ECMO in the Cardiac Arrest setting

Anne-Marie Guerguerian MD PhD
Assistant Professor of Critical Care Medicine & Pediatrics
Medical Director, ECMO Program
Scientist in Neurosciences & Mental Health, Research Institute
Hospital for Sick Children, University of Toronto
Disclosure

• No financial conflict of interest
• No financial support from any ECLS vendors
• Research funding
  – SickKids Research Institute
  – Ontario Neurotrauma Foundation
ECMO for Neuro–cardio–pulmonary

• E–CPR in 2011: alternative approach or superior approach to traditional cardiopulmonary resuscitation – or when can it be?
• If it is to be used, it must be used with an expert team model of care approach
• It’s not a parachute for a person who can’t fly a airplane
Outline

• Definitions
• Basic objectives and principles
• Indications & Consensus recommendations in 2010
• Methods & Outcomes
  – Preclinical
  – Clinical
• Future directions
Definitions

ECPR: Extracorporeal cardiopulmonary resuscitation is the rapid deployment of extracorporeal membrane oxygenation (ECMO) – or cardiopulmonary bypass– to provide immediate cardiovascular support for patients who have cardiac arrest unresponsive to conventional CPR measures  Morris 2004
AHA 2010

• ECPR may be beneficial for infants and children with cardiac arrest if they have heart disease amenable to recovery or transplantation and

• the arrest occurs in a highly supervised environment such as an ICU with existing clinical protocols and available expertise and equipment to rapidly initiate ECPR.
AHA 2010 cont’

- There is insufficient evidence for any specific threshold for CPR duration beyond which survival with ECPR is unlikely.

- ECPR may be considered in cases of environmentally induced severe hypothermia (temperature <30°C) for pediatric patients with out-of-hospital cardiac arrest if the appropriate expertise, equipment, and clinical
SickKids Definition

• Use of ECMO using veno–arterial cannulation for cardiopulmonary resuscitation either refractory – or unlikely to be responsive to – conventional CPR

• Since 2000: Pre-assembled–pre–primed heparin bonded circuit, electrolyte solution with centrifugal pump & oxygenator
Basic objectives

• Resuscitation & Neuroprotection
• “Time is brain” : within minutes of cardiopulmonary arrest
  – Excitotoxic cell death pathways
  – Apoptotic cell death pathways
  – Multiple concurrent pathways
Preclinical

Coronary perfusion pressure

CPB

CPR

Angelos 1990
Emergency preservation and resuscitation with profound hypothermia, oxygen, and glucose allows reliable neurological recovery after 3 h of cardiac arrest from rapid exsanguination in dogs

Xianren Wu, Tomas Drabek, Samuel A Tisherman, Jeremy Henchir, S William Stezoski, Sherman Culver, Jason Stezoski, Edwin K Jackson, Robert Garman and Patrick M Kochanek

<table>
<thead>
<tr>
<th></th>
<th>O+G+</th>
<th>O+G-</th>
<th>O-G+</th>
<th>O-G-</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Dead</td>
<td></td>
<td></td>
<td>p&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>4 Coma</td>
<td></td>
<td>*</td>
<td>***</td>
<td>**</td>
</tr>
<tr>
<td>3 Severe Disability</td>
<td></td>
<td>*</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>2 Moderate Disability</td>
<td>****</td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>1 Normal</td>
<td>**</td>
<td>**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Final overall performance category (OPC) at 72 h after 3 h of cardiac arrest. O+G+: 100% O2 with 2.5% glucose in normal saline; O+G-: 9% O2 with normal saline; O-G+: 100% N2 with 2.5% glucose in normal saline; O-G-: 100% N2 with normal saline.

Preclinical canine model
Exsanguination, prolonged CA, deep Hypothermia, slow rewarming, mild hypothermia, O + glucose delivery
ELSO Registry 1990–2011 46,509 total

<table>
<thead>
<tr>
<th>Total N</th>
<th>5009</th>
<th>5423</th>
<th>1347</th>
</tr>
</thead>
</table>

Cases reported
- Survived ECLS
- Survived to Discharge

Survived ECLS

Survived to Discharge
ELSO Registry 1990–2010
Cardiac Outcomes by Dx & Age

% Survival

- CHD
- Cardiac Arrest
- Cardiogenic Shock
- Cardiomyopathy
- Myocarditis
- Other

0 - 30d
31 d - 1 y
1 y - 16 y
ELSO Registry 1990–2011
46,509 total cases reported

Survived ECLS
Survived to Discharge

<table>
<thead>
<tr>
<th></th>
<th>Total N</th>
<th>Respiratory</th>
<th>Cardiac</th>
<th>ECMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>2620</td>
<td>1680</td>
<td>591</td>
<td></td>
</tr>
</tbody>
</table>
• ELSO Adults 1992–2007
• 295 subjects/297 runs (11% of adult ELSO)
• 27% survived
• 75% cardiac 91% VA (81% fem)
• Unfavorable: pre–ecmo hypoxemia and peri–ecmo dialysis
• Favorable: percutaneous cannulation
• ELSO Registry 1992–2005 < 18 years
  – 22% Acute neurologic injury
  – 11% Brain death
  – 7% cerebral infarction
  – 7% cerebral hemorrhage
• Favorable factors in cardiac disease sample: less severe pre–ECMO acidosis and uncomplicated interval
• Unfavorable factors: ph < 7.2, need dialysis, CPR during ECMO
ELSO 1992–2005 < 18 years


Year of ECMO Support:
- CNS injury
- No CNS injury

Barrett 2009
• ELSO 1992–2005 Pediatrics < 18 years
• 682 patients
• Survival hospital discharge 38%
• Favorable pre–ecmo: cardiac disease & neonatal respiratory disease and pH > 7.2
• Unfavorable ecmo: acidosis,

Thiagarajan 2007
Outcomes among neonates, infants, and children after extracorporeal cardiopulmonary resuscitation for refractory in-hospital pediatric cardiac arrest: A report from the National Registry of CardioPulmonary Resuscitation*

Tia T. Raymond, MD; Christopher B. Cunyngham, MD; Marita T. Thompson, MD; James A. Thomas, MD; Heidi J. Dalton, MD; Vinay M. Nadkarni, MD; for the American Heart Association National Registry of CPR Investigators

• 2000–2007 IHCPA NRCPR Pediatrics
• Favorable pre–ecmo: cardiac disease
• Unfavorable: renal insufficiency (pre & peri), metabolic/electrolyte abnormalities, NaHCO3 (or THAM)
CPR duration & calendar time

Kane 2010
Survival outcomes after rescue extracorporeal cardiopulmonary resuscitation in pediatric patients with refractory cardiac arrest

Bahaaldin Alsoufi, MD, Osman O. Al-Radi, MD, Rakan I. Nazer, MD, Colleen Gruenwald, CCP, CPC, Celeste Foreman, CCP, CPC, William G. Williams, MD, John G. Coles, MD, Christopher A. Caldarone, MD, Desmond G. Bohn, MD, and Glen S. Van Arsdell, MD

- 2000–2005 80 children
- 54% survived ECMO
- 34% survived hospital discharge
- **Cause of death** ischemic brain injury

2005–2010 Cohort
B. Sivarajan & R. Sanan
Long–term evaluation ongoing

Figure 1. Graph showing the relationship between the probability of unfavorable outcome (death or stroke) as related to pre-ECMO CPR duration.
When minutes count—the fallacy of accurate time documentation during in-hospital resuscitation

William Kaye a, b, *, Mary Elizabeth Mancini c, 1, Tanya Lane Truitt d, 2

a Department of Surgery, University of Virginia Medical School, Charlottesville, VA, USA

• Accuracy...
Rescue ECMO in Children

Crisis resource management paradigms & Team education and competency

Video-tape as a learning and evaluation tool following series of Mock Rescue ECMO

Dr. Afrothite Kotsakis
SickKids

- People: experts building on expertise
- Equipment: similar
- Location: In-hospital CPA only for E-CPR
- Cannulation location: ICU, OR, CDIU-IGT
- Communication: people & paging
- Simulation: in situ and wet lab
CCU/Code Blue Team Focuses on Resuscitation Measures

“ECPRweightkg
CCU-76-1

Critical Care Staff Physician

E-CPRTeam & Equipment
CV Surgeon
Perfusionist
ECMO Specialist

Dial 911 or 5555
Request E-CPR team

Page 2
SickKids – E-CPR Simulation program

- Leader: Afrothite Kotsakis, Cecilia Hyslop, Lisa Davey, Leanne Davidson, Jason McCartney, Sophie Joseph, Osami Honjo
- Team: inter-professional
- High level commitment
- Quantitative and Qualitative evaluations
- Event debriefing
- Quantitative performance improvement process
Gaps & Future directions

• Immediate indications vs. delayed indications
• Temperature management: hypothermia? How much? When? for how long and how do we re-warm?
  – Detailed protocols for rewarming and weaning
• Co-interventions
  – Surgical: cannulation
  – Blood product exposure
Acknowledgements

Desmond Bohn & Colleen Gruenwald & Glen Van Arsdell
Critical Care Medicine, Cardiovascular Surgery, Perfusion, Hospital for Sick Children
ECLS/AT Education Committee: Simulation & Education
Dr. A. Kotsakis, Cecilia Hyslop, Lisa Davey, Leanne Davidson, Jason McCartney, Sophie Joseph, Osami Honjo
Long term outcomes CCCU Dr. Ben Sivarajan & Renee Sananes
PICU & CCCU Staff Physicians
35 + Bedside ECMO Specialists, RN, RTs, Physiotherapists, Pharmacists, Dieticians
SickKids’ Critical Care Medicine & Cardiovascular Surgery Fellows
Heart Center Cardiovascular Surgeons & Perfusion Department
Helena Frndova, Norbert Chin, Jackie Stockoe