong>1-year survival</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-hospital cardiac arrest</td>
<td>0.99</td>
<td>0.73–1.33</td>
<td>0.95</td>
</tr>
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<td>Time interval from collapse to start of extracorporeal life support (every 1 min)</td>
<td>0.98</td>
<td>0.96–0.99</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Initial rhythm of ventricular fibrillation</td>
<td>1.28</td>
<td>0.98–1.70</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Should We Emergently Revascularize Occluded Coronaries for Cardiac Arrest?

Rapid-Response Extracorporeal Membrane Oxygenation and Intra-Arrest Percutaneous Coronary Intervention

Eisuke Kagawa, MD; Keigo Dote, MD, PhD; Masaya Kato, MD, PhD; Shota Sasaki, MD, PhD;

Hiroshima, Japan

OHCA ECPR patients, N = 63

IHCA ECPR patients, N = 103

Emergency coronary angiography, N = 118

Non-emergency coronary angiography, N = 48

Non-ACS, N = 37

Non-ACS, N = 43

ACS, N = 81

ACS, N = 5

Intra-arrest PCI

Non-intra-arrest PCI

N = 61

N = 61

N = 13

N = 7

N = 2

N = 3

ROSBB

Non-ROSBB

N = 0
Should We Emergently Revascularize Occluded Coronaries for Cardiac Arrest?
Rapid-Response Extracorporeal Membrane Oxygenation and Intra-Arrest Percutaneous Coronary Intervention

Eisuke Kagawa, MD; Keigo Dote, MD, PhD; Masaya Kato, MD, PhD; Shota Sasaki, MD, PhD;

Circulation  September 25, 2012

Background—Extracorporeal membrane oxygenation (ECMO) and percutaneous coronary intervention (PCI) may be useful in cardiopulmonary resuscitation. However, little is known about the combination of ECMO and intra-arrest PCI. This study investigated the efficacy of rapid-response ECMO and intra-arrest PCI in patients with cardiac arrest complicated by acute coronary syndrome who were unresponsive to conventional cardiopulmonary resuscitation.

Methods and Results—This multicenter cohort study was conducted with the use of the database of ECMO in Hiroshima City, Japan. Between January 2004 and May 2011, rapid-response ECMO was performed in 86 patients with acute coronary syndrome who were unresponsive to conventional CPR. The median age of the study patients was 63 years, and 81% were male. Emergency coronary angiography was performed in 81 patients (94%), and intra-arrest PCI was performed in 61 patients (71%). The rates of return of spontaneous heartbeat, 30-day survival, and favorable neurological outcomes were 88%, 29%, and 24%, respectively. All of the patients who received intra-arrest PCI achieved return of spontaneous heartbeat. In patients who survived up to day 30, the rate of out-of-hospital cardiac arrest was lower (58% versus 28%; \( P=0.01 \)), the intra-arrest PCI was higher (88% versus 70%; \( P=0.04 \)), and the time interval from collapse to the initiation of ECMO was shorter (40 [25–51] versus 54 minutes [34–74 minutes]; \( P=0.002 \)).

Conclusions—Rapid-response ECMO plus intra-arrest PCI is feasible and associated with improved outcomes in patients who are unresponsive to conventional cardiopulmonary resuscitation. On the basis of these findings, randomized studies of intra-arrest PCI are needed. (Circulation. 2012;126:1605-1613.)
### Should We Emergently Revascularize Occluded Coronaries for Cardiac Arrest?

Rapid-Response Extracorporeal Membrane Oxygenation and Intra-Arrest Percutaneous Coronary Intervention

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**Hiroshima, Japan**

<table>
<thead>
<tr>
<th></th>
<th>In-hospital cardiac arrest</th>
<th>Out-of-hospital cardiac arrest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>N = 44</strong></td>
<td><strong>N = 42</strong></td>
</tr>
<tr>
<td>Collapse to CPR (min)</td>
<td>0 (0-1)</td>
<td>2 (1-5)</td>
</tr>
<tr>
<td>Collapse to ECMO (min)</td>
<td>33 (25-50)</td>
<td>65 (50-78)</td>
</tr>
<tr>
<td>ER to of ECMO (min)</td>
<td></td>
<td>38 (26-59)</td>
</tr>
<tr>
<td>Weaning from ECMO</td>
<td>28 (64%)</td>
<td>15 (36%)</td>
</tr>
<tr>
<td>30-day survival</td>
<td>18 (41%)</td>
<td>7 (17%)</td>
</tr>
<tr>
<td>Favourable neurological outcome</td>
<td>15 (34%)</td>
<td>6 (14%)</td>
</tr>
</tbody>
</table>
Extracorporeal Cardiopulmonary Resuscitation for Patients With Out-of-Hospital Cardiac Arrest of Cardiac Origin: A Propensity-Matched Study and Predictor Analysis

Kunihiko Mackawa, MD; Katsutoshi Tanno, MD, PhD; Mamoru Hase, MD, PhD; Kazuhisa Mori, MD, PhD; Yasufumi Asai, MD, PhD

Objectives: Encouraging results of extracorporeal cardiopulmonary resuscitation for patients with refractory cardiac arrest have been shown. However, the independent impact on the neurologic outcome remains unknown in the out-of-hospital population. Our objective was to compare the neurologic outcome following extracorporeal cardiopulmonary resuscitation and conventional cardiopulmonary resuscitation and determine potential predictors that can identify candidates for extracorporeal cardiopulmonary resuscitation among patients with out-of-hospital cardiac arrest of cardiac origin.

Design: Post hoc analysis of data from a prospective observational cohort.


Patients: A total of 162 adult patients with witnessed cardiac arrest of cardiac origin who had undergone cardiopulmonary resuscitation for >20 min (53 in the extracorporeal cardiopulmonary resuscitation group and 109 in the conventional cardiopulmonary resuscitation group).

Interventions: None.

Measurements and Main Results: The primary endpoint was neurologically intact survival at three months after cardiac arrest. We used propensity score matching to reduce selection bias and balance the baseline characteristics and clinical variables that could potentially affect outcome. This matching process selected 24 patients from each group. The impact of extracorporeal cardiopulmonary resuscitation was estimated in matched patients. Intact survival rate was higher in the matched extracorporeal cardiopulmonary resuscitation group than in the matched conventional cardiopulmonary resuscitation group (29.2% [7/24] vs. 8.3% [2/24], log-rank $p = 0.018$). According to the predictor analysis, only pupil diameter on hospital arrival was associated with neurologic outcome (adjusted hazard ratio, 1.39 per 1-mm increase; 95% confidence interval, 1.09–1.78; $p = 0.008$).

Conclusions: Extracorporeal cardiopulmonary resuscitation can improve neurologic outcome after out-of-hospital cardiac arrest of cardiac origin; furthermore, pupil diameter on hospital arrival may be a key predictor to identify extracorporeal cardiopulmonary resuscitation candidates. (Crit Care Med 2013; 41:0–0)

Keywords: cardiopulmonary arrest; cardiopulmonary bypass; cardiopulmonary resuscitation; extracorporeal circulation; extracorporeal membrane oxygenation; out-of-hospital cardiac arrest
## Extracorporeal Cardiopulmonary Resuscitation for Patients With Out-of-Hospital Cardiac Arrest of Cardiac Origin: A Propensity-Matched Study and Predictor Analysis

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**Sapporo, Japan**

<table>
<thead>
<tr>
<th>Time courses</th>
<th>Overall ($n = 162$)</th>
<th>ECPR ($n = 53$)</th>
<th>CCPR ($n = 109$)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrest to EMS, min</td>
<td>6 (3–10)</td>
<td>6 (2–9)</td>
<td>7 (3–10)</td>
<td>0.44</td>
</tr>
<tr>
<td>EMS to hospital, min</td>
<td>26 (19–33)</td>
<td>25 (20–32)</td>
<td>26 (19–34)</td>
<td>0.73</td>
</tr>
<tr>
<td>Arrest to hospital, min</td>
<td>33 (25–42)</td>
<td>33 (25–41)</td>
<td>33 (26–43)</td>
<td>0.53</td>
</tr>
<tr>
<td>Arrest to basic life support (cardiac arrest time), min</td>
<td>4 (0–9)</td>
<td>2 (0–8)</td>
<td>5 (0–9)</td>
<td>0.13</td>
</tr>
<tr>
<td>Arrest to first defibrillation, min</td>
<td>10 (6–16)</td>
<td>10 (7–17)</td>
<td>8 (6–16)</td>
<td>0.40</td>
</tr>
<tr>
<td>Arrest to advanced life support, min</td>
<td>23 (17–31)</td>
<td>21 (15–25)</td>
<td>26 (18–32)</td>
<td>0.011</td>
</tr>
<tr>
<td>Basic life support to CPR termination (CPR duration), min</td>
<td>52 (43–65)</td>
<td>49 (41–59)</td>
<td>56 (47–66)</td>
<td>0.042</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Overall ($n = 162$)</th>
<th>ECPR ($n = 53$)</th>
<th>CCPR ($n = 109$)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality in the emergency room, $n$ (%)</td>
<td>84 (51.9)</td>
<td>2 (3.8)</td>
<td>82 (75.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Survival to discharge, $n$ (%)</td>
<td>24 (14.8)</td>
<td>17 (32.1)</td>
<td>7 (6.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Survival at 3 mos, $n$ (%)</td>
<td>20 (12.3)</td>
<td>15 (28.3)</td>
<td>5 (4.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cerebral Performance Category status 1 or 2 at 3 mos, $n$ (%)</td>
<td>11 (6.8)</td>
<td>8 (15.1)</td>
<td>3 (2.8)</td>
<td>0.006</td>
</tr>
</tbody>
</table>
## Extracorporeal Cardiopulmonary Resuscitation for Patients With Out-of-Hospital Cardiac Arrest of Cardiac Origin: A Propensity-Matched Study and Predictor Analysis

Kunihiro Mackawa, MD; Katsutoshi Tanno, MD, PhD; Mamoru Hase, MD, PhD; Kazuhisa Mori, MD, PhD; Yasufumi Asai, MD, PhD

Sapporo, Japan

### Table: Time courses and Outcome

<table>
<thead>
<tr>
<th>Time Courses</th>
<th>ECPR matched ($n = 24$)</th>
<th>CCPR matched ($n = 24$)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrest to EMS, min</td>
<td>5 (2–10)</td>
<td>4 (0–8)</td>
<td>0.33</td>
</tr>
<tr>
<td>EMS to hospital min</td>
<td>25 (21–30)</td>
<td>24 (17–31)</td>
<td>0.56</td>
</tr>
<tr>
<td>Arrest to hospital min</td>
<td>31 (25–37)</td>
<td>28 (23–34)</td>
<td>0.31</td>
</tr>
<tr>
<td>Arrest to basic life support (cardiac arrest time, min)</td>
<td>2 (0–8)</td>
<td>0 (0–5)</td>
<td>0.30</td>
</tr>
<tr>
<td>Arrest to first defibrillation, min</td>
<td>11 (7–17)</td>
<td>8 (5–9)</td>
<td>0.035</td>
</tr>
<tr>
<td>Arrest to advanced life support, min</td>
<td>23 (14–27)</td>
<td>20 (16–27)</td>
<td>0.99</td>
</tr>
<tr>
<td>Basic life support to CPR termination (CPR duration, min)</td>
<td>49 (43–66)</td>
<td>52 (43–65)</td>
<td>0.98</td>
</tr>
</tbody>
</table>

### Outcome

<table>
<thead>
<tr>
<th>Outcome</th>
<th>ECPR matched ($n = 24$)</th>
<th>CCPR matched ($n = 24$)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality in the emergency room, $n$ (%)</td>
<td>23 (95.8)</td>
<td>9 (37.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Survival to discharge, $n$ (%)</td>
<td>9 (37.5)</td>
<td>3 (12.5)</td>
<td>0.093</td>
</tr>
<tr>
<td>Survival at 3 mos, $n$ (%)</td>
<td>9 (37.5)</td>
<td>2 (8.3)</td>
<td>0.036</td>
</tr>
<tr>
<td>Cerebral Performance Category status 1 or 2 at 3 mos, $n$ (%)</td>
<td>7 (29.2)</td>
<td>2 (8.3)</td>
<td>0.14</td>
</tr>
</tbody>
</table>
Extracorporeal Cardiopulmonary Resuscitation for Patients With Out-of-Hospital Cardiac Arrest of Cardiac Origin: A Propensity-Matched Study and Predictor Analysis

Kunihiko Mackawa, MD; Katsutoshi Tanno, MD, PhD; Mamoru Hase, MD, PhD; Kazuhisa Mori, MD, PhD; Yasufumi Asai, MD, PhD

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Sapporo, Japan

Neurologically intact survival

Log-rank p = 0.018
Objective: Encouraging results of extracorporeal cardiopulmonary resuscitation for patients with refractory cardiac arrest have been shown. However, the independent impact on the neurologic outcome remains unknown in the out-of-hospital population. Our objective was to compare the neurologic outcome following extracorporeal cardiopulmonary resuscitation and conventional cardiopulmonary resuscitation and determine potential predictors that can identify candidates for extracorporeal cardiopulmonary resuscitation among patients with out-of-hospital cardiac arrest of cardiac origin.

Design: Post hoc analysis of data from a prospective observational cohort.


Patients: A total of 162 adult patients with witnessed cardiac arrest of cardiac origin who had undergone cardiopulmonary resuscitation for >20 min (53 in the extracorporeal cardiopulmonary resuscitation group and 109 in the conventional cardiopulmonary resuscitation group).

Interventions: None.

Measurements and Main Results: The primary endpoint was neurologically intact survival at three months after cardiac arrest. We used propensity score matching to reduce selection bias and balance the baseline characteristics and clinical variables that could potentially affect outcome. This matching process selected 24 patients from each group. The impact of extracorporeal cardiopulmonary resuscitation was estimated in matched patients. Intact survival rate was higher in the matched extracorporeal cardiopulmonary resuscitation group than in the matched conventional cardiopulmonary resuscitation group (29.2% [7/24] vs. 8.3% [2/24], log-rank \( p = 0.018 \)). According to the predictor analysis, only pupil diameter on hospital arrival was associated with neurologic outcome (adjusted hazard ratio, 1.39 per 1-mm increase; 95% confidence interval, 1.09–1.78; \( p = 0.008 \)).

Conclusions: Extracorporeal cardiopulmonary resuscitation can improve neurologic outcome after out-of-hospital cardiac arrest of cardiac origin; furthermore, pupil diameter on hospital arrival may be a key predictor to identify extracorporeal cardiopulmonary resuscitation candidates. (Crit Care Med 2013; 41:0–0)

Key Words: cardiopulmonary arrest; cardiopulmonary bypass; cardiopulmonary resuscitation; extracorporeal circulation; extracorporeal membrane oxygenation; out-of-hospital cardiac arrest
Guidelines for indications for the use of extracorporeal life support in refractory cardiac arrest

Uncertainty

Possible indication
- Refractory CA

Cardiac drug Intoxication
- Hypothermia (≤ 32°C)
- Signs of life per-CPR

Assessment of no-flow duration
- 0-5 min
- > 5 min or no witness
  - Rhythm assessment
    - VT, TP, VF
    - Asystole Agonal rhythm

Assessment of low-flow duration
- ETCO₂ ≥ 10 mmHg AND Low-flow ≤ 100 min
- ETCO₂ < 10 mmHg OR Low-flow > 100 min

No indication
- Comorbidities
Extracorporeal life support following out-of-hospital refractory cardiac arrest

Morgan Le Guen¹, Armelle Nicolas-Robin¹, Serge Carreira¹, Mathieu Raux¹, Pascal Leprince², Bruno Riou³*, Olivier Langeron¹

Abstract

Introduction: Extracorporeal life support (ECLS) has recently shown encouraging results in the resuscitation of in-hospital (IH) refractory cardiac arrest. We assessed the use of ECLS following out-of-hospital (OH) refractory cardiac arrest.

Methods: We evaluated 51 consecutive patients who experienced witnessed OH refractory cardiac arrest and received automated chest compression and ECLS upon arrival in the hospital. Patients with preexisting severe hypothermia who experienced IH cardiac arrest were excluded. A femorofemoral ECLS was set up on admission to the hospital by a mobile cardiothoracic surgical team.
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Critical Care 2011, 15:R29
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Results: Fifty-one patients were included (mean age, 42 ± 15 years). The median delays from cardiac arrest to cardiopulmonary resuscitation and ECLS were, respectively, 3 minutes (25th to 75th interquartile range, 1 to 7) and 120 minutes (25th to 75th interquartile range, 102-149). Initial rhythm was ventricular fibrillation in 32 patients (63%), asystole in 15 patients (29%) patients and pulseless rhythm in 4 patients (8%). ECLS failed in 9 patients (18%). Only two patients (4%) (95% confidence interval, 1% to 13%) were alive at day 28 with a favourable neurological outcome. There was a significant correlation (r = 0.36, P = 0.01) between blood lactate and delay between cardiac arrest and onset of ECLS, but not with arterial pH or blood potassium level. Deaths were the consequence of multiorgan failure (n = 43; 47%), brain death (n = 10; 20%) and refractory hemorrhagic shock (n = 7; 14%), and most patients (n = 46; 90%) died within 48 hours.

Conclusions: This poor outcome suggests that the use of ECLS should be more restricted following OH refractory cardiac arrest.
This poor outcome suggests that the use of ECLS should be more restricted following OH refractory cardiac arrest. Collapse to functional ECMO support should be <60 minutes. Scoop and run strategy+++
Improvement strategies
Patient triage

Who should benefit ECPR?
Improvement strategies

Reduce low-flow

Improvement strategies

Reduce low-flow

BCLS

7 ± 7 min

Collapse

ACLS

16 ± 9 min

61 ± 19 min
Improvement strategies

Reduce low-flow

Reduce on-scene time
Improvement strategies

Change our mind

Lamhaut, *Resuscitation* 2013

Now

NF\(\text{BLS/ALS}\) Transfer ECLS

NF\(\text{BLS/ALS}\) ECLS

NF\(\text{BLS}\) ECLS
Guidelines...
2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Terminating Resuscitative Efforts in an ALS Out-of-Hospital System
A different rule may be useful when the additional diagnostic and therapeutic capabilities of an advanced life support EMS response are available to the victim. The National Association of EMS Physicians (NAEMSP) suggested that resuscitative efforts could be terminated in patients who do not respond to at least 20 minutes of ALS care. An ALS termination of resuscitation rule was derived from a diverse population of rural and urban EMS settings. This rule recommends considering terminating resuscitation when ALL of the following criteria apply before moving to the ambulance for transport (see Figure 2): (1) arrest was not witnessed; (2) no bystander CPR was provided; (3) no ROSC after full ALS care in the field; and (4) no AED shocks were delivered.
ECPR, also known as venoarterial extracorporeal membrane oxygenation, may be considered as an alternative to conventional CPR for select patients with refractory cardiac arrest when the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support.
2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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.

Circulation November 3, 2015
Controlled clinical trials are needed to assess the clinical benefits of ECPR versus traditional CPR for patients with refractory cardiac arrest and to determine which populations would most benefit.
The Future...

But is-it really reasonable?
UMAC, Paris Marathon, 2010...
UMAC, Paris Marathon, 2010...

45 yrs old male, Cardiac arrest at the 25th km, Bystander CPR
ECMO primed in the SAMU ambulance,
ECMO initiated within 45 min after CA, Anterior MI, PCI, ECMO weaned after 10 days
However, anoxic encephalopathy due to poor initial resuscitation
Conclusion

• **YES**, refractory CA patients can benefit from ECPR
  - High commitment of the ECMO rescue team
  - **ONLY if ECMO circuit runs within 60 min of Collapse**
  - **First** organize efficient *in-hospital* rescue teams

• ECPR for out-of-hospital cardiac arrest?
  - Need for a *change in paradigm*
  - ECMO decision after only **10 min of refractory CPR**
  - *“Scoop and Run”* to the nearest ECMO center, with CPR machine...
  - Deny indication if Collapse-ECMO will be >60 min