Resuscitating Resuscitation

Charles Lick MD
Robert Kempenich
Janet Steinkamp
- >240,000 ED patients/year
- Fairview Southdale
- Fairview Ridges
- Methodist
- Mercy
- Unity
- Buffalo
Allina Medical Transportation

- Serving 75 communities and 9 counties
- 58,000 ambulance responses annually
- A leader and innovator in emergency medical services
- More than 370 dedicated employees
- Providing priority medical dispatch and 911 pre-arrival instructions
- Providing 911 emergency and scheduled ambulance service, Greater Minnesota Ride Program and specialized wheelchair transport
What is Sudden Cardiac Arrest (SCA)?

- Electrical system in the heart malfunctions
- Heart unexpectedly and abruptly stops beating
- Usually caused by an abnormal heart rhythm called *Ventricular Fibrillation*
Is SCA the Same as a Heart Attack?

- NO

- A heart attack is the death of heart muscle tissue caused by a blockage in the arteries that supply blood to the heart.
Is There Any Treatment for Ventricular Fibrillation (VF)?

The only effective treatment for VF is an electrical shock delivered by a defibrillator.

- CPR (Cardiopulmonary Resuscitation) can help maintain the flow of oxygen to the brain and vital organs, but
- CPR cannot convert VF to a normal rhythm.
How Serious is SCA?
(Deaths per year in the U.S.)

Sudden Cardiac Arrest

- Prevalence
  - 1000/day in-hospital
  - 1000/day out-of-hospital

- Almost always fatal
  - In-hospital survival rate: ≈ 20%
  - Out-of-hospital: 5%

- Adequate blood flow to vital organs is the key to patient survival and quality of life.
> 40+ Years of CPR
Cardiac Arrest Today:

Nearly Everyone Dies
Average 5% Survival rate

10 - 20% of normal blood flow to the heart
20 - 30% of normal blood flow to the brain
Toilet plunger successful in CPR
Toilet plunger inspires improved CPR

UCSF invention may help revive heart attack victims

By Leslie Prichep, Staff Writer

A UCSF invention may help revive heart attack victims, according to a new study. The invention, called the "HeartSaver," was developed by a team of researchers led by Dr. Michael J. Pichard. The device uses a novel mechanism to deliver a high-pressure shock to the heart in an attempt to restart it.

The HeartSaver is a small, handheld device that can be used by anyone to deliver the shock. The researchers tested the device on a group of volunteers and found that it was able to successfully restart the heart in 80% of cases. The device is currently undergoing further testing and is expected to be available for sale in the near future.

The researchers hope that the HeartSaver will become a widely used tool for treating heart attacks, as it can be used by anyone with no special training. They are also working on developing a version of the device that can be used in hospital settings.

The study was published in the journal Circulation. The researchers are now planning to conduct a larger trial to further test the effectiveness of the HeartSaver in real-world settings.

Source: UCSF
A 4-site Demonstration Project in Austin TX, Columbus OH, Anoka County MN, and St. Cloud MN deploying recent advances in resuscitation science to dramatically increase resuscitation rates after cardiac arrest.
Multi-Level Efforts

- Widespread CPR Training (e.g. CPR Anytime)
- AEDs
- Public Education

Lay Public

First Responder

Survival

Hospital

EMS

- Rapid Response
- Start CPR immediately
- Rapid AED application
- High Quality CPR
- ITD (ResQPOD)

Resuscitation Centers of Excellence
- Hypothermia
- 24/7 Revascularization
- ICDs

- High Quality CPR
- IO drug delivery prn
- ITD (e.g. ResQPOD)
- Automated CPR Devices
### Intervention Outcome Relationships in Take Heart America

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Effect</th>
<th>Expected absolute survival rate ↑ over baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bystander CPR &lt;br&gt;CPR Anytime in schools, homes &amp; public meeting places</td>
<td>• Rapid EMS notification  &lt;br&gt;• Start circulation</td>
<td>2 - 5%</td>
</tr>
<tr>
<td>AED Use &lt;br&gt;Widespread strategic AED deployment</td>
<td>• Reduce time to 1st shock in VF patients</td>
<td>4 - 6%</td>
</tr>
<tr>
<td>Improved CPR Quality &lt;br&gt;Prevent hyperventilation, continuous chest compressions, CPR pre/post shock, intra-osseous drug delivery</td>
<td>• Increase circulation to heart &amp; brain  &lt;br&gt;• Increase O₂ &amp; drug delivery</td>
<td>4 - 6%</td>
</tr>
<tr>
<td>Impedance Threshold Device (ITD) e.g. ResQPOD BLS &amp; ALS deployment</td>
<td>• Increase circulation to heart &amp; brain  &lt;br&gt;• Increase O₂ &amp; drug delivery</td>
<td>5%</td>
</tr>
<tr>
<td>Cooling &amp; Cardiology F/U &lt;br&gt;Standard hypothermia protocols, cardiac angiography &amp; EP evaluation</td>
<td>• Revascularization  &lt;br&gt;• Prevent sudden cardiac death</td>
<td>5 - 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 - 32%</td>
</tr>
</tbody>
</table>
Renewed Focus on CPR

- CPR is Important

- Bystander CPR doubles survival of OOH arrest
- Beneficial prior to defibrillation of prolonged VF
  - Till the very last second
- Beneficial immediately post-defibrillation
  - To “prime heart” for next defibrillation attempt
- To treat PEA
Renewed Focus on CPR

Not enough people get CPR

- Only 1/3 of OOH sudden cardiac arrest victims get CPR prior to EMS arrival (peds and adults)

Renewed Focus on CPR

Not enough people who get CPR, get good CPR

- Too few chest compressions
- Chest compressions are too weak
- Too many ventilations
- Too many interruptions
This life was saved by someone who knew CPR.
Key New Resuscitation Interventions

- Widespread public CPR training and public awareness
  - AHA’s *CPR Anytime for Family & Friends*
  - E.g. Junior and senior high school students, family members of high-risk patients
  - Survivor network participation
  - St Cloud– all 9th graders/families trained CPR
CPR. A lifesaving action.

Two steps to save a life.

1) Call 911
2) Push hard and fast in the center of the chest.
100 BPM

- 1979
- #1 Song
- Stayin’ Alive
100 BPM

- Queen
- “Another One Bites The Dust”
More Rapid Response of Critical Elements

- Widespread automatic external defibrillator (AED) deployment
AEDs Improve Survival

Survival vs. Time*

Chance of survival reduced 7-10% each minute

Heart Safe Communities

> 1000 AEDs

- 2001 Start
- MSP Airport
  - 65 AEDs - United Hospital Foundation
- NW Metro
  - Mercy Unity Foundation - > 140 AEDs
    - Elk River 20 AEDs
- Churches
- Businesses
- Schools
Heart Safe Communities

- AED Package $1500-$2200
  - AED
  - Wall Mount Cabinet
  - Site Visit
  - CPR-AED Training
  - Program Assistance
Key New Resuscitation Interventions

Improved CPR devices
e.g. Impedance threshold Device [ResQPOD™] & techniques for EMS that double circulation and monitor CPR quality
How CPR Causes Forward Blood Flow

Compression Phase

Cardiac Pump Theory
- Heart is squeezed between sternum & spine.

Thoracic Pump Theory
- Chest acts as a bellows: compression causes a positive pressure that forces blood out of the heart (cardiac output).
Decompression Phase

- A small, but important, vacuum (negative pressure) forms in the chest relative to atmospheric pressure, drawing blood back into the chest and heart.
- The more blood that returns to the heart (preload), the more that is circulated forward (cardiac output) on the next compression.
- Conventional CPR is inherently inefficient because the vacuum is quickly equalized through an open airway.
Greater vacuum (negative pressure) in the chest during chest compressions, which leads to...

Conventional CPR

Conventional CPR w/ ResQPOD

Ventilation

Enhanced vacuum

Chest compressions
Chest Decompression (Chest Wall Recoil)

ResQPOD prevents the influx of unnecessary respiratory gases into the chest, enhancing the negative pressure (vacuum) in the chest.

Chest Compression

Patient can freely exhale.

Patient Ventilation

Patient can be freely ventilated.

Spontaneous Breathing

Air will enter patient if at least -10 cmH₂O pressure is generated during breathing.
Greater venous return (preload) and coronary blood flow, which leads to...

Greater cardiac output on the next compression, which leads to...

Improved blood flow to vital organs.
A Tale of Seven EMS Systems: An Impedance Threshold Device and Improved CPR Techniques
Double Survival Rates after Out-of-hospital Cardiac Arrest

Authors:
Aufderheide TP, Birnbaum M, Lick C, Myers B, Romig L, Stothert J, Vartanian L.

Sites: Milwaukee WI, Madison WI, Anoka County MN, Wake County NC, Pinellas County FL, Omaha NE, Cypress Creek TX

Presented at the Wolf Creek Resuscitation Conference June 2007.
To be presented and published at the American Heart Association Scientific Sessions November 2007
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<td>15.7%** (n=893)</td>
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<td>40/232 (17.2%)</td>
<td>62/221 (28.1%)*</td>
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<td>28/624 (4.5%)</td>
<td>29/358 (8.1%)**</td>
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*p<0.01 for all patients and VF patients

**p<0.03 for non-VF patients
Better CPR

- CPR before and after Shock
- Devices for circulation double circulation
- Control ventilation rate and volume
- Hand position and Chest wall recoil

All 911 responders (including police) carry and AED and ITD and have continuous retraining
New AHA CPR Guidelines

- Nov 2005
- Emphasis on Chest Compressions/Improving Blood Flow

- www.amtems.com/newcpr
Nothing New after all these years....
Its time to finally move ahead
For 50 years we have been sitting here: It's time to finally move ahead.
Arctic Sun Device

- Non-invasive thermal regulating system
- Circulating water temperature ranges between 4-42°C
- Machine monitors and adjusts to the patients core temperature every minute
- Can decrease patient temperature by 1.4°C/hr
Key New Resuscitation Interventions

Post-resuscitation protocols for induced hypothermia, coronary revascularization & implantable defibrillators
St Cloud Experience
Cardiac Arrest at Sunday dinner
911
Sartell MN Fire Department
New CPR + ResQPOD
AED Defibrillation
Comatose and seizure in ER
24 hour cooling
Implantable defibrillator for undiagnosed cardiomyopathy
Back at work full time within 3 weeks
Children 8 and 10 and very happy
22th Take Heart America SAVE in St. Cloud, MN!
A Tale of Seven EMS Systems: An Impedance Threshold Device and Improved CPR Techniques Double Survival Rates after Out-of-hospital Cardiac Arrest

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## Hospital Discharge Results

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* p<0.01 for all patients and VF patients

** p<0.03 for non-VF patients
Dawn,

I just wanted to give you a brief update on the impact that ResQPod is having around St. Dominic. This device is having what is probably the biggest impact on influencing the outcomes of "code situations" of anything I've ever used in my 25 years in the field. At first I was honestly a little skeptical but when I took time to think through it, it seemed to make a lot of sense! The results we've seen have confirmed those suspicions.

I'm not sure what success is being seen in other places, but we're excited what is happening here. Just thought we would let you know!

Take care,

Ken Thigpen, BS, RRT
Administrative Director, Pulmonary Services
St. Dominic Hospital
Jackson, MS
Inhospital Cardiac Arrest

Return of Spontaneous Circulation

<table>
<thead>
<tr>
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<th>Old CPR</th>
<th>New CPR + ITD</th>
</tr>
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<tbody>
<tr>
<td>N</td>
<td>157</td>
<td>136</td>
</tr>
<tr>
<td>%</td>
<td>33%</td>
<td>58%</td>
</tr>
</tbody>
</table>

75% Improvement
Odds ratio: 2.80
95% CI: 1.69, 4.64
P<0.001

Thigpen et al. accepted for presentation: ACEP’s - April 2008
Inhospital Cardiac Arrest

Survival to Hospital Discharge

- Old CPR: N = 157, 17% survival
- New CPR + ITD: N = 136, 28% survival

62% Improvement
Odds ratio: 1.87
95% CI: 1.03, 3.41
P = 0.034
In-hospital Cardiac Arrest with the ResQPOD and New CPR:
St. Cloud Hospital, St. Cloud MN

Code Blues and Survivors January 2005 thru Present

ResQPOD + New CPR
In-hospital Cardiac Arrest with the ResQPOD and New CPR: St. Cloud Hospital, St. Cloud MN

Code Blue Survival Rates January 2005 to Present

Survival Rate / Month

ResQPOD + New CPR
We had our first therapeutic hypothermia patient admitted on Monday. He had a witnessed arrest at around 1pm Monday and was in ICU by 3:30pm. The lines were placed, paralytics/sedatives started and the cooling blanket applied by 4:30pm. He reached the goal of 92.3 degrees by around 7pm. On admission he was comatose and decorticating. Last night at 7pm we started rewarming him. He was normo-thermic this morning. His drips were weaned and his initial responses were the same as pre-cooling - comatose, decerebrating, similar eye movements. About 11am he woke up - and I mean woke up! He is tracking, following commands, even gave his family a thumbs up! He looks great!

Roberta Basol
Novel Minnesota heart project saves lives
By Maura Lerner, Star Tribune, Minneapolis October 25, 2007

Sauk Rapids-Rice High School freshman Coney Smith, right, got help from cardiac arrest survivor Bob Kempenich, age 52, during CPR training at school
Take Heart St. Cloud, MN patient (Heather, age 29) and family treated in Spring 2006

Data from Take Heart America Program in St. Cloud from Dec ’05 – Jan ‘08

83 patients with out-of-hospital cardiac arrest from all causes treated:
  53% alive and well
49 patients with VF witnessed prehospital arrest: 63% alive and well
This represents a 131% increase in survival over 12 months prior to Take Heart St. Cloud

(presented at AHA Nov 2007)
Robin experienced cardiac arrest on December 17, 2007 in Pequot Lakes, MN. She had a prior history of a heart valve replacement after having rheumatic fever as a child. She was out for the evening when she suddenly fell to the ground. 911 was called and a young man started bystander CPR.

When emergency personnel arrived they continued CPR and used a defibrillator to shock her. A helicopter landed outside the restaurant on the street and she was then airlifted by directly to the St. Cloud Hospital. She arrested again 10 minutes away from the hospital but this time could not be resuscitated with CPR and shock therapy. She received new CPR in the emergency department with the ResQPOD circulatory enhancer device and an automated CPR device called the LUCAS for 49 minutes. After finally regaining a pulse she was transported to the Central MN Heart Center Cath Lab where she received a stent and was then cooled for 24 hours in the Cardiac Care Unit. Warming was initiated early in the day on December 20, 2007 – her 46th birthday.

On Christmas Robin told her husband, ‘these new clothes are very nice but I would have preferred a diamond’.
Allina Experience
Mercy Hospital Cooling Experience

- 20 pts over 12 months

  - 11 VF/VT arrest
    - 82% had good CNS outcome
      - 9 disch home
      - 2 died (1 had met Ca colon, 1 had extensive IHD) (Death rate- 18%)

  - 9 Asystole/agonal rhythm/PEA
    - 11% had good CNS outcome
      - 6 expired (Death rate – 66%)
      - 1 comfort care only
      - 1 long term care
      - 1 disch home
### Randomized, controlled trials

#### Outcomes in Rx vs control groups

<table>
<thead>
<tr>
<th></th>
<th>Good neuro outcome (disch home or to rehab)</th>
<th>Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercy VF/VT group</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td>9 hosp European study</td>
<td>55% vs 39%</td>
<td>41% vs 55%</td>
</tr>
<tr>
<td>273 pts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australian study 77 pts</td>
<td>49% vs 26%</td>
<td>51% vs 68%</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
Allina Hospitals and Clinics

● Abbott Northwestern
● United
● Mercy/Unity

● Level One Heart Attack- STEMI – “RAT”
● Hypothermia
● ResQPod
### Allina Cardiac Arrest 2007 Hypothermia Patients

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercy Hospital</td>
<td>53%</td>
</tr>
<tr>
<td>Abbott Northwestern</td>
<td>48%</td>
</tr>
<tr>
<td>United</td>
<td>80%</td>
</tr>
</tbody>
</table>

- Majority from out state
## Allina Medical Transportation Experience

- **Jan 2006 ResQPod – “New CPR”**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Resus. Attempts</th>
<th>ROSC</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>532</td>
<td>307</td>
<td>33%</td>
<td>9.2%</td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td>294</td>
<td></td>
<td>14.4%</td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
<td>15.5%</td>
</tr>
</tbody>
</table>
Dawn, age 34, had a cardiac arrest. Her husband, an EMT, started CPR. After a 35 minute resuscitation that included use of the ResQPOD, she was brought to Mercy Hospital. After cooling she woke up but her heart was so bad she was transferred to the U of Minn for a heart transplant. She is back to work at Wells Fargo and never needed a heart transplant.
Ben is 21. He stayed up late to watch the Stanley cup playoffs in 2006. Mom, a night nurse, was home that night.

At 3 AM the dog started barking and Ben’s brother woke up to let him outside, only to realize the dog did not need to relieve himself but wanted to alert the family about Ben, who was breathing with irregular loud groaning noises.

Ben was in cardiac arrest.

911 was called, mom started CPR, police responded with an AED but he remained in cardiac arrest. Allina EMS arrived and used the ResQPOD in conjunction with defibrillation.

Ben was brought to Mercy Medical Center comatose, underwent therapeutic hypothermia, and recovered totally. Ben is currently a marketing major at UMD, getting As and Bs. He has an ICD.

When it all works, it is miraculous!
A plan: ‘Take Heart America’

Program aims to improve cardiac-arrest survival rates

By Robert Davis
USA TODAY

AUSTIN — Here in the heart of Texas, a grass-roots effort is taking shape that doctors believe could double survival from one of the nation’s leading killers: sudden cardiac arrest.

The pilot program Take Heart America, which is being launched in Austin, St. Cloud, Minn., and Columbus, Ohio, is designed to combine simple steps that improve cardiac-arrest survival and apply them as a cohesive effort involving citizens, rescuers and doctors.

The doctors and researchers who make a difference, but taken together they make a bigger difference,” says Keith Lurie, an electrophysiologist at the Central Minnesota Heart Center at St. Cloud Hospital who helped develop Take Heart America. “We’re putting simple technology in a package and delivering it to a community.” If it dramatically increases survival rates, the team will deliver a blueprint to any city that wants it, Lurie says.

Sudden cardiac arrest claims 900 lives a year, the American Heart Association says. The survival rate is low: The national average is 5%.

Take Heart America, coordinated by a
LUCAS in action
Mercy Unity Hospital Foundation

$500,000 over 2 years
Robert Kempenich
Lessons from Europe

No Resuscitation Center ('96-'98)
  neurologically intact neuro survival: 15/58 (26%)

Resuscitation Center Concept
  neurologically intact neuro survival: 34/61 (56%)
  [thrombolytics (49%)cooling (77%)/PCI (77%)]

Sunde et al. Resuscitation 2007; 7329-39
Pushing the Envelop: Treating Patients with Neurological Awakening like STEMIs

Patients with signs of neuro activity during CPR who cannot be resuscitated after 30 min of should go straight to the cath lab while getting automated CPR

- Witnessed arrest, short down time before some CPR started (<3min)
- Younger and otherwise functional (<70 y.o.)
- Neuro activity during CPR (pulling tube, opening eyes, moving limbs, gasping develops)
- No known other untreatable co-morbidities
Experience in Europe

55 y.o. Michelin Man
ST seg elevation on ECG
VF
30 min CPR with ITD + LUCAS – no Return of Spontaneous Circulation
Cath lab with ongoing CPR, open LAD, resuscitation
Back to work
Where do we go from here?

- Constitute National Coalition to Develop Level 1 Cardiac Arrest Resuscitation Center Protocols and Guidelines
  - Cooling
  - Cardiac Catheterization
  - Critical Care
  - EPS and ICDs
  - Technologies to maintain pump support
  - Train the next generation of MDs/RNs
- State and Federal Policy on Quality
- Tie outcomes to reimbursement
- Mandates
2009-2012?
Multi-Level Efforts

- Widespread CPR Training (e.g. CPR Anytime)
- AEDs
- Public Education

Lay Public

First Responder

Survival

Hospital

EMS

- Rapid Response
- Start CPR immediately
- Rapid AED application
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- High Quality CPR
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Resuscitation Centers of Excellence
- Hypothermia
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Survivors