ECPR: An emerging strategy for cardiac arrest

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Conventional CPR is ineffective
Conventional CPR is ineffective

25% of normal cardiac output
<table>
<thead>
<tr>
<th>EMS assessed</th>
<th>Survival to Discharge (95% CI), %</th>
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<tbody>
<tr>
<td>Any age</td>
<td>5.6 (5.3–5.8)</td>
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<tr>
<td>Adults</td>
<td>6.4 (6.1–6.7)</td>
</tr>
<tr>
<td>Children</td>
<td>6.2 (4.2–8.1)</td>
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<tr>
<td>Unknown age</td>
<td>0.1 (0–0.1)</td>
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<tr>
<td>EMS treated</td>
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<tr>
<td>Any age</td>
<td>10.6 (10.1–11.2)</td>
</tr>
<tr>
<td>Adults</td>
<td>10.8 (10.3–11.3)</td>
</tr>
<tr>
<td>Children</td>
<td>7.3 (5.0–9.6)</td>
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<tr>
<td>Unknown age</td>
<td>3.3 (0–7.9)</td>
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<tr>
<td>VF</td>
<td></td>
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<tr>
<td>Any age</td>
<td>29.0 (27.3–30.7)</td>
</tr>
<tr>
<td>Adults</td>
<td>29.0 (27.3–30.7)</td>
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<tr>
<td>Children</td>
<td>36.0 (17.2–54.8)</td>
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<tr>
<td>Bystander-witnessed VF</td>
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<tr>
<td>Any age</td>
<td>31.4 (29.2–33.7)</td>
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<tr>
<td>Adults</td>
<td>31.2 (28.9–33.5)</td>
</tr>
<tr>
<td>Children</td>
<td>53.3 (28.1–78.6)</td>
</tr>
</tbody>
</table>
INSANITY: doing the same thing over and over again and expecting different results.

~ Albert Einstein
Cardiac Arrest

Report of Application of External Cardiac Massage on 118 Patients

James R. Jude, M.D., William B. Kouwenhoven, Dr. Ing., and G. Guy Knickerbocker, M.S.E., Baltimore

Fig. 2.—Method of applying external cardiac massage. Costal margins are outlined. Note that heel of transversely placed lower hand alone touches lower sternum. Pressure must force sternum inward 1½ to 2 in.

Fig. 3.—Examples of arterial blood pressure developed with external cardiac massage. Age and size of chest did not greatly affect ability to obtain good blood pressure.

24% survival to hospital discharge
Other inventions from the 1950s
Other inventions from the 1950s
Still at it...
ECPR

• Initiation of extracorporeal membrane oxygenation (ECMO) for the treatment of cardiac arrest
Why ECPR?

• Failed conventional ACLS
• Pre-morbid status good
• Reversible cause
  – A bridge to definitive treatment
ECPR: The Setup

VA-ECMO
ECPR: The setup
ECPR: The Setup
ECPR: The Setup
Current Evidence and Guidelines
Is an emergency department-based ECPR program feasible?
Opportunities and Barriers for ECPR in Canada

Potential Candidates for a Structured Canadian ECPR Program for Out-of-Hospital Cardiac Arrest

Brian Grunau, MD*†§; Frank Xavier Scheuermeyer, MD, MHSct; Dion Stub, MD, PhD∗¶; Robert H. Boone, MD, MSc***; Joseph Finkler, MD, MSc†; Sarah Pennington, RN††; Sarah Ann Carriere, RN∗‡; Anson Cheung, MD∗§; Ruth MacRedmond, MD∗‡‡; Jamil Bashir, MD∗§§; Jim Christenson, MD∗†***

• Estimated 10% of all EMS-treated cases of OHCA fulfilled their ECPR criteria
• approximately 1/3 of these (12 pts/year) refractory to conventional resuscitation.

PILOT STUDY UNDERWAY
Emergency physician-initiated extracorporeal cardiopulmonary resuscitation

Joseph M. Bellezzo\textsuperscript{a,\star}, Zack Shinar\textsuperscript{a,b}, Daniel P. Davis\textsuperscript{c}, Brian E. Jaski\textsuperscript{b}, Suzanne Chillcott\textsuperscript{b}, Marcia Stahovich\textsuperscript{b}, Christopher Walker\textsuperscript{b}, Sam Baradarian\textsuperscript{b}, Walter Dembitsky\textsuperscript{b}

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\textsuperscript{c} University of California, San Diego, Emergency Medicine, 200 West Arbor Drive #8676, San Diego, CA 92103-8676, United States
Take home points

- An ER-based ECPR program is feasible
- ER docs can be trained to put patients on pump but it isn’t easy
- 27% eligible for ECPR survived with good neuro function
- 63% on pump survived with good neuro function
The CHEER Trial

Clinical Paper

Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial)

Dion Stub c,f,g, Stephen Bernard a,b,d,* , Vincent Pellegrino a, Karen Smith b,d,e, Tony Walker d, Jayne Sheldrake a, Lisen Hockings a, James Shaw a,b,c, Stephen J. Duffy a,b,c, Aidan Burrell a,b, Peter Cameron a,b, De Villiers Smit a, David M. Kaye a,b,c

• Case series
• Refractory OHCA and IHCA (>30 mins)
• Age 18-65
• Cardiac etiology
• VF
• <10 minutes to CPR
• IHCA – MD discretion
The CHEER Trial

Out-of-hospital cardiac arrest (n = 11)
- Initial Rhythm VF (n=11)
  - ROSC in E & TC prior to ECMO support (n=2)
    - ECPR (n=9)
      - ROSC (n=3)
        - Die prior to ECMO wean (n=4)
        - Die post ECMO wean (n=1)
      - No ROSC (n=1)
        - ECMO wean (n=4)

In-hospital cardiac arrest (n = 15)
- Initial Rhythm VF (n=6) VT (n=2) Asystole (n=3) PEA (n=4)
  - Initial Rhythm VF (n=15)
    - ROSC (n=15)
      - Die prior to ECMO wean (n=6)
      - ECMO Wean (n=9)

45% Survival
CPC 1-2

60% Survival
CPC 1-2

Survive (n = 5)
Survive (n = 9)

Fig. 1. Outcome of 26 non-post cardiotomy patients with refractory cardiac arrest. CHEER – Mechanical CPR, Hypothermia, ECMO and Early Reperfusion, E&T – Emergency and Trauma Center, VF – ventricular fibrillation, ROSC – return of spontaneous circulation, ECMO – extracorporeal membrane oxygenation, ECPR – extracorporeal membrane oxygenation facilitated cardiopulmonary resuscitation.
20 studies (n=833)

Heterogeneity

- Observational studies and case reports
- age 16-75yrs
- failed CPR prior to ECPR 10-30 min
- Time to cannulation
- Post arrest care
• Survival
  – Discharge: 22%, 13% with CPC 1-2 (n=833)
  – 3 months: 21%, 15% with CPC 1-2 (n=115)
  – 6 months: 16%, 9% with CPC 1-2 (n=377)
Does ECPR improve outcomes compared to conventional CPR?

The jury is out....
Comparing extracorporeal cardiopulmonary resuscitation with conventional cardiopulmonary resuscitation: A meta-analysis

Su Jin Kim\(^a\), Hyun Jung Kim\(^b\), Hee Young Lee\(^c\), Hyeong Sik Ahn\(^b\), Sung Woo Lee\(^a,\)*

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>ECPR Events</th>
<th>CCPR Events</th>
<th>Risk Ratio</th>
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<tr>
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<td>Total</td>
<td>Total</td>
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<td>1.2.1 at discharge</td>
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<td>8</td>
<td>1.88 [0.88, 3.99]</td>
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<td>46</td>
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<td>8</td>
<td>11</td>
<td>0.82 [0.37, 1.81]</td>
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<td>1.21 at discharge</td>
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<td>Heterogeneity: Tau(^2) = 0.21; Chi(^2) = 6.28, df = 3 (P = 0.10); I(^2) = 52%</td>
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<td>Test for overall effect: Z = 1.93 (P = 0.05)</td>
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1.2.2 at 3 - 6 months

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<td>15</td>
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<td>Test for overall effect: Z = 3.73 (P = 0.0002)</td>
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1.2.3 at 1 year

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<td>13</td>
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<td>1.2.3 at 1 year</td>
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<td>Heterogeneity: Tau(^2) = 0.00; Chi(^2) = 0.64, df = 1 (P = 0.43); I(^2) = 0%</td>
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<td>Test for overall effect: Z = 1.95 (P = 0.05)</td>
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Test for subarous differences: Chi\(^2\) = 0.80, df = 2 (P = 0.67). I\(^2\) = 0%

Resuscitation 2016 103 106-16
Challenges with ECPR observational studies

• Patient selection
  – Inclusion/exclusion criteria
  – Selection bias

• Variable ECPR implementation
  – Primary management strategy for cardiac arrest versus after failed conventional CPR
  – Time to cannulation
  – Variable co-intervention
Treatment Recommendation
We suggest ECPR is a reasonable rescue therapy for selected patients with cardiac arrest when initial conventional CPR is failing in settings where this can be implemented (weak recommendation, very-low-quality evidence).

NO RCTs
ECPR RCTs are happening!

• Emergency Cardiopulmonary Bypass for Cardiac Arrest n=40; **Vienna**
• Hyperinvasive Approach in Cardiac Arrest, n=170; **Prague**
• A Comparative Study Between a Pre-hospital and an In-hospital Circulatory Support Strategy (ECMO) in Refractory Cardiac Arrest NCT02527031; n=210; **France**
Can ECPR provide new opportunities for deceased donation?
**Treatment Recommendation:**
We recommend that all patients who have restoration of circulation after CPR and who subsequently progress to death be evaluated for organ donation (strong recommendation, low-quality evidence).
• 88/160 potential and 17/160 actual deceased organ donors (15 NDD, 2 DCD) were identified among the non-survivors in 8 studies
Organ donation after ECPR

- Needs to be considered as an outcome in all future studies of ECPR

- Thorny ethical issues need to be addressed
  - Distinction between using ECMO for organ preservation in the dead versus ECPR resuscitation attempt and organ donation considered if non survivor

- Neuroprognostication during ECPR is poorly understood
Sponsor and Enablers

Canadian Blood Services
it's in you to give

RiM 2016
Resuscitation in Motion
A conference igniting Canadian and international synergies for future impact in resuscitation science
Why have a meeting?

- Emergence of ECPR as a viable strategy to save lives
- Pioneering ECPR programs launched in Canada and the United States
- Resuscitation and Organ Donation communities exploring strategies to optimizing donation after cardiac arrest
Unique Canadian Opportunities

- Established and developing Canadian infrastructure for collaborative research in resuscitation
Short Term Objectives and Outcomes

1. **To review evidence** in support of ECPR as it relates to the Canadian health care setting;

2. **To identifying barriers and opportunities** for ECPR implementation and study in Canada;

3. **To determine the feasibility** of a research program for ECPR in the Canadian setting;

4. **To Identify overarching issues** outside the clinical setting which may impact on ECPR implementation in Canada (e.g., ethics, costs vs benefits, training and education requirements, etc.).
Long Term Objectives

1. **To develop commitment and engagement of interdisciplinary clinical investigators in the development of a collaborative resuscitation outcomes research network;**

2. **Informing others** of this work through the publication of a proceedings paper based on the meeting.
MEETING CONCLUSIONS

- Consensus ECPR is a potentially viable strategy to save lives in Canada.
- Efficacy has not been proven, equipoise remains.
- High priority research questions identified.
- Cost-effectiveness and ethical implications in the Canadian setting need to be determined.
- Opportunities for multidisciplinary research.

- Next meeting – CIHR Planning and Dissemination Grant.
- Meeting report publication pending.