Advances in Resuscitation Science

September 23, 2016

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University of Minnesota
Cardiac Electrophysiologist, St. Cloud Hospital
Chief Medical Officer, ZOLL Minneapolis

Minneapolis, Minnesota
Disclosures

Dr. Lurie is a practicing cardiac electrophysiologist, a medical researcher at University of Minnesota and Hennepin County Medical Center, and a consultant for ZOLL Medical.

Saving the Brain During CPR and After ROSC
The Science of Resuscitation

- Historical perspectives
- Status quo update
- What’s new?
- A peek at the future

Cardiac Arrest Today

- Leading cause of death in the U.S.
  - > 350,000 out of hospital
  - > 350,000 in hospital
  - Average age: 66 years old
Cardiac output under best conditions limited during standard CPR

Cardiac output during standard CPR

- Pre-Arrest Baseline: 100%
- With CPR: 15.7%

Standard CPR

- Standard CPR (S-CPR) is the cornerstone of resuscitation care; usually first option
- S-CPR provides 25-33% normal blood flow to the heart and brain
- Inadequate blood flow to the heart and brain contributes to the high mortality rates

S-CPR remains the cornerstone of resuscitation care; essentially unchanged for > 50 years

Status Quo Update
~7% Survival with Good Brain Function

Inherent Limitations of Standard CPR

- Blood flow is limited
- Difficult to perform correctly without feedback tools
- Initial reintroduction of blood flow may cause injury
- Increases arterial and venous pressures simultaneously which may cause head injury

These limitations must be overcome to improve outcomes
What Does Success Look Like?

>30% Survival with Good Brain Function
Index Case 1987

- Saved by a Household Plunger
- San Francisco General Hospital

CPR: The P Stands for Plumber’s Helper.
Lurie et al - JAMA 1990

JAY LENO
FIRST NIGHT
Opening Doors

New Approach to CPR
New Approach to Brain Injury
New Approach to Hypotension

Improving Flow
Harnessing the Intrathoracic Pump
Despite More AEDs, Survival Rates Remain Low

Seattle AED Experience – one of the best!

Influence of CPR Prior to Defibrillation After Out-of-Hospital Ventricular Fibrillation

Cobb et al. JAMA 1999

Cobb et al. JAMA 281:1182, 1999
Active Compression Decompression (ACD) CPR

Metronome

Force Gauge

Suction Cup

Handle

Compression

Compress to recommended depth (e.g., 2 inches)
Decompression

Decompress with up to 20 lbs (10 kg) of lift

Randomized Clinical Trial (Paris, France)
Survival After Cardiac Arrest

Was something missing with ACD CPR by itself?

The Impedance Threshold Device is Born
Each time the chest wall recoils following a compression, the impedance threshold device (ITD) transiently blocks air/oxygen from entering the lungs, creating a small vacuum in the chest, resulting in improved cardiac preload.

Founding Concept

How does it work?

Greater vacuum (negative pressure) in the chest during chest wall recoil leads to increased venous return and circulation and lower ICP.
Using an ITD

Human Data
Blood Pressure during Conventional CPR +/- ITD

Milwaukee, WI

Systolic BP

<table>
<thead>
<tr>
<th>Sham ITD</th>
<th>Active ITD</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>85</td>
</tr>
</tbody>
</table>

*p<0.05

Diastolic BP

<table>
<thead>
<tr>
<th>Sham ITD</th>
<th>Active ITD</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>

BP after 14 Minutes of ITD Use

n = 22

No Silver Bullet for Sudden Cardiac Arrest

- Improved circulation is not enough
- High quality CPR is essential
- A systems-based approach is key

CPR Quality Affects Outcomes

- A decade of mistakes
- A long detour….
What is High Quality CPR?

Excessive Ventilation can be DEADLY

Ventilation Strategies

Excessive Ventilation can be DEADLY
Death by Hyperventilation

Ventilation rate: 47/min

Lots of Ventilation Options

None
50:2
30:2
15:2
5:1
Improving EMS with “CC” Only CPR

Minimally Interrupted Cardiac Resuscitation by Emergency Medical Services for Out-of-Hospital Cardiac Arrest

Context: Out-of-hospital cardiac arrest is a major public health problem.

Objective: To investigate whether the survival of patients with out-of-hospital cardiac arrest would improve with minimally interrupted cardiac resuscitation (MICR), an

- **Interventions:**
  1. Significantly delay intubation
  2. 200 compressions before first shock
  3. Minimize pre and post shock pauses
  4. Primary focus on compressions, secondary focus ventilation

- **Tripled** survival to hospital discharge (3.8% → 9.1%)

Bobrow et al – JAMA 2008

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How Important is Mouth-to-Mouth?
2 vs 10: Effect on Brain O2 Tension

<table>
<thead>
<tr>
<th></th>
<th>Brain O2 Tension (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>15</td>
</tr>
<tr>
<td>CPR</td>
<td>4</td>
</tr>
</tbody>
</table>

*p<0.03

Lurie et al - Resp Care 2008

30:2 vs Continuous Compressions for BLS?

Nichol et al, NEJM 2015

Intervention: CCC with asynchronous breaths @ 10/min
Control: 30:2

No reported statistically significant difference in outcomes (hospital discharge with favorable neurological function):

CCC – 7%
30:2 – 7.7%

P=0.09
Whoooo

Not so fast....

Outcomes in Patients Included in the Primary Analysis

### Survival with Favorable Brain Function

<table>
<thead>
<tr>
<th></th>
<th>N Engl J Med 2015;373:2203-2214</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survival with Favorable Brain Function</strong></td>
<td></td>
</tr>
<tr>
<td>CCC —</td>
<td>7.6%</td>
</tr>
<tr>
<td>30:2 —</td>
<td>9.6%</td>
</tr>
<tr>
<td>P&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>


### Table 1: Outcomes in Patients Included in the Primary Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention Group (N=1361)</th>
<th>Control Group (N=1429)</th>
<th>Adjusted Difference (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety population</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total no.</td>
<td>1361</td>
<td>1429</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival to discharge ---</td>
<td>1127</td>
<td>1152</td>
<td>-0.5 (-1.3 to 0.2)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### Adjusted analyses of primary outcome

- Adjusted for study site
- Adjusted for age
- Adjusted for sex
- Adjusted for public location
- Adjusted for bystander-witnessed
- Adjusted for bystander-initiated CPR
- Adjusted for duration until EMS arrival
- Adjusted for all the above covariates

### Additional analyses of primary outcome

- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)

### Adjustments for other covariates

- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)
- Treatment determined by automated algorithms — no./total no. (%)

### Safety population

- Total no. 1361
- Survival to discharge 1127
Effect of No Ventilation

Normal Ventilation (Inflated Lungs)  No Ventilation (Deflated lungs)

Importance of Complete Recoil

Ventilation  Compressions / Decompressions

(mmHg)
Chest Compression & Release

Does the rate of Chest Compression Release Velocity Effect Survival?

**YES!**

Clinical paper


Alexander Koivu,*, Tyler F. Vadeboncoeur*, Uwe Stolz†, Daniel W. Spalte†, Tane Insana*, Annemarie Silver*, Bentley J. Bobrow*†,‡,§

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*Present address: Emergency Medicine and Trauma Services, Saint Joseph's Hospital, Philadelphia, PA 19107-6244, United States.
Favorable Neurological Outcome Significantly Associated with Chest Compression Release Velocity

<table>
<thead>
<tr>
<th>Chest Compression Release Velocity</th>
<th>Favorable Neurological Outcome (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast CCRV (≥400 mm/sec)</td>
<td>18%</td>
</tr>
<tr>
<td>Moderate CCRV (300-399.9 mm/sec)</td>
<td>10%</td>
</tr>
<tr>
<td>Slow CCRV (&lt;300 mm/sec)</td>
<td>4%</td>
</tr>
</tbody>
</table>

P<0.001

Outcome Results from Improved BLS and ALS, Including ITD Use

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Intervention</th>
<th>P-value</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC</td>
<td>30.4%</td>
<td>34.1%</td>
<td>0.022</td>
<td>1.18 (1.022, 1.366)</td>
</tr>
<tr>
<td>Hospital Discharge</td>
<td>9.7%</td>
<td>12.6%</td>
<td>0.007</td>
<td>1.34 (1.078, 1.671)</td>
</tr>
<tr>
<td>HD (VF)</td>
<td>19.0%</td>
<td>31.1%</td>
<td>&lt;0.001</td>
<td>1.91 (1.384, 2.667)</td>
</tr>
<tr>
<td>CPC 1 or 2</td>
<td>31.4%</td>
<td>55.2%</td>
<td>0.033</td>
<td>2.68 (1.027, 7.213)</td>
</tr>
</tbody>
</table>

Survival with good brain function significantly improved with high quality CPR and use of ITD

Aufderheide et al. Heart Rhythm 2010
Results: Of 8718 patients included in the analysis, 4345 were randomly assigned to treatment with a sham ITD and 4373 to treatment with an active device. A total of 260 patients (6.0%) in the sham-ITD group and 254 patients (5.8%) in the active-ITD group met the primary outcome (P=0.71).

Conclusions: Use of the ITD did not significantly improve survival with satisfactory function among patients with out-of-hospital cardiac arrest receiving standard CPR.

Variable Quality of Conventional CPR

Wide variations in practice even in some of the best EMS systems (data from NIH-funded Resuscitation Outcomes Consortium - ROC)

Variable compression depth and rate limit blood flow and worsens outcomes

Compression Depth

Compression Rate

Variations in CPR quality strongly linked to outcomes

Survival with Good Brain Function (ROC PRIMED)
Correct Rate and Depth are CRITICAL

Survival with MRSS3 (Sham)  Survival with MRSS3 (Active)
The Sweet Spot for Neurologically-Sound Survival

(Contour plots of all ROC survivors using proportion of good survivors in each cell and canonical analysis for optimization)

**Sham ITD**
- Rate = 108 cpm
- Depth = 4.6 cm

**Active ITD**
- Rate = 106 cpm
- Depth = 4.8 cm

Sugiyama et al, 2016

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Lessons from ROC PRIMED: Subjects who received Quality CPR
(rate 80-120/minute; depth 4-6 cm; fraction ≥50%)

Yannopoulos et al. AHA 2014
Métronome

High Quality CPR

- Essential for saving lives
- To be performed well, rate (100-110), depth (2”), and release monitoring and feedback is needed
- Devices such as the ITD need high-quality CPR to work
- Training and feedback to rescue personnel are essential
- Automated CPR devices also provide sustained, high quality CPR
Better circulation is needed but often not enough

Take Heart America

- **Dystanders**
  - Provide the critical immediate response
  - Learn CPR and how to use an AED
  - Recognize sudden cardiac arrest
  - Send someone to call 911 and get an AED

- **First Responders**
  - Assume responsibility for continued life-saving through:
    - Rapid response
    - High-performance CPR
    - Use of impedance threshold device (ITD)
    - Rapid AED placement

- **Hospital Staff at a Cardiac Arrest Center**
  - Get the patient to neurologically intact survival through:
    - Therapeutic hypothermia
    - Jelly 
    - Electrophysiology
    - Cardiac catheterization
    - Tracking outcomes

- **EMS Personnel**
  - Provide additional life-saving measures through:
    - High-performance CPR
    - Advanced airway management
    - Use of impedance threshold device (ITD)
    - Intravenous drug delivery
    - Automated CPR devices (optional)

651-402-5636
www.TakeHeartAmerica.org
Meet Ben

- Bystander CPR (mom)
- AED (first responders)
- ITD & high quality CPR (Allina EMS)
- Hypothermia (Mercy Medical Center)
- ICD (Mercy Medical Center)
- Now: Marketing @ Medtronic

Transformative Technologies

- Bystander CPR Education
- AED
- AICD
- Angiography
- Automated CPR
- IO Meds
- Therapeutic Hypothermia

A plan: ‘Take Heart America’
Program aims to improve cardiac arrest survival rates
Results from Take Heart America

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Control (N = 1063)</th>
<th>Intervention (N = 247)</th>
<th>OR (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC</td>
<td>40 (38%)</td>
<td>116 (47%)</td>
<td>1.46 (0.90, 2.40)</td>
<td>0.129</td>
</tr>
<tr>
<td>Hospital discharge:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>9 (8.5%)</td>
<td>48 (19%)</td>
<td>2.60 (1.19, 6.26)</td>
<td>0.011</td>
</tr>
<tr>
<td>CPC Score</td>
<td>1.63 ± 0.52</td>
<td>1.38 ± 0.70</td>
<td>N/A</td>
<td>0.341</td>
</tr>
</tbody>
</table>

Survival rates with good brain function doubled with AHA-recommended transformative technologies

Lick et al. Crit Care Med 2010

Implementation of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital Cardiac Arrest Improves Patient Survival and Neurological Outcome

Christy L. Hopkins, MD; Chris Burk, NREMT-P; Shane Moser, AAS; Jack Meersman, NREMT-P; Clair Baldwin, NREMT-P; Scott T. Youngquist, MD, MSc

Introduction—Survival from out-of-hospital cardiac arrest (OHCA) varies by community and emergency medical services (EMS) system. We hypothesized that the adoption of multiple best practices to focus EMS crews on high-quality, minimally interrupted cardiopulmonary resuscitation (CPR) would improve survival of OHCA patients in Salt Lake City.

Methods and Results—In September 2011, Salt Lake City Fire Department EMS providers underwent a systemwide restructuring of care for OHCA patients that focused on the adoption of high-quality CPR with minimal interruptions and offline medical review of defibrillator data and feedback on CPR metrics. Victims were directed to ST-elevation myocardial infarction receiving centers.

Prospectively collected data on patient survival and neurological outcome for all OHCAs were compared.

In the postintervention period, there were 407 cardiac arrests with 65 neurologically intact survivors (16%), compared with 330 cardiac arrests with 25 neurologically intact survivors (8%) in the preintervention period.

Conclusions—A multifaceted protocol, including several American Heart Association best practices for the resuscitation of patients with OHCA, was associated with improved survival and neurological outcome.

(J Am Heart Assoc. 2016;5:e002892
doi: 10.1161/JAHA.115.002892)

Key Words: cardiac arrest • emergency medical services
Implementation of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital Cardiac Arrest Improves Patient Survival and Neurological Outcome

How Long Should We Perform CPR?
Automated CPR Plays an Important Role in Transport

- Transport (AHA recommended)
- Prolonged resuscitations (rescuer fatigue)
- Helps maintain high quality CPR
- Understaffed crews
- Cath lab

Autopulse

Thumper Michigan Instrumental Life-Stat

LUCAS

Defibtech Lifeline ARM
High Quality CPR

68 Minutes with Automated CPR + ITD

Compliance

Challenge

Opportunity
Systems Approach to Cardiac Arrest in Alameda County, CA

Cardiac Arrest Survival

Ventricular Fibrillation / Pulseless Ventricular Tachycardia

Enhancements for Prehospital Cardiac Arrest Resuscitation

Compliance is a Challenge

<table>
<thead>
<tr>
<th></th>
<th>Full Bundle (ITD, automated CPR, and TH)</th>
<th>No Bundle (No ITD, no automated CPR, no TH)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All rhythms</td>
<td>37.8% (34/90)</td>
<td>12.1% (132/1090)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>VF</td>
<td>62.5% (20/32)</td>
<td>29.1% (60/206)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Non-VF</td>
<td>24.1% (14/58)</td>
<td>8.1% (72/884)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Survival to Hospital Discharge with CPC≤2

<table>
<thead>
<tr>
<th></th>
<th>All rhythms</th>
<th>VF</th>
<th>Non-VF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>25.3% (21/83)</td>
<td>51.7% (15/29)</td>
<td>11.1% (6/54)</td>
</tr>
<tr>
<td>P-value</td>
<td>0.001</td>
<td>0.004</td>
<td>0.054</td>
</tr>
</tbody>
</table>

Only 10% of patients were treated with the full bundle
What’s Next?

ResQ Trial: 2 CPR Methods

Standard CPR (S-CPR)  ACD-CPR + ITD (ACD+ITD)

versus
**Blood Flow to Heart and Brain**

**Porcine V-Fib Model**

![Graph showing blood flow to heart and brain](image)

**ACD+ITD work synergistically to achieve desired effect**


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**Mechanism of Benefit**

ACD+ITD lowers ICP faster and for a longer duration during CPR

![Graph showing mechanism of benefit](image)

Metzger et al. Critical Care Medicine, 2012
Mechanism of ACD-CPR + ITD
(from pig studies)

- Lowers intrathoracic pressure
- Enhances venous return to right heart
- Lowers ICP
- Increases cerebral and coronary perfusion and circulation

Prior ACD+ITD Human Trials

Four European clinical trials in out-of-hospital cardiac arrest (OHCA) subjects showed that ACD+ITD:

1. Augmented hemodynamics and circulation (ACD +/- ITD)
   n=21 subjects; Plaisance et al., Circulation 2000;101:989

2. Lowered intrathoracic pressures (ACD +/- ITDs: facemask vs. ET tube)
   n=13 subjects; Plaisance et al., Critical Care Medicine 2005;33:990

3. Increased 1-hour survival (witnessed) (S-CPR vs. ACD+ITD)
   n=210 subjects; Wolcke et al., Circulation 2003;108:2201

4. Increased 24-hour survival (ACD +/- ITD)
   n=400 subjects; Plaisance et al., Resuscitation 2004;61:265

ResQCPR improved hemodynamics and short-term survival vs. controls
The ResQ Trial
A Pivotal Trial comparing S-CPR vs ACD+ITD

- Randomized, prospective, multicenter (7 US sites)
- NIH-funded
- Compliant with NIH and FDA regulations
- Oversight: DSMB and CEC
- Compared ACD+ITD versus S-CPR in 2470 subjects with out-of-hospital non-traumatic cardiac arrest

Aufderheide et al. Lancet 2011;377:301-311

One Year Survival

<table>
<thead>
<tr>
<th></th>
<th>S-CPR</th>
<th>ResQCPR</th>
<th>Relative Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac etiology (n=1655)</td>
<td>6.0% (48/794)</td>
<td>9.0% (74/822)</td>
<td>49%</td>
</tr>
<tr>
<td>All patients (n=2470)</td>
<td>5.8% (68/1171)</td>
<td>7.8% (96/1233)</td>
<td>34%</td>
</tr>
</tbody>
</table>

First Medical Device approved by FDA to increase likelihood of survival after non-traumatic cardiac arrest
Greg was our EP Fellow in 2007
He is currently practicing in Houston

What can We do today to increase survival rates?

- Focus on quality CPR
  - Compression rate – use CPR feedback
  - Compression depth 2 inches – use CPR feedback
  - Full and rapid RECOIL – use CPR feedback or active decompression CPR
  - Correct ventilation rate/volume
- 30:2 for BLS
- ITD and ACD-CPR
- Automated CPR + ITD
Potential Future Advances

Better FLOW
- Head up CPR to enhance brain flow
- Peri-shock care/ PEA with synchronized CPR
- Ongoing CPR to the cath lab and ECMO
- Post-resuscitation active (a) IPR improves brain flow

Better HEALING
- Reperfusion injury protection
- More rapid cooling for neuro-protection

The Inspiration
A Problem in South Korea
Head Up vs Head Flat CPR

Inherent Limitation of Flat CPR

Chest compressions increase arterial and venous pressures simultaneously, delivering a bidirectional high pressure compression wave to the brain with every compression.

What is the optimal head position during CPR?

Hypothesis:

In cardiac arrest, elevation of the head with simultaneous use of CPR circulatory enhancement technologies (e.g. ITD) will reduce cerebral venous pressure, lower ICP, and improve outcomes.
Supine 0° CPR + ITD  30° Whole Body Tilt Head Down CPR + ITD

Change of position (CPR rate 100/min)

Supine 0° CPR  30° Whole Body Tilt Head Up CPR + ITD

Change of position (CPR rate 100/min)
Head-Up CPR: Effect on Mean ICP

ICP decreases with head elevation during CPR + ITD
Debaty et al. Resuscitation, 2015

Brain Blood Flow Depends on Head Position

Brain blood flow is highest with head up CPR + ITD
Conclusions re: Head Up CPR

1. A potential breakthrough in understanding how to save the brain during CPR.
2. Head up CPR with the ITD enhances cerebral circulation by increasing blood flow to the brain and lowering resistance to blood flow within the brain.
3. Further research is needed.

9/22/2016 Why Rialto Fire Department sees heart attack survival rates 3 times above national average

http://www.sbsun.com/health/20160920/whyrialtofiredepartmentseeshartattacksurvivalrates3timesabovenationalaverage
San Bernardino County Sun (http://www.sbsun.com)
By Jim Steinberg, The Sun

Tuesday, September 20, 2016
RIALTO >> The Fire Department here has seen survival rates for sudden cardiac arrest that are three times the national average. The department credits its focused planning effort that has resulted in new procedures and the acquisition of specialized equipment.

“There is no single element of what we were trying to do here that is a silver bullet, but the combination of approaches is showing great results,” said Fire Chief Mat Fratus.
The survival rate for Rialto is 32 percent with a five year goal of increasing to 50 percent or more, Fratus said.
9/22/2016 Why Rialto Fire Department sees heart attack survival rates 3 times above national average

“Here are some of the elements in Rialto’s success:

• Automated CPR resuscitation systems that allow department responders to provide other services while machine delivers CPR.
• Heads up CPR allowing improved blood circulation and oxygen delivery to the brain.
• Use of ResQPOD device, which serves as a regulator to restrict unnecessary airflow into the chest during CPR. This improves blood flow to the brain, fire officials say.
• Rapid response time and bystander CPR.”

URL: http://www.sbsun.com/health/20160920/whyrialtofiredepartmentseesheartattacksurvivalrates3timesabovenationalaverage

Better Perfusion to and in the Cath Lab and Beyond
Recent Case

Message from Dr. Yannopoulos – January 31, 2016:

“Back after two vessel angioplasty!!!!

Great CPR Etco2 in the 40s
Ph 7.05
Let's hope he will do good

Great job Gents!!
He had no chance without the ECMO
100% death!
He was on ECMO for 45 min before he had ROSC after PCI”

Minnesota Resuscitation Consortium’s Advanced Perfusion and Reperfusion Cardiac Life Support Strategy for Out-of-Hospital Refractory Ventricular Fibrillation

Demetris Yannopoulos, MD; Jason A. Bartos, MD, PhD; Cindy Martin, MD; Ganesh Raveendran, MD, MPH; Emil Missov, MD, PhD; Marc Conterato, MD; R. J. Frascone, MD; Alexander Trembley, BS; Kevin Sippreil, MD; Ranjit John, MD, PhD; Stephen George, MD, PhD; Kathleen Carlson, MD; Melissa E. Brunsvold, MD; Santiago Garcia, MD; Tom P. Aufderheide, MD

Seventy-eight percent of patients survived to hospital admission and 55% (10 of 18) survived to hospital discharge, with 50% (9 of 18) achieving good neurological function (cerebral performance categories 1 and 2). No significant ECMO-related complications were encountered.

Conclusions—The MRC refractory VF/VT protocol is feasible and led to a high functionally favorable survival rate with few complications. (J Am Heart Assoc. 2016;5:e003732 doi: 10.1161/JAHA.116.003732)
Opportunity

For all patients between 18-75 years of age, 50% more could be alive and functional with today’s technologies!

Reperfusion Injury Protection

THE NEW ENGLAND JOURNAL OF MEDICINE

REVIEW ARTICLE

MECHANISMS OF DISEASE

Myocardial Reperfusion Injury

Derek M. Yellon, D.Sc., and Derek J. Hausenloy, Ph.D.

Coronary heart disease is the leading cause of death worldwide, and 3.8 million men and 3.4 million women die of the disease each year. After an acute myocardial infarction, early and successful myocardial reperfusion with the use of thrombolytic therapy or primary percutaneous coronary intervention (PCI) is the most effective strategy for reducing the size of a myocardial infarct and improving the clinical outcome. The process of restoring blood flow to the ischemic myocardium, however, can induce injury. This phenomenon, termed myocardial reperfusion injury, can paradoxically reduce the beneficial effects of myocardial reperfusion.

From the Heart and Cardiovascular Institute, University College London Hospital and Medical School, London. Address reprint requests to Dr. Yellon at the Heart and Cardiovascular Institute, University College London Hospital and Medical School, 67 Clarendon Mews, London WC1E 6HX, United Kingdom, or at derek.yellon@ucl.ac.uk.

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Systematic Approach to Survival after Cardiac Arrest
A Bundled-Approach to Organ Preservation

<table>
<thead>
<tr>
<th></th>
<th>Optimize Perfusion</th>
<th>Minimize Cellular Permeability</th>
<th>Restore Blood Brain Barrier</th>
<th>Optimize Intra-cellular Metabolism and Biochemistry</th>
<th>Minimize Post-Resuscitation Injury Cascades</th>
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</thead>
<tbody>
<tr>
<td>CPR Devices and Head Position</td>
<td>X</td>
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<tr>
<td>Synthetic surfactants</td>
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<td>Anesthetics, Inert gases, Cyclosporin A, Valproic Acid, other</td>
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<td>Hypothermia</td>
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<td>Revascularization</td>
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</tr>
</tbody>
</table>

Lurie et al 2015 Anesthesia and Analgesia

After 50 + years

- We have made some progress.
- We are still at the beginning.
- The unexpected detours are as important as the planned route.
- With our better understanding of CPR and new devices we must save more lives.
Little Serenity Joy:
15 months old and status post in utero
Take Heart America CPR
Take Heart America Save

Best Practice
Celebrate your saves
Track your outcomes

Thank You!

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