Update on IHCA and E-CPR

Elapavaluru Subbarao MD
Associate Medical Director CTICU
Assistant Professor, Temple University School of Medicine
Dept. of Cardiothoracic and Vascular Surgery
Allegheny General Hospital
Pittsburgh

No Disclosures
Learning objectives:

- To describe IHCA epidemiology, incidence and outcomes
- Understand IHCA and its unique arrest characteristics
- Provide an overview of E-CPR in patients with IHCA

History of cardiopulmonary resuscitation or resuscitation science
Resuscitation science and collaboration

1958 Peter Safar
•Mouth to mouth breathing no artificial airway

1960 Kowenhoven
•Closed chest cardiac massage (n=14) Survival benefit

1960 Maryland Medical Society
•Foundation for Chest compressions and rescue breathing

1962 Lown and colleagues
•DC monophasic defibrillator

1966 AHA
•First CPR guidelines

Resuscitation science and collaboration
Anyone, anywhere, can now initiate cardiac resuscitative procedures. All that is needed are two hands.

In-hospital cardiac arrest

- Approximately 200,000 cases per year
- Major public health concern
- Survival rates have increased, and half of adults have ROSC following an IHCA
- Less than a quarter survive to hospital discharge
  - Merchant et al., 2001
  - Chan et al., 2010
  - Morrison et al., 2013
  - Nadkarni et al., 2006
  - Girotra et al., 2012
Epidemiology – IHCA

Incidence: 6.65 (3.8 to 13.1) per 1000 admissions

Outcomes:
- Survival to discharge: 18%
- CPC: 73%

Survival to hospital discharge after IHCA

Chan et al. 2010
Nadkarni et al. 2006
Morrsion et al. 2013

Trends in Survival after In-Hospital Cardiac Arrest


- IHCA at 374 hospital in the GWTG-R registry
- 2000-2009 n=84,625 patients
- Primary outcome-temporal trends in risk adjusted rates of survival to discharge
- Secondary outcomes – survival during acute resuscitation or post resuscitation care and neurological outcome

Survival to Discharge (%)
Trends in Survival after In-Hospital Cardiac Arrest

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>67.3±15.4</td>
<td>66.5±15.6</td>
<td>65.9±15.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male sex — no. (%)</td>
<td>13,382 (57.3)</td>
<td>19,050 (58.4)</td>
<td>16,546 (58.3)</td>
<td>0.07</td>
</tr>
<tr>
<td>Black race — no./total no. (%)</td>
<td>4,723/21,894 (21.8)</td>
<td>6,381/19,726 (21.4)</td>
<td>6,048/26,414 (22.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Characteristics of cardiac arrest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial cardiac-arrest rhythm — no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Asystole</td>
<td>9,423 (39.9)</td>
<td>12,576 (38.6)</td>
<td>9,915 (34.9)</td>
<td></td>
</tr>
<tr>
<td>Pulsless electrical activity</td>
<td>8,653 (16.7)</td>
<td>13,343 (40.9)</td>
<td>13,215 (46.5)</td>
<td></td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>3,999 (16.9)</td>
<td>3,878 (11.9)</td>
<td>2,952 (10.4)</td>
<td></td>
</tr>
<tr>
<td>Pulsless ventricular tachycardia</td>
<td>1,548 (6.6)</td>
<td>2,086 (6.6)</td>
<td>2,107 (6.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Hospital location of arrest — no. (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intensive care unit</td>
<td>13,189 (55.8)</td>
<td>18,852 (57.8)</td>
<td>16,859 (59.4)</td>
<td></td>
</tr>
<tr>
<td>Monitored unit</td>
<td>4,735 (20.6)</td>
<td>7,269 (22.3)</td>
<td>7,100 (25.2)</td>
<td></td>
</tr>
<tr>
<td>Nonmonitored unit</td>
<td>5,769 (24.2)</td>
<td>6,482 (20.9)</td>
<td>4,270 (15.4)</td>
<td></td>
</tr>
<tr>
<td>Arrest at night (11 p.m. to 7 a.m.) — no./total no. (%)</td>
<td>8,368/23,316 (35.9)</td>
<td>11,410/32,323 (35.3)</td>
<td>9,880/28,168 (35.1)</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Survival to discharge %: 13.7 to 22.3 (1.03 - 1.06) p < 0.001
Neurological outcome %: 32.9 to 28.1 (0.97 - 1.00) p = 0.02

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Epidemiology-IHCA

<table>
<thead>
<tr>
<th>Presenting Arrhythmias</th>
<th>IHCA</th>
<th>OHCA</th>
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</thead>
<tbody>
<tr>
<td>% Total cardiac arrest</td>
<td>% Survive to discharge</td>
<td>% Total cardiac arrest</td>
</tr>
<tr>
<td>VF/VT – Shockable</td>
<td>17.4</td>
<td>32.6</td>
</tr>
<tr>
<td>Asystole</td>
<td>28</td>
<td>2.3</td>
</tr>
<tr>
<td>PEA</td>
<td>54.3</td>
<td>44.3</td>
</tr>
<tr>
<td>Other</td>
<td>Not reported</td>
<td>Not reported</td>
</tr>
</tbody>
</table>

Chan, 2015
Daya et al., 2015
**Causes of IHCA – Incidences and rate of recognition**

D. Bergum et al., Resuscitation 87(2015)63-68

<table>
<thead>
<tr>
<th>Etiology reliably determined</th>
<th>258</th>
<th>85%</th>
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</thead>
<tbody>
<tr>
<td>Correctly recognized by ET during ALS</td>
<td>198</td>
<td>66%</td>
</tr>
<tr>
<td><strong>Cardiac</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td>156</td>
<td>60%</td>
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<tr>
<td>4H4T</td>
<td>108</td>
<td>42%</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>51</td>
<td>20%</td>
</tr>
<tr>
<td>Thrombosis</td>
<td>12</td>
<td>5%</td>
</tr>
<tr>
<td>Others</td>
<td>40</td>
<td>16%</td>
</tr>
<tr>
<td>Unknown</td>
<td>44</td>
<td>15%</td>
</tr>
<tr>
<td><strong>4H4T</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hypoxia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hypovolemia</td>
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<td></td>
</tr>
<tr>
<td>- Hyperkaliemia</td>
<td></td>
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<tr>
<td>- Hypokaliemia</td>
<td></td>
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</tr>
<tr>
<td>- Hypothermia</td>
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<td></td>
</tr>
<tr>
<td>- Thrombosis</td>
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<td></td>
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<tr>
<td>- Tamponade</td>
<td></td>
<td></td>
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<tr>
<td>- Tension PTX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Toxication</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sepsis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cerebral bleed</td>
<td></td>
<td></td>
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<tr>
<td>- CVA</td>
<td></td>
<td></td>
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<tr>
<td>- Aortic dissection</td>
<td></td>
<td></td>
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<tr>
<td>- Aneurysm rupture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Seizure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- GI Bleeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Unknown</td>
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</tr>
</tbody>
</table>

**Presence of causes in 302 IHCA episodes**

**Predictors of OHCA/IHCA**

**Predictors of survival after OHCA**

- Witnessed by a bystander 6.4-13.5%
- Bystander CPR 3.9-16.1%
- Witnessed by EMS 4.9-18.2%
- Initial shockable rhythm 14.8-23.0%
- ROSC in the field 15.5-33.6%


**Predictors of survival after IHCA**

- Initial rhythm shockable 85%
- Arrest in the ICU 56%
- Epinephrine within 2 mins of arrest 54%
- Witnessed 52%

*Fennelly NK et al. Ir Med J 2014;107(4): 105-7*
Resuscitation Practices Associated With Survival After In-Hospital Arrest
Paul S Chan et al., GWTG-R Investigators. JAMA April 2016

<table>
<thead>
<tr>
<th>Hospital Resuscitation Strategy or Factor</th>
<th>P value</th>
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<tbody>
<tr>
<td>1. Frequency of review of IHCA cases</td>
<td>.03</td>
</tr>
<tr>
<td>2. Monitoring for interruptions of chest compressions</td>
<td>.01</td>
</tr>
<tr>
<td>3. Adequate resuscitation training</td>
<td>.02</td>
</tr>
</tbody>
</table>

Impact of resuscitation system errors on survival from in-hospital cardiac arrest
J.P. Ornato et al; Resuscitation 2011

- 108,636 patients
- 8 years period
- Resuscitation system errors were committed in 40.4% of VF/pVT initial rhythm and in
- 26.8% of those with non VF/VT
- System errors associated with decreased survival from IHCA in adults
  - Delay in drug administration > 5 mins
  - Defibrillation
  - Airway management
  - Chest compression errors

Public health importance
Saves 21,000-44,000 additional lives per year in the US from IHCA.
Rapid Response Systems
The Impact of implementing a rapid response system: A comparison of cardiopulmonary arrests and mortality among four teaching hospitals in Australia
Chen et al., Resuscitation 2014

Implementation of RRS
Rapid followed by a significant decline in IHCA rate (50%) and IHCA-related mortality. No changes in 1-year mortality after IHCA for all hospitals

Implications:
200,000 CA in the USA: 20% IHCA survival rate
Reducing 50% rate in IHCA would save 80,000 lives each year

Does early intubation saves lives within 15 mins?
Association Between Tracheal Intubation During Adult IHCA and Survival
GWTG-R Investigators JAMA 2017;317(5):494-506

- Observational study with propensity-matched cohort
- 2000-2004
- n = 108,079 at 668 hospitals
- Survival in intubated patients was lower
  - 16.3% vs 19.4% (p < .001)
- ROSC was lower
  - 57.8% vs 59.3% (p < .001)
- CPC score of 1 or 2
  - 10.6% vs 13.6% (p < .001)
Mechanisms for poor outcomes in early intubation:

- Prolonged interruption in chest compressions
- Hyperventilation and hyperoxia (poor outcomes)
- Delay in defibrillation or epinephrine administration
- Delays in time to intubate could result in inadequate oxygenation and ventilation
- Unrecognized esophageal intubation or dislodgement

Mechanical versus manual chest compressions for cardiac arrest: a systematic review and meta-analysis

Li et al., Scandinavian J of Trauma, Resuscitation and Emergency Medicine. 2016 24:10

- No survival benefit
- May be harmful
In-hospital use of Automatic External Defibrillators and Automatic External Cardioverter and Defibrillators (AEDs/AECDs)

- No RCT comparing AEDs with manual defibrillators
- Observational studies showed no improvements in survival to hospital discharge for IHCA
- Recommendations:
  - Use areas of the hospital where there is a risk of delayed defibrillation
  - Manual defibrillation should be used in preference to an AED when available
  - AECDs may have a role in areas of hospital that are heavily monitored units

- Chan PS et al; NEJM 2008
- Forcina MS et al; CCM 2009
- Smith RJ et al; CCM 2009
- Chan et al; JAMA 2010
- Smith RJ et al; Resuscitation 2011
- Gibbison B et al; EBM 2011

ACLS Algorithm 2015
Improving CPR Performance
BS Nassar MD and R Kerber MD Chest 2017

**Optimize chest compressions**
- Adequate depth and rate: 2 inches /100-120/min, good chest recoil
- Provide feedback to the rescuer
- Train leader to recognize rescuer fatigue

**Avoid Hyperventilation**
- Emphasize compression over ventilation
- Consider compression-only CPR, where appropriate

**Capnogram**
- Monitor capnogram for compression adequacy
- To detect ROSC
- To guide the duration of resuscitation

**Encourage Interosseous access**
- Less training, > 80% success rate and rapidly placed in 20s to 2 mins
- Similar PK and absorption
- Preferred route tibia, humerus, sternum
- AHA/ERC recommended vascular access

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**CPR Depth and Rate**
Compression rate between 60-120 / min: greater CPP generated and survival increases

Maximal benefit is in the range of 100 to 120 compressions/min; survival declines above or below this

*Idris AH et al., Circulation 2012*
*Idris AH et al., CCM 2015*
Improving CPR Performance
BS Nassar MD and R Kerber MD
Chest 2017

CPR depth and rate
• Compression depth is associated with a favorable outcome in both OHCA/IHCA
• In animal models, compression to 25% of the AP diameter of the chest generates CPP > 15 mmHg
• In adults, the benefit of compression plateaus at between 4.5 cms and 6 cms

Capnography -ETCO₂
• ETCO₂ reflects Cardiac output
• Low ETCO₂ reflects inefficient compressions
• ETCO₂ < 10 mmHg after 20 min CPR is associated with high mortality
• ETCO₂ surge indicates brisk pulmonary blood flow on restoration of a perfusing rhythm
• ETCO₂ holds true for both ETT and supraglottic airways

1. Shibutani K et al; Anesth Analg.1994
2. Weil MH et al ; CCM.1985
**Post-cardiac arrest syndrome: clinical manifestations, and potential treatments**

ILCOR consensus statement

*Resuscitation (2008)*79,350-379

<table>
<thead>
<tr>
<th>Post-cardiac arrest brain injury</th>
<th>Post-cardiac arrest myocardial dysfunction</th>
<th>Systemic ischemia/reperfusion response</th>
<th>Persistent precipitating pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coma, Seizures, Stroke, brain death</td>
<td>• AMI, Hypotension, Dysrhythmias, CV collapse</td>
<td>• Tissues hypoxemia/ischemia, Hypotension, Fever, Hyperglycemia</td>
<td>• Cardiovascular disease, Pulmonary disease, CNS, Infection (pneumonia, sepsis), Toxicology DOD</td>
</tr>
</tbody>
</table>

Therapeutic hypothermia
Mechanical ventilation
Seizure control

PCI
Hemodynamic optimization
IV fluids
Inotropes/Vasopressors
MCS/E-CPR

Glucose control
Antibiotics
Disease specific interventions

**PCAS: monitoring options**

- Trend serum lactate
- Central lines, arterial catheters

- ICU echocardiography
- Cardiac output either invasive or non-invasive

- Serial neuro exams
- EEG
- HCT/MRI – no rush for prognostication
Post-cardiac arrest syndrome

- TTM 33-36°C X 24 hrs with slow rewarm at 0.5°/hr
- Cardiac catheterization and coronary Interventions
- Hemodynamic goals MAP > 65 mmHg
- Avoid too many vasoactive agents
- Glycemic control targets
- Delay prognostication

Hypothermia trials in cardiac arrest

- **NEJM 2002 European Trial**
  - 32°C vs 34°C
  - Positive study favoring saving lives and neuroprotection

- **NEJM 2002 Bernard**
  - 33°C vs normothermia
  - Positive study with survival benefit

- **NEJM 2013 TTM trial**
  - 33°C vs 36°C
  - 33°C conferred no benefit compared with 36°C
Targeted Temperature Management at 33°C vs 36°C after Cardiac Arrest

TTM Trial Investigators. NEJM 2013

In unconscious survivors of out-of-hospital cardiac arrest of presumed cardiac cause, hypothermia at a targeted temperature of 33°C did not confer a benefit compared with a targeted temperature of 36°C.


Neuroprognostication after IHCA

Critical Care Management after Cardiac Arrest
Friberg, Cronberg. Semin Neurol 2016;36:542-549
Neuroprognostication after IHCA
Critical Care Management after Cardiac Arrest
Friberg and Cronberg. Semin Neurol 2016;36:542-549

Multimodal approach
- Neurological exam (corneal, pupillary, SSEP)
- EEG
- SSEP

Biochemical markers
- Neuron-specific enolase (NSE) trend
- Lactic acid trend: no need if normal

Radiology
- HCT
- MRI

Code team IHCA

Respiratory therapist /Airway Manager

RN for administration of drugs and fluids

House staff for procedures

CPR person 1

CPR person 2

RN code supervisor

Pharmacist

RN with code cart
What is ECPR?

- VA-ECMO applied emergently during cardiac arrest is termed ECPR
- Goal is to maintain end organ perfusion
- Allows interventions to reverse the underlying cause, such as revascularization, embolectomy, etc.
- Bridge to myocardial recovery or LVAD or considerations for transplantation

Case 1.
E-CPR: IHCA in CTICU – Acute malfunction of impella

- 63 M with history of hypertension, dyslipidemia
- Late presentation of acute anterior wall MI, cardiogenic shock, EF 15%, AKI (Cr - 6)
- Cath – High-grade Prx LAD, RCA, moderate LM, akinetic apex
- Echo had LV thrombus
- Was placed on Impella 5L, dopamine and norepinephrine. Intubated and transferred to our CTICU
Case 1.
E-CPR: IHCA in CTICU – Acute malfunction of Impella

- **ICU day 2** - acute hypotension and no flows on Impella. Impella shutdown, CPR 30 mins in CTICU
- Emergent percutaneous bedside VA-ECMO placed while CPR in progress and cooled via circuit (E-CPR)
- **ICU days 3-4** - HM-II LVAD placed, VAE removal in OR
- **POD 5** extubated. Mild CVA (CPC 1)
- **CRRT** with slow and quick recovery of renal function with good urine output

- **POD9** Transferred to step down
- Transfer to inpatient rehab
- **LOS Hospital** - 27 days
- **ICU LOS** - 9 days
- LTAC - Rehab - 28 days
- Last IHD
  TDC removed as an outpatient

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**Case 1.**
E-CPR: IHCA in CTICU – Acute malfunction of Impella

**Lactic acid trend**

**Impella - 5 clot**

**Clot in the inflow**
**Case 1.**
E-CPR: IHCA in CTICU – acute malfunction of impella > E-CPR/VA-E > LVAD placement

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**Case 1.**
E-CPR: IHCA in CTICU – acute malfunction of impella > E-CPR/VA-E > LVAD placement

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Case 2.
E-CPR - ICU - Cardiac arrest
Postpartum cardiomyopathy

- 19 F Primi GIP1AO
- Delivered a FT male infant in a normal PV delivery.
- Prenatal history unremarkable. Noted to be HTN during delivery.
- Discharged on day 2/3, home on anti-HTN

- **Postpartum day 3:** admitted to ED for dyspnea, bloody sputum, hypoxic, SBP 190/120s. PE ruled out
- Intubated and admitted to ICU
- On **PPD 4:** Bradycardia / PEA arrest CPR for 40 minutes with ROSC and followed commands with neuro intact
- Precut VA ECMO was placed at OSH due to unstable BP and transferred to AGH

TEE at AGH EF 15% with global dysfunction - peripartum CM ACC-AHA stage D, NYHA IV with normal LV RV
BP managed with sodium nitroprusside and diuretic therapy
8/4/17: Day 6, serial ECHO good, heart function recovery, EF to 45 - 50% and was switched to VV ECMO

ECMO days: 6 (VA>VV)
LOS: 15 days

Maternal mortality has increased by 26.4% in the US

*Lancet 2016*
E-CPR in a case of postpartum cardiomyopathy

**Day 1 VA ECMO**

**Day 10 ECMO decannulation**

**Day 6 VVE decannulated**
Case 3.  
E-CPR in cardiac catheterization lab

- 64 M  
- Elective cardiac catheterization  
- Aortic valve 0.4 cm², mean gradient 71 mmHg, EF 65%  
- On cath table while engaging, the LCA became hypotensive and acute hypotension was arrested  
- CPR (ACLS), refractory CPR  
- E-CPR was placed via groin vessels while CPR in progress  
- Neuro exam ok, moving all limbs  
- Taken to OR for an urgent AVR 25 mm bioprosthetic valve placement  
- LOS 7 days  
- Neuro exam intact on discharge

E-CPR in cardiac catheterization lab

CXR with venous cannula position  

R Femoral artery 18 F  
R Femoral vein 24 F
E-CPR in cardiac catheterization lab

Pre ECMO

Post ECMO
With NGT injection

Post AVR

Adult ECMO

VV ECMO
Acute hypoxic respiratory failure/ARDS of varied etiology

VA ECMO
Cardiogenic shock (AMI, massive PE, cardiomyopathy, myocarditis)
Postcardiotomy states

E-CPR
(percutaneous VA ECMO during refractory cardiac arrest)

IHCA

OHCA
ECPR for in-hospital cardiac arrest

1. Continuous chest compression until start of extracorporeal circulation
2. Catheterisation to femoral artery and vein during chest compression
3. Start extracorporeal circulation
4. Increase of oxygenated blood flow to heart, brain, kidney, and other organs
   - Induced hypothermia or not
5. Correct causes of arrest
   - Monitor complications
   - Increase of survival rate in cardiac arrest

Cannulation

- Arterial Cannula 15-19 F
- Venous 19-21 F

- Primarily emergent percutaneous
- Emergent cut down
- Central cannulation

CTS
Intensivist x 2
Interventional cardiologist
ED

Perfusionist bedside
ECMO RN /Specialist
ECMO cart / ECPR cart

Complications of E-CPR

- CVA > 7%
- Cannula site bleeding > 20%
- GI bleeding requiring transfusion or intervention is > 6%
- What happened to non survivors?
  - Sepsis
  - Overwhelming hematological issues
  - AKI
- Lower extremity ischemia
- Lower extremity amputation
- Fasciomyotomy /compartment syndrome
- Hematological-thrombocytopenia
- Acquired von Willebrand disease
- DIC
- Hemolysis
- Stroke

Distal perfusion catheter
limb ischemia

From 2003 to 2014, survival to discharge was 29% in those who received ECPR. Despite advances in the provision of ECMO care and increasing patient comorbidities, there has been no change in risk-adjusted survival over time.
ECPR for in-hospital cardiac arrest

### ECLS Registry Report

**International Summary - July, 2017**

**Extracorporeal Life Support Organization**
2800 Plymouth Road
Building 350, Room 303
Ann Arbor, MI 48109

**July, 2017**

#### Overall Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Total Runs</th>
<th>Survived ECLS 69%</th>
<th>Survived to DC or Transfer</th>
<th>Neonatal</th>
<th>Pulmonary</th>
<th>Cardiac</th>
<th>ECLS</th>
<th>Pediatric Pulmonary</th>
<th>Cardiac</th>
<th>ECLS</th>
<th>ADIR Pulmonary</th>
<th>Cardiac</th>
<th>ECLS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neonatal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20,105</td>
<td>2,338</td>
<td>357</td>
<td>1,952</td>
<td>4,007</td>
<td>41%</td>
<td>666</td>
<td>4,067</td>
<td>41%</td>
<td>87,566</td>
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<tr>
<td><strong>Cardiac</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7,066</td>
<td>4,727</td>
<td>5%</td>
<td>2,067</td>
<td>4,067</td>
<td>41%</td>
<td>466</td>
<td>4,067</td>
<td>41%</td>
<td>26,719</td>
</tr>
<tr>
<td><strong>ECLS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,613</td>
<td>1,029</td>
<td>0%</td>
<td>666</td>
<td>4,067</td>
<td>41%</td>
<td>466</td>
<td>4,067</td>
<td>41%</td>
<td>10,252</td>
</tr>
<tr>
<td><strong>Pediatric</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6,087</td>
<td>6,020</td>
<td>0%</td>
<td>4,812</td>
<td>4,941</td>
<td>51%</td>
<td>1,568</td>
<td>4,941</td>
<td>51%</td>
<td>8,040</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87,566</td>
<td>60,443</td>
<td>0%</td>
<td>48,172</td>
<td>48,172</td>
<td>55%</td>
<td>26,719</td>
<td>48,172</td>
<td>55%</td>
<td>65,688</td>
</tr>
</tbody>
</table>

**Centers by year**

Wednesday, July 19, 2017

(c) 2017 Extracorporeal Life Support Organization
ECPR studies on IHCA

<table>
<thead>
<tr>
<th>Author</th>
<th>Country</th>
<th>Year</th>
<th>Propensity-Matched</th>
<th>Study Design</th>
<th>Clinical Outcome</th>
<th>Survival Hospital</th>
</tr>
</thead>
</table>
| Chen et al.     | Taiwan  | 2008 | E-CPR + CPR        | Prospective        | Mortality                         | 28.8% vs 12.3% \( p \leq 0.0001 \)  
1yr: 18.6% vs 9.7% \( p = 0.007 \) |
| Shin et al.     | Korea   | 2011 | CPR Alone          | Retrospective      | Mortality or significant neurological impairment | 60 60  
In-hospital HR 0.17 \( 95\% \text{ CI } 0.04-0.71 \)   
6 months: HR 0.48 \( 95\% \text{ CI } 0.29-0.77 \)   
2 years: 80% vs 95% \( p = -0.002 \) |

**Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis**

Chen et al., *The Lancet* 2008

- \( n = 975 \) IHCA patients in a university teaching hospital in Taiwan
- 113 CCPR vs 59 ECPR
- 3-yr prospective observational propensity-matched study
- Age 18-75 yrs, witnessed IHCA
- Use of ECLS > 10 mins of CPR (E-CPR) compared with patients receiving conventional CPR
- Primary endpoint: survival to discharge
## Inclusion criteria:
- Adult IHCA of cardiac origin
- CPR > 10 mins
- Witnessed

## Exclusion criteria:
- CPR < 10 mins
- Age > 75
- Irreversible brain damage
- Terminal malignancy
- Traumatic bleeding
- Non-cardiac arrest
- DNR

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### Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis

Chen et al.; The Lancet 2008

- Call to team arrival: 5-7 mins during day and 15-30 mins during night
- If spontaneous ROC was sustained for more than 20 mins after the team arrived, ECLS was not offered
- Team waited at least 10 mins if ROSC for continued for < 20 mins

- Heparin-bonded circuit
- Centrifugal pump
- Hollow fiber oxygenator (Medtronic, Anaheim, CA USA)
- No hypothermia, only maintained normothermia
- ECLS withdrawn if severe neurological impairment > 7 days
- Cerebral performance category score 1-5 was used
Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis

Chen et al.; The Lancet 2008

- 3-year prospective observational study
- E-ECMO for 59 patients
- Age 18-75 years
- Witnessed IHCA of cardiac origin
- CPR > 10 mins
- Propensity score-matched with CCPR

ECPR is associated with improved survival and neurological outcome

Longer CPR is associated with poor prognosis

PEA and asystole have poorer survival than pVT or VF

ECPR had a short-term and long-term survival benefit over conventional CPR in patients with IHCA of cardiac origin
Establishment and standardization of resuscitative VA-ECMO in clinical practice

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Suggestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary teams</td>
<td>Experienced Intensivist*2, cardiac surgery, perfusionist, cardiology</td>
</tr>
<tr>
<td>Indications</td>
<td>Age &lt; 65, reversible cause, witnessed arrest, other resuscitation characteristics</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Significant comorbid conditions, terminal illness, DNR status, poor vascular disease?, aortic insufficiency?, coagulopathy?</td>
</tr>
<tr>
<td>Technique</td>
<td>Peripheral vs central DPC, limb protection strategies, image guidance</td>
</tr>
<tr>
<td>Management</td>
<td>CTICU, anticoagulation, temperature management, monitoring, neurological management, weaning and decannulation issues</td>
</tr>
</tbody>
</table>

Singal RK et al.; Canadian Journal of Cardiology 33(2017) 51-60

Indications: Cardiac arrest refractory to ACLS
Suspected reversible cause (cardiac, pulmonary embolism, drug intoxication or hypothermia)

Age < 65
Witnessed CA
Beginning of CPR < 5 mins after CA

YES NO

Medical Management

Contraindications:
Asystole
End tidal CO2 < 13
Lactate > 13
Known medical condition with poor prognosis
Outside business hours

YES NO

E-CPR

Singal RK et al.; Current and Future Status of ECPR for IHCA
Canadian Journal of Cardiology 33 (2017) 51-60
Knowledge gaps / future of ECPR in IHCA

• Randomized controlled trials are needed to assess the effect of ECPR vs CCPR
• Patient selection for ECPR in IHCA
• What is the optimal TTM for patients on ECPR after CA?
• What are reliable prognostic factors for patients with ECPR after CA?

Where does the AHA stand on ECPR in an IHCA setting?

• Class IIb Level of Evidence C (Weak recommendation, very low quality evidence)

• “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)”.
  – AHA /ACLS guidelines 2015
Conclusion

In summary:

In-hospital cardiac arrest is a major public health concern with a modest survival rate to discharge.

Survival with ECPR to hospital discharge ranges widely from 20% to 46%.

Survival correlates with age, duration of CPR, etiology and reversibility – PATIENT SELECTION.

E-CPR in hospital cardiac arrest is a rescue procedure with special goals regarding intervention and outcomes.

How can we improve survival in IHCA?

Leadership

Teamwork
Thank you
esrccm@gmail.com