Optimizing Outcomes in Cardiac Arrest

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2012
Out of Hospital Cardiac Arrest Data

- 300,000 out-of-hospital Cardiac Arrests
- 53% Survive to transport = 159,000
- Resuscitation was attempted in 100,000 patients
  - 25% of ALL Cardiac Arrests
- 40,000 patients survive to hospital admission
  - 10% of ALL Cardiac Arrests
- Overall VF Survival to Discharge Rate = 8%
The OOH survival to hospital discharge rates based on initial rhythm presentation:

- PEA = 5%
- Asystole = 2%
- VF = 19%
Medications and Cardiac Arrest
Are medications in Cardiac Arrest effective?

- NO increased survival to hospital discharge post arrest

- **Atropine**
  - Increases mortality in PEA
    - 2010 AHA guidelines removed Atropine in PEA
  - Worsens neurological outcomes with NO value in Asystole

- **Epinephrine**
  - Improves ROSC rates for non shockable rhythms
  - Does NOT improve survival to discharge outcomes
    - Early Administration may be beneficial
ROSC
Return Of Spontaneous Circulation

- Restoration of a spontaneous perfusing rhythm

- ROSC results in a “normal” ECG and vitals
  - Only is an intermediate goal in resuscitation

- Remember - We are still “coding” the brain

1. Initial EtCO2 >10 **AND**
2. The absence of a falling EtCO2 >25% from baseline
  - Associated with a ROSC in OOH cardiac arrest
    - *Prehosp. Disaster Med. 2011 Jun*
MAP - Mean Arterial Pressure

- Perfusion pressure in the body organs
  - Average arterial pressure during a single cardiac cycle

- Normal MAP is between 70 -110 mmHg
  - If the MAP falls < 70 mmHg the end organs will not receive enough blood flow & will become ischemia

- MAP > 60 mmHg is needed to JUST perfuse the organs
  - MAP > 65 is required for Brain perfusion
Cardiac Arrest and Ventricular Fibrillation

- The most common cause of VF is a AMI
- 60% of VF arrests are witnessed
- 80% occur at home
- 71% of VF ROSC patients have coronary artery disease
- 50% of VF ROSC have acute coronary artery occlusion
2013 STEMI Guidelines

- Therapeutic Hypothermia should be started immediately for all comatose STEMI and Out of Hospital cardiac arrests due to VF / VT

- Immediate PCI is indicated in all STEMI arrest patients including those receiving Therapeutic Hypothermia
  - STEMI resolution on route to the ED does NOT = NO STEMI
    - These patients need to go directly for immediate PCI
Phases of Ventricular Fibrillation

Phase 1 - Electrical Phase

- 0 - 5 minutes
- Myocardium has neither used up all of its energy stores nor undergone serious cellular damage
- Responds well to IMMEDIATE defibrillation
- Myocardium is able to respond to the electrical defibrillation and generate a perfusing rhythm
- Thus ICD and AED's have been so successful

Survival Rates of Cardiac Arrest Patients

Source: 2010 Journal of the American College of Cardiology
Phase 2 - Circulatory Phase

- 5 – 10 minutes after a cardiac arrest
- Patients with VF > 5 minutes
- 2 minutes of good CPR prior to defibrillation
- Defibrillating without doing CPR first is more likely to convert the rhythm to Asystole or PEA.

"PRIME THE PUMP"

Hemodynamic Response to 15 Chest Compressions During Ventricular Fibrillation
Phase 3 - Metabolic Phase

- 10 minutes or more after the arrest
- The least understood phase
- Toxins begin to circulate throughout the body
- Resulting in systemic cell death
- Only Therapeutic Hypothermia slows cell death
- Medications may actually worsen cell death
- Every 1 minute delay lowers survival rates by 10%

![Graph showing the chance of survival from cardiac arrest over minutes to defibrillation](image)
Recurrent Ventricular Fibrillation

- Ventricular Fibrillation that **recurs > 5 seconds** after initially successful defibrillation

- Longer the duration of the Ventricular Fibrillation the higher the defibrillation threshold is due to:
  - Prolonged Cardiac Ischemia – Increased Cell death
  - Elevated Acidosis levels – Anaerobic metabolism
  - Electrophysiological deterioration of the heart
Shock Resistant Ventricular Fibrillation

Ventricular Fibrillation that persists after 3 failed defibrillation attempts

20% of all cardiac arrests are shock-resistant

95% of these patients will die

Amiodarone and Vasopressin are safe and beneficial

Successful defibrillation depends on the amount of current traveling through the heart – OHMS LAW

Double sequential defibrillation

Ohm's Law

Electric current = Voltage / Resistance
Resuscitation NOT Resurrection!
Re-evaluated our traditional approach to Cardiac arrest

Survival from cardiac arrest continues to be low when following the 2005 recommended guidelines for CPR in individuals with out-of hospital cardiac arrest
- 2005 Review of out-of-hospital cardiac arrests in Los Angeles
- Neurologically intact survival was 1.4%

2005 -2010 basic cardiac life-support CPR puts undue emphasis on ventilation, which is appropriate for respiratory arrest but inappropriate for cardiac arrest
Bystander CPR is performed < 30% of cases

Bystanders refrain from providing conventional CPR for a variety of reasons – WHY?:

- Fear of causing harm
- Fear of contracting infectious disease
- Complexity of the psychomotor task
- Panic
- Reluctance to make mouth-to-mouth contact
Surviving a Cardiac Arrest with Bystander CPR only

- Favorable neurological survival rates in those who received chest compressions **AND** were given mouth-to-mouth breathing was **10.2%**

- Patients surviving with a favorable neurological outcomes was **22%** if bystanders administered chest compressions **without** mouth-to-mouth

  - *Survival improved when bystanders were coached by the dispatcher to do chest compression-only CCR*
University of Arizona
CCR Study with Shockable Rhythms

Survival rates

- 47.2%
- 19.6%

Survivors with good neurologic outcome

- 83.3%
- 77.8%

C - C - R / C - A - B
C - P - R / A - B - C

PUSH HARD AND PUSH FAST SAVES LIVES!
University of Arizona changed the rules for adult CPR

- The mantra of "A-B-C" is now C-A-B / **C-C-R**

- Airway management in cardiac arrest is a lower priority

- Good continuous chest compressions and early EPI are the most important interventions when VF is present

- Patients who survive cardiac arrest should then be treated with early PCI and Therapeutic Hypothermia
2010 The Lancet: Chest Compression only CPR

- Proved that Chest compression only method of CPR improved survival rates over standard CPR
  - Principal investigator Peter Nagele, MD

- Data from 3 studies in a meta-analysis were analyzed and survival rates compared in more than 3,700 cardiac arrest patients

- Standard CPR vs. Chest Compression ONLY CPR
5% survived if NO CPR was performed.

6% survival in patients receiving standard CPR
- A-B-C: 30 compressions and 2 breaths

11% survived if bystanders continued chest compressions ONLY and did NOT stop for any mouth-to-mouth breaths until EMS arrived.

Why?
CPR Fraction

Annals of Emergency Medicine 2009

Survival From Prolonged Cardiac Arrest Relates to the Coronary Perfusion Pressures Generated During Chest Compression

![Pressure (mm Hg) vs. Outcome](chart)

- **24-hour Survivors**
- **Resuscitated But Expired**
- **Could Not Resuscitate**

Coronary perfusion pressure is the determinant of successful cardiac resuscitation - ROSC

- Must sustain >15 mmHg coronary perfusion pressures
CPR Compression Rates and Cardiac Outcomes

- Chest compressions rate should be 120 / minute
- As CPR rate increases depth of compressions decrease
- 7% decline in the depth of compressions at 2 minutes
  - Rescuer fatigue at about 3 minutes w/o CPR rate change
- 2 inch depth of chest compressions are required
  - No increased survival for > 2 inches of compression
Interrupting Chest Compressions

Every 1 second pause in compressions results in a 1% reduction of the chance of obtaining a ROSC.

It takes 10 compressions before you begin to perfuse the coronary arteries to > 15mmHg.

It takes 30 seconds to begin to perfuse the brain.

How then should we deal with airway management?
CPR Interruptions

Perishock Pause - Circulation 2011

- Does the length of the perishock pause influence survival?
  - Perishock pauses are pauses in chest compressions before and after defibrillatory shock

- 815 VF / VT patients from ROC data - 2300 shocks studied

- Optimal pause times < 20 seconds

- Pauses > 20 seconds increase mortality

- Longer perishock and preshock pauses were independently associated with a decrease in survival to hospital discharge
Mechanical CPR vs. Manual CPR

- No definitive data supporting or refuting the use of mechanical CPR devices
- Allows healthcare providers to concentrate on the patient without the worry of quality of compressions
- Added safety for EMS providers
  - For prolonged transport times
    - Continuous consistent compressions
NOT - Chest Compression only CPR

- Trauma
- Drowning
- Pediatrics

- Conditions NOT directly related to heart function
  - Standard CPR will be required = 30 / 2
    - In THESE cases getting \( O_2 \) into the system is crucial
Intubation

Sometimes the best solution for unruly patients.
Controversies exist regarding airway management in cardiac arrest patients

Which airway is best?

ETI vs. SGA vs. BVM vs. NRB vs. NC?

What device provides the best chance of survival to neurologic discharge and why?

Does a single medic and cardiac arrest influence care?
Apneic Oxygenation

- Extends the safe apnea time beyond that which can be achieved only by pre-oxygenation

- Alveoli will continue to take up oxygen even without diaphragmatic movements or lung expansion

- In healthy patients, under ideal circumstances, PaO₂ can be maintained at >100 mm Hg for up to a 100 minutes without a single breath
  - The lack of ventilation will eventually cause marked hypercapnia and significant acidosis
    - Accumulation of CO₂ is the limiting factor in respiratory acidosis
Apneic Oxygenation - Theory

- Apneic oxygenation using a nasal cannula, an idea espoused by Dr. Richard Levitan
  - Professor of Emergency Medicine at Jefferson Medical College

- Desaturation to below 70% FiO$_2$ puts patients at risk for dysrhythmia, hemodynamic decompensation, hypoxic brain injury, and death

- Oxygen was absorbed from the patients alveoli by a pulmonary blood flow gradient – High to Low
  - NRB masks set at 15 L / minute for patients with normal ventilator patterns are capable of delivering near 90% FiO.
    - Apnea time can be increased by maintaining high flow O$_2$ via NC 15L, along with the BVM / NRB during the time of ET placement
Association of Pre-hospital Advanced Airway Management With Neurologic Outcome and Survival in Patients With Out-of-Hospital Cardiac Arrest

649,654 consecutive adult patients in Japan who had an OHCA and in whom resuscitation was attempted by emergency responders with subsequent transport to medical institutions

January 2005 through December 2010
- **BVM ventilation**
  - 367,837 (57%)

- **Advanced Airway Management**
  - 6% Endotracheal intubation
  - 37% Supraglottic airways
    - 281,522 (43%)
Rate of favorable neurological outcome using Advanced Airway Management = 1.1%

Rate of favorable neurological outcome with BVM management = 2.9%

Odds of neurologically favorable survival were significantly lower both for endotracheal intubation and for supraglottic airways.
2006-8 Retrospective study from Mecklenburg EMS

Analyzed 1,142 cardiac arrests

Examined the impact of Pre-hospital ETI attempts on:
- ROSC rates
- Survival to discharge in out-of-hospital cardiac arrest
Patients with NO ETI attempts were 2.3 times more likely to obtain ROSC compared to individuals with 1 successful ETI attempt.

 Patients with NO ETI attempt were 5.5 times more likely to discharged home alive compared with those patients with 1 successful ETI attempt.

Increased ETI attempts = Negative outcomes in SCA
Looked at airway options used by EMS personnel OTHER than ETI in patients with out of hospital cardiac arrest and compared their resuscitation rates

- January 1, 2005 thru September 28, 2008
- 1,019 adult OOH cardiac arrest patients in the analysis
  - 3 rounds of CPR ~ 8 minutes

**Bag-valve-mask ventilation**
- Forced air flow into the patient’s lungs

**NRB - Facemasks with a continuous flow of oxygen**
- Passive air flow
Neurologically intact survival after witnessed cardiac arrest with a shock able heart rhythm:

- Bag-valve-mask ventilation = 25.8%
- Passive oxygen flow method = 38.2%

During resuscitation patients in cardiac arrest should receive “passive ventilation”
Compared 1097 patients receiving CPR vs. 339 CCR
- Utstein Pre – hospital VF arrest in adults

“Gentle” ventilations 50 : 2, with NRB mask
- No intubation for 3 cycles ~ 8 minutes

Survival to Discharge increased from 22% to 44%

88% of these survivors were discharged with good neurologic outcomes
Cardio Cerebral Resuscitation

Annals of Emergency Medicine 2008

- Studied CCR for pre-hospital witnessed arrests with an initial shockable rhythm

- Patients given early IV Epinephrine WITH:
  - NRB only OR
  - Until ROSC OR
  - 5 cycles of compressions + shocks = 12 minutes

- Overall Survival increased from 20% to 47%

- Neurologic Survival to discharge increased 15% to 39%
Non-Rebreather Mask (NRB)

- Good early airway management in cardiac arrest

- Provides 65 - 80% of $\text{FiO}_2$
  - $\text{FiO}_2 = \%$ of oxygen participating in gas-exchange

- Patients with DIB are provided with $\text{O}_2$ enriched air > atmospheric $\text{FiO}_2$
  - Natural air is 20.9% oxygen = $\text{FiO}_2$ of 0.21

- NRB has been shown to provide a buffer as long as 8 min before the saturation drops below the 90%
## Passive O₂ Flow vs. Forced Ventilation

<table>
<thead>
<tr>
<th>Passive Oxygen Flow</th>
<th>BVM Oxygenation</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Lowers Intra thoracic pressure</td>
<td>□ Raises Intra thoracic pressure</td>
</tr>
<tr>
<td>□ No Hyperventilation</td>
<td>□ Hyperventilation increased</td>
</tr>
<tr>
<td></td>
<td>□ With its side effects</td>
</tr>
<tr>
<td>□ Uses O₂ in lungs and circulates it in the body</td>
<td>□ LESS coronary perfusion pressure</td>
</tr>
</tbody>
</table>
Compression Only CCR

- Compression only CCR uses the $O_2$ in lungs which is carried throughout the body by the circulating blood.

- Ventricular Fibrillation does not need immediate $O_2$.

- Asystole / PEA / long down times will need $O_2$.

- Oxygenate and ventilate - NOT intubate!
  - GOAL is the elimination of the anaerobic by product $CO_2$. 
ETI Post Cardiac Arrest
Hyperventilation MUST be avoided

- Systemic hypotension
- Myocardial depression
- Increases O₂ free radicals
- Increased intra thoracic pressure
- Decreases Coronary perfusion pressures
- Decreases Cerebral perfusion pressures
- LOWERS OVERALL SURVIVAL RATES

- Ventilation rates should be **1 EVERY 10 seconds** for successfully ETI patients post Cardiac Arrest
Et CO$_2$ / Capnography

- Reflects the cellular production & transport of CO$_2$
  - Tissues metabolic rate
  - Ventilation rate
  - Blood flow / circulation

- **End Tidal CO$_2$ = Cardiac Output**
  - Reflects the QUALITY of CPR
  - Instant analysis of ongoing cellular metabolism

- Normal = 35 - 45mmHg
  - Prolonged CO$_2$ < 10 mmHg = Clinical death
Impedance Threshold Device - ITD

- Designed to enhance venous return and cardiac output during CPR by lowering intrathoracic pressures - which improves cardiac filling in diastole

- 2012 NEJM study showed that the ITD did NOT improve survival with satisfactory function among patients with out-of-hospital cardiac arrest receiving standard CPR
Goals of Therapeutic Hypothermia

- Stretch Time
- Slow cellular metabolism
  - 6% drop for every 1°C drop in temperature
- Minimize cellular toxin levels and its effects
- Minimize cellular reperfusion injuries
So...Let's Change How We Approach Cardiac Arrest

Because the people who are crazy enough to think they can change the world are the ones who do.
Polk County 2000 square miles
Population 630,000
99,421 calls in Polk County
74,505 patients transported
5 hospitals
3 Municipal ALS fire rescue departments
  Multiple BLS agencies
Integrated 911 – Medical priority dispatch
32 ALS ambulances
1,000 pre-hospital providers
Goals of the Cardiac Arrest Protocol

- Continuous Non interrupted Chest Compressions
- 2 minutes of HIGH QUALITY CPR between medications
  - Early Bystander CPR improves survival to discharge

- I Gel / NRB / BVM / 15L NC with OPA
  - *No ET intubation for Cardiac Arrest patients*
  - *Humeral IO no IV’s*
  - *Nasal Capnography with ETCO₂*

- Initiating Therapeutic Hypothermia in the field
  - IO 4C NS - 30 ml / Kg - to a maximum of 2L
  - 1 Ice pack to the head + 2 to the neck – Carotid Cooling
    - *Cooling with large volumes of cold fluid post ROSC is NOT recommended*
VF / VT Arrest

Cardiac Arrest Protocol

- Immediate Defibrillation
- NRB with NC or BVM – 10 min
- Continuous uninterrupted chest compressions in 2 min. intervals between checks for VS
- 5 Rounds of IO medications in TOTAL
- Defibrillation 200J – Maximum 3
- Double sequential defibrillation for Refractory VF 200J + 200J = 400J
- I-Gel placed after 5 cycles
- I-Gel placed immediately
- Continuous uninterrupted chest compressions for 2 min before check for VS and Defibrillation
- 1 Round of IO medications
- Defibrillation 200J – Maximum 3
- Double sequential defibrillation for Refractory VF 200J + 200J = 400J

WITNESSED ARREST

UNWITNESSED ARREST
**PEA / Asystole**

**Cardiac Arrest Protocol**

- Immediate placement of the I-Gel – NO ET intubation
- IO Epinephrine in both arrhythmias
- Begin continuous Cardiac compressions at 120 / min
- **PEA cocktail is initiated:**
  - IO 1 amp HCO3 IVP
  - 1 amp D50 – assuming accu. check is < 60
  - 500ml NS bolus
  - Narcan 2mg IV

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### Pulseless Electrical Activity (PEA) Causes

<table>
<thead>
<tr>
<th>The 6 H’s</th>
<th>The 6 T’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperkalemia</td>
<td>Tamponade (cardiac)</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>Tension pneumothorax</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>Thrombosis (pulmonary embolus)</td>
</tr>
<tr>
<td>Hydrogen ion access (acidosis)</td>
<td>Thrombosis (myocardial infarction)</td>
</tr>
<tr>
<td>Hypovolemia</td>
<td>Toxins</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>Trauma</td>
</tr>
</tbody>
</table>
Optimizing Post Resuscitation Care

Therapeutic Hypothermia patients should be cooled to 36°C

Every VF arrest with ROSC should receive early PCI

Awake arrest patients should receive immediate PCI

Cardiac arrest patients in a coma should be continued with Therapeutic hypothermia and PCI on awakening

PCI improves survival to hospital discharge and cerebral performance in patients with or without ST elevation
How do we Measure Cardiac Arrest Data?
Utstein Criteria

- Standardization for Cardiac arrest survivability
  - Contributed to a greater understanding of the elements of resuscitation and has facilitated progress toward an international consensus on science and resuscitation
    - Helps compare systems effectiveness

- Witnessed cardiac arrest
- Presumed of cardiac origin
- Presenting with VF or VT
## AHA - National Cardiac Arrest Data

<table>
<thead>
<tr>
<th>Statistical Update</th>
<th>Out-of-Hospital Cardiac Arrest</th>
<th>In-Hospital Cardiac Arrest</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Incidence</td>
<td>Bystander CPR (overall)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>359,400</td>
<td>40.1%</td>
</tr>
<tr>
<td>2012</td>
<td>382,800</td>
<td>41.0%</td>
</tr>
</tbody>
</table>
# LAKE EMS: 2012-2013

## Cardiac Arrest ROSC Rates

<table>
<thead>
<tr>
<th>ROSC Obtained</th>
<th>National Average</th>
<th>Lake EMS 2012 FY</th>
<th>Compression Only CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cardiac Arrest</td>
<td>19%</td>
<td>40%</td>
<td>41.5%</td>
</tr>
<tr>
<td>PEA / Asystole</td>
<td>5%</td>
<td>31%</td>
<td>31%</td>
</tr>
<tr>
<td>Ventricular Fibrillation</td>
<td>21%</td>
<td>60%</td>
<td>68%</td>
</tr>
<tr>
<td>Utstein</td>
<td>22%</td>
<td>68%</td>
<td>71%</td>
</tr>
<tr>
<td>Survival to Discharge</td>
<td>8%</td>
<td>26%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Double Sequential Defibrillation – 6 / 13 ROSC = 46% Success
<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Arrests</td>
<td>736</td>
<td>796</td>
</tr>
<tr>
<td>ROSC</td>
<td>26%</td>
<td>28%</td>
</tr>
<tr>
<td>VF / VT ROSC</td>
<td>45%</td>
<td>46%</td>
</tr>
<tr>
<td>Utstein Survival to Discharge</td>
<td>53%</td>
<td>56%</td>
</tr>
<tr>
<td>Peds. ROSC</td>
<td>2/18 = 11%</td>
<td>7/21 = 33%</td>
</tr>
<tr>
<td>Peds. Survival to Discharge</td>
<td>= 0%</td>
<td>= 71%</td>
</tr>
</tbody>
</table>
Dispatch initiating on scene CCR with AED

VF / VT arrests with ROSC should have immediate PCI + TH
- EMS to PCI < 120 minutes – goal of < 90 minutes

Airway of secondary importance in cardiac arrest ONLY
- NRB / 15L NC – Passive Oxygenation till O₂ saturation < 70%
- I – Gel if O₂ saturation < 70%

Optimal Compression rates in CPR = 120 / minute
- 2 inch depth of compressions
- Minimize OFF chest time – CPR Fraction 80-90%
- Early Defibrillation and Epinephrine
Success is not what you have done compared to what others have done. Success is what you have done compared to what you were supposed to do.

Tony Evans