OUT-OF-HOSPITAL CARDIAC ARREST CARE

CONTROVERSIES AND NON-CONTROVERSIES

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Professor of Emergency Medicine, Univ of Pittsburgh

DISCLOSURE: POTENTIAL CONFLICTS

• MEDICAL ADVISORY BOARD, OXYSURE SYSTEMS INC, FRISCO, TX
• MEDICAL DIRECTOR AND CO-FOUNDER, SUDDEN CARDIAC ARREST ASSOCIATION
THE FACES OF SUDDEN DEATH

http://kenheart.org/html/memorials.html

Overall survival = 7.9%

Table 4. Incidence and Outcome of EMS-Treated Out-of-Hospital Cardiac Arrest

<table>
<thead>
<tr>
<th></th>
<th>Alabama (n = 267)</th>
<th>Dallas (n = 1296)</th>
<th>Iowa (n = 801)</th>
<th>Milwaukee (n = 1386)</th>
<th>Ottawa (n = 575)</th>
<th>Pittsburgh (n = 750)</th>
<th>Portland (n = 796)</th>
<th>Seattle (n = 1170)</th>
<th>Toronto (n = 1504)</th>
<th>Vancouver (n = 1186)</th>
<th>Overall</th>
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<tbody>
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<td>Adjusted incidence rate per 100,000</td>
<td>40.3</td>
<td>82.9</td>
<td>51.3</td>
<td>38.7</td>
<td>45.1</td>
<td>51.1</td>
<td>47.0</td>
<td>74.4</td>
<td>57.0</td>
<td>52.8</td>
<td>66.0</td>
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<td>Adjusted mortality rate per 100,000</td>
<td>96.9</td>
<td>77.2</td>
<td>44.4</td>
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<td>47.1</td>
<td>41.0</td>
<td>62.3</td>
<td>50.6</td>
<td>46.9</td>
<td>50.0</td>
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<td>Cause-fatality rate, %</td>
<td>91.7</td>
<td>92.6</td>
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<td>Survival to discharge, %</td>
<td>3.2</td>
<td>4.5</td>
<td>11.0</td>
<td>9.7</td>
<td>5.3</td>
<td>7.0</td>
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<td>16.3</td>
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Abbreviations: EMS, emergency medical services. *All rates were unequal across sites except P < .001.
HIGH PERFORMANCE CPR

4-Person Pit Crew CPR Example (2 BLS and 2 ALS)

**POSITION 1 (BLS)**
- Access patient and start CPR
- Alternate 100 compressions with rescue breaths
- Maintain full cycle every 15 compressions

**POSITION 2 (BLS)**
- Attach monitor/defibrillator pads
- Alternate 100 compressions with ventilation
- Maintain full cycle every 15 compressions

**POSITION 3 (ALS)**
- Administer medications or alternative therapy
- Apply CPR
- Monitor chest/Kick immediately after each 25 compressions
- Perform 25 compressions and 2 ventilations
- Monitor capnography, if available

**POSITION 4 (ALS Team Leader)**
- Start CPR
- Administer ACLS therapies
- Administer airway
- Administer ventilations
- Consider intubation
- Use CPR monitor

**KET**
- Brisk
- Circulation/Arterial
- Peripheral/Distal
- I.V. for resuscitation devices
- Allograft Urgent Care

*HeartLander*
Current survival

TO BREATHE OR NOT TO BREATHE?
VENTILATION IN THE 1700’S: BLOWING SMOKE UP YOUR...

A brave German doctor administers an enema of tobacco smoke to a corpse in this curious late eighteenth-century plate.

CPR WITH CHEST COMPRESSION ALONE OR WITH RESCUE BREATHING (SEATTLE)

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<th>Outcome</th>
<th>All Sites</th>
<th>Two Sites Assessing Neurologic Status</th>
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<tr>
<td></td>
<td>Chest Compression Alone (N=981)</td>
<td>Chest Compression plus Rescue Breathing (N=960)</td>
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<td>no. of patients/total no. (%)</td>
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<td>percentage points</td>
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<td>P Value</td>
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<td>Pulse present at end of EMS care</td>
<td>335/962 (34.8)</td>
<td>296/942 (31.4)</td>
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<td>3.4 (-0.8 to 7.6)</td>
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<td>Survival to hospital discharge</td>
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<td>105/956 (11.0)</td>
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<td>1.5 (-1.4 to 4.4)</td>
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<td>CPC 1 or 2 at hospital discharge</td>
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<td>94/653 (14.4)</td>
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<td>73/633 (11.5)</td>
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<td>2.9 (-0.8 to 6.5)</td>
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<td>0.13</td>
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CI denotes confidence interval, and EMS emergency medical services.
† The absolute difference in outcome between the two groups was derived by subtracting the value for the group assigned to chest compressions plus rescue breathing from the value for the group assigned to chest compressions alone.
‡ In the Cerebral Performance Category (CPC) classification, category 1 represents good cerebral performance, 2 moderate cerebral disability, 3 severe cerebral disability, 4 coma or vegetative state, and 5 death.

CHEST COMPRESSION—ONLY CPR BY LAY RESCUERS AND SURVIVAL FROM OUT-OF-HOSPITAL CARDIAC ARREST (ARIZONA)

Table 3. Survival and Odds Ratios for Various Risk Factors

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<tr>
<th>Characteristic</th>
<th>No./Total No.</th>
<th>% (95% CI)</th>
<th>Crude</th>
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<td>Bystander CPR</td>
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<td>Witnessed arrest</td>
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<td>No</td>
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<td>Yes</td>
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<td>Nonshockable</td>
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<td>Shockable</td>
<td>257/1511</td>
<td>17.0 (15.4-19.2)</td>
<td>9.75 (7.52-12.97)</td>
<td>5.16 (3.78-7.05)</td>
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</table>

Survival after Bystander CPR for OHCA in Arizona (2005 to 2010)
Compress Only CPR Advocated and Taught

A. All OHCA
   AOR 1.6 (95% CI, 1.08-2.35)

   Survival to Hospital Discharge
   - Std-CPR: 7.8%
   - COCPR: 13.3%

B. Witnessed/Shockable
   P < 0.001

   Survival to Hospital Discharge
   - Std-CPR: 17.7%
   - COCPR: 33.7%

SO, COMPRESSION-ONLY CPR OK

...FOR LAY RESCUERS / BYSTANDERS

BUT WHAT SHOULD HEALTH CARE PROFESSIONALS DO?

https://www.verywell.com/cardiac-arrest-causes-1258733
• 23,000 patients enrolled
• Compared continuous compressions & asynchronous ventilations 10/min with 30:2 (pause for compressions max of 5 seconds)

**The Results**

• No difference between groups in survival to hospital discharge or neuro status
HYPERVENTILATION-INDUCED HYPOTENSION DURING CPR

- Observational study N=21 (Milwaukee)
- Ventilation rates were too high
- Reproduced in pig lab
- Excessive ventilation leads to:
  - Increased intrathoracic pressure
  - Decreased coronary perfusion
  - Decreased survival rates

Aufderheide T. Circulation 2004

SEARCHING FOR A LIFESAVING POTION
MEDICATIONS PROVEN TO IMPROVE OUTCOME IN CARDIAC ARREST:

- 
- 
- 

TIME TO DRUG IN ANIMAL STUDIES:
- 9.5 MINUTES

TIME TO DRUG IN HUMAN STUDIES:
- 17.7 MINUTES
- RITTENBERGER ET AL 2006; RESUSCITATION 72:201-206.
Survival varies with time – swine model

Probability of ROSC by time to first medication.

Full line: ACLS protocol
Dashed line: CPR with immediate drug cocktail protocol
AKA: “Ninja CPR”

Rittenberger et al. 2007; Resuscitation, 72:154-160.

Time to administration of epinephrine and outcome after in-hospital cardiac arrest and non-shockable rhythms: retroactive analysis of large in-hospital data registry (n=25095)
Donnino M et al.
BMJ 2014;348:g3028
One Year Survival of Patients Randomized to Receive IV Drugs During CPR or NO Drugs
Glassweegen et al
JAMA. 2009 Nov 25;302(20):2222-9

Outcome when adrenaline (epinephrine) was actually given vs. not given – post hoc analysis of a randomized clinical trial
Theresa M. Glassweegen, Lars Wik, Kjetil Sunde, Petter A. Steen
Resuscitation 2012, 83(3): 327–332
EPI

• HOW MUCH?
• HOW OFTEN?
• HOW EARLY?
• SPECIFIC INDICATIONS VS ALL ARRESTS?

DESTINATION (RECEIVING FACILITY)

CLOSEST ED, PCI CENTER, CARDIAC ARREST CENTER?
WHY DID THEY ARREST?

Positive Cardiac Catheterizations by Rhythm

Positive = at least 1 vessel with ≥ 70% lesion

Reynolds et al 2009

ACS COMMON!

• Up to 80% have MI as etiology for CA
• 2 Recent Consults:
  • 33 M with 99% LAD and 70% Circumflex
  • 35 F with 100% RCA
• 12 lead ASAP
• Not IF they need a cath, but WHEN!
CATHETERIZATION DOUBLES GOOD OUTCOMES

- **GOOD OUTCOME FOR**
  - 52 / 96 (54%) CASES WITH CATH VERSUS
  - 36 / 145 (28%) OF CASES WITH NO CATH

- **CATH HAS 2.16 [1.12, 4.19] ODDS RATIO OF GOOD OUTCOME** (AFTER ADJUSTING FOR COMA, HYPOTHERMIA, STEMI, AGE, SEX, IN-HOSPITAL OR OUT-OF-HOSPITAL AND INITIAL RHYTHM)

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**Original Article**

Prognostic Implications of Level-of-Care at Tertiary Heart Centers Compared With Other Hospitals After Resuscitation From Out-of-Hospital Cardiac Arrest

Helle Søholm, MD; Jesper Kjaergaard, MD, PhD, DMSc; John Bro-Jeppesen, MD, PhD; Jakob Harvig Thomsen, MD; Freddy Lippert, MD; Lars Køber, MD, DMSc; Niels A Nielsen, MD, PhD; Magaly Esguiz, MD; Morten Steens, MD; Michael Wanscher, MD, PhD; Finn Michael Karlsen, MD, PhD; Christian Hassager, MD, DMSc

2 Tertiary “Heart” Hospitals
6 Other “non-Heart Hospitals”
In Denmark
N=1393 Cardiac Arrest with No STE
(STEMI automatically goes to heart center)

2 Tertiary “Heart” Hospitals
6 Other “non-Heart Hospitals

Association between treatment at an ST-segment elevation myocardial infarction center and neurologic recovery after out-of-hospital cardiac arrest

Bryan E. Muntana, MD, MAS, a, Deborah B. Diercks, MD, MSc, a Machelle D. Wilson, PhD, b and James F. Holmes, MD, MPH c Sacramento, CA and Davis, CA
“Heart” Hospitals = STEMI Centers

- Mumma (2014) characterized California hospitals by
  - 24/7 PCI capable,
  - >40 OHCA patients per year,
  - Post-arrest temperature plan


Disposition of 7,780 OHCA patients in California

Survival in California after Cardiac Arrest (Mumma 2015)

- Odds ratio for good neurological recovery compared to Non-STEMI center at
  - STEMI center (<40 cases/yr) 1.32 (1.06-1.64)
  - STEMI center (>40 cases/yr) 1.63 (1.35-1.97)

- N=7,725 cases adjusted for all other covariates related to outcome
EMERGENCY CARDIOPULMONARY BYPASS

ECB FUNCTIONS
**ECLS VS STANDARD CPR**

- 3 YEAR PROSPECTIVE OBSERVATIONAL STUDY (TAIWAN)
  - E-CPR=59, C-CPR=113
  - WITNESSED IN-HOSPITAL ARREST WITH CPR>10 MIN.

![Graph showing survival rate to discharge](image)


**IMPLEMENTING ECB IN ED**

- PRE-ARRIVAL NOTIFICATION BY EMS
- CALL CT SURGERY (OR CCM) ATTENDING ON CALL
  - CALL AS EARLY AS POSSIBLE
- REQUIRES PERFUSIONIST—NOT ALWAYS IN HOSPITAL
- PRESERVE VASCULAR ACCESS SITE
  - FEMORAL VEIN AND ARTERY PREFERRED
THE “CHEER” TRIAL

- ALFRED HOSPITAL AND AMBULANCE VICTORIA, MELBOURNE
- MECHANICAL CPR, HYPOThERMIA, ECMO AND EARLY REPERFUSION
- ENROLLED 26 PATIENTS (11-OOH, 15-IN)
- ROSC IN 25
- SURVIVAL TO D/C W/GOOD NEURO RECOVERY – 54%
- PCI – 42%
- PULMONARY EMBOLECTOMY IN 1


INTEGRATION WITH EMS IS CRITICAL

Preplanning is a must—coordinated effort!

Designated hospital(s)

Criteria for patients who may benefit
- Refractory VF
- Hypothermic arrest
- CA or severe shock from drug overdose
- CA with other known potentially reversible cause
- Severe cardiogenic shock
MECHANICAL CPR DEVICES

HELICOPTER TRANSPORT ON ECB
Post Cardiac Arrest Care Program

- Coordination with EMS/referring hospitals
- Maintain cerebral perfusion
  - Blood pressure support
  - Titrated ventilation (CO2)
- Coronary vasculature assessment
- Targeted temperature management
- Neurologic monitoring and support
- Post acute phase: EP, rehab (physical and mental)

This isn’t for everyone…

A good freeze saves lives

1. After a heart attack is noticed, patient receives ice or cold saline solutions delivered quickly through an intravenous line. 
2. Once patient is moved to an intensive care unit, medications begin; one method uses thin pads wrapped around the chest and thighs, over which cold saline solution flows through tubes connected to a computer. 
3. Pads are connected to a computer that regulates the fluid and keeps the patient’s body temperature at about 95 degrees; doctors can also monitor the patient’s core temperature. 
4. After 24 hours, the computer begins to warm the patient slowly, over 42 hours, and the medications that have kept the patient alive are discontinued; doctors watch to see how the patient responds.
VOLUME MATTERS

Table 4
Results of the logistic regression model for in-hospital mortality for patients admitted to the ICU after cardiac arrest.

<table>
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<th>Variable</th>
<th>OR</th>
<th>95% CIs</th>
<th>p value</th>
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<td>Hospital volume (cases/year)</td>
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<tr>
<td>&lt;20</td>
<td>1.00</td>
<td>0.55–1.11</td>
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<td>20–34</td>
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<td>35–50</td>
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<td>≥50</td>
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</table>

Carr BG, et al. 2009 Resuscitation


CENTER FOR POST-ARREST CARE

PROGRAM
1. Written Protocols
2. Multiple Specialties
3. QI Programs
4. Research
5. Education

COMPREHENSIVE CARE
1. Hypothermia
2. Cerebral Blood Flow
3. Use Local Data to Prognosticate
4. Early Cardiac Intervention
5. Systematic Rehabilitation
NOT SO CONTROVERSIAL

IMMEDIATE CPR & CALL TO 9-1-1

EARLY DEFIBRILLATION

HIGH QUALITY CHEST COMPRESSIONS
AN ARMY OF WILLING AND READY CITIZENS

SWEDEN!
• 2.75 million people trained in CPR (9.6 million people in Sweden)

• 65% CPR before EMS arrival

• 15% survival in B-CPR group

• 5% survival in no B-CPR group
UNITED STATES AND CANADA

- AHA NUMBER TRAINED IN CPR
  - ~6% OF US POPULATION (ANNUAL TRAINING OF 18 M / 320 M)
- ROC 2011 DATA
  - ONLY 32% OF CARDIAC ARREST VICTIMS RECEIVE Bystander CPR
  - ONLY 2% HAVE AN AED APPLIED BEFORE PROFESSIONAL RESPONDERS ARRIVE
- CARES 2014 DATA
  (HTTPS://WWW.MYCARES.ORG)
  - 40% Bystander CPR
  - 4% AED APPLIED

Sweden - Bystander CPR

- Teach in schools
  - Starts in elementary school in Scandinavia
- Require CPR for high school graduation
  - Better than kick-ball
- Require CPR for jobs where caring for others
  - Daycare, babysitting, bus drivers, teachers, etc.
- Require CPR for driver’s license
IMMEDIATE BYSTANDER ACTION

EMS DISPATCHERS

WHAT THE CREWS THINK I DO.
WHAT MY BOSS THINKS I DO.
WHAT THE PUBLIC THINKS I DO.
WHAT MY WIFE THINKS I DO.
WHAT FRIENDS THINK I DO.
WHAT I REALLY DO.

CPR in Schools
35 states and DC | 70% of public high school graduates

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Total: 3,177,000
Real-time alerting

- 911 connected
  - Pre-arrival instructions to caller
  - Registry of AED locations
  - Text messaging to potential responders
  - Phone apps (Fire Department)
- Site-based alerts
  - Notify on-site response team
  - AED triggered alarms

PULSE POINT APP
EARLY DEFIBRILLATION

"DON'T WAIT, DEFIBRILLATE"

Presenting rhythm

EMS studies report decreasing incidence/frequency VF


Public access defibrillation trials show higher rate

- PAD Trial – 60%
USA-ROC STUDY

• REVIEW OF CARDIAC ARRESTS IN TEN AREAS IN US AND CANADA (21 MILLION POPULATION)

• SURVIVAL TO HOSPITAL DISCHARGE:
  OVERALL: 7%
  BYSTANDER CPR BUT NO AED: 9%
  AED APPLIED: 24%
  AED SHOCK: 38%

Weisfeldt et al, JACC, 2010

Survival for OOH-VF

Estimated Time from Collapse to Defibrillator Shock (minutes)

Cardiac-rehabilitation programs, electrophysiology laboratories

Weaver WD et al. NEJM 2002; 347:1223
SOME UNFORTUNATE FACTS

BYSTANDER CPR – 32%

BYSTANDER AED – 2%

Linking dispatch to AEDs

- Retrospective review of OOHCA in Seattle
- 736 CAs 2007-2009
- AEDs applied:
  - Bystanders: 2.9%
  - Police first responders: 1.3%
- Nearby AED identified by dispatch: 8.1%
- Potential to increase bystander AED use
BYSTANDER AUTOMATED EXTERNAL DEFIBRILLATOR USE AND CLINICAL OUTCOMES AFTER OUT-OF-HOSPITAL CARDIAC ARREST: A SYSTEMATIC REVIEW AND META-ANALYSIS

MATHIAS J. HOLMBERGA, MIKAEL VOGNSEN A, MIKKEL S. ANDERSEN C, MICHAEL W. DONNINO, LARS W. ANDERSEN

RESUSCITATION (AVAILABLE ONLINE 6 SEPTEMBER 2017)
HIGH QUALITY COMPRESSIONS

• DEPTH (2.4 IN; 5-6 CM)
• RATE (100-120)
• COMPLETE RECOIL
• MINIMAL PAUSES (30:2 OR CONTINUOUS)

*Key is adequate coronary perfusion pressure*

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Resuscitation Science

Chest Compression Fraction Determines Survival in Patients With Out-of-Hospital Ventricular Fibrillation

Jim Christenson, MD; Douglas Andrusiek, MSc; Siobhan Everson-Stewart, MS; Peter Kudenchuk, MD; David Hostler, PhD; Judy Powell, BSN; Clifton W. Callaway, MD, PhD; Dan Bishop, Christian Vaillancourt, MD, MSc; Dan Davis, MD; Tom P. Aufderheide, MD; Ahamed Idris, MD; John A. Stouffer; Ian Stiell, MD, MSc; Robert Berg, MD; and the Resuscitation Outcomes Consortium Investigators
DETAILS: WHAT CAN YOU MEASURE?

- CPR Fraction = Proportion of time when compressions are being done
- Compression Depth
- Complete Release = Not “leaning on the patient” during upstroke
- Ventilation

CPR DURING ROC CLINICAL TRIAL PARTICIPATION (PITTSBURGH)
PIT CREW APPROACH

High Performance CPR / ACLS

Cardiac and ICU care

Nearby Laypersons Activated

Enhanced CPR Instruction by Call Taker

911

Specialized Hospitals

Cardiac and ICU care

CHANGE PUBLIC BEHAVIOR

CALIFORNIA REPUBLIC
THE CHAIN OF SURVIVAL

Layperson responders
- Recognition and activation of emergency response system
- Immediate high-quality CPR
- Rapid defibrillation
- Basic and advanced emergency medical services
- Advanced life support and post-arrest care

Regional health care systems

Interventions
- Population-based training
- Telephone-assisted CPR
- Notification of nearby volunteer responders by mobile phone
- Treatment at tertiary care hospitals
- Treatment at cardiac care centers

Expected outcomes
- Increase rate of CPR initiated before ambulance arrival
- 10% immediately with rapid interventions
- Achieve >50% rates over time
- Reliable delivery of effective post-CPR care

THANKS FOR YOUR ATTENTION!