What Works (& Doesn't Work) in Cardiac Arrest Resuscitation

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Departments of Emergency Medicine & Medicine
University of Virginia
We will discuss......

• Reordering the Alphabet
• Cardiopulmonary Resuscitation
• Defibrillation
• Airway Management
• Vascular Access
• Medication Administration
• Post-Resuscitation Care

The History of Resuscitation

"Ancient" The Heat Method

1700 The Fumigation Method

1750 The Barrel Roll Method

1825 The Russian “Snow Packing” Method

1840 The Trotting Horse Method

1930 The Rocking Method

1530 The Bellows Method

1775 The Inversion Method

1750 The Barrel Roll Method

In the old days……

• The “ABCs”
  – Airway management
  – Appropriate oxygenation & ventilation
  – Rhythm therapy & augmented perfusion
• Significant emphasis in all patients….
  – defibrillation
  – on invasive airway placement
  – administration of cardioactive medications
• Less emphasis on high quality, uninterrupted chest compressions

Today….  

• The “CABs”
• Emphasis on…. 
  – Chest compressions
  – Defibrillation
  – Recognition of non-cardiac causes with tailored RX
  – Post-resuscitation care
• “Less of a priority”
  – Placement of invasive airways early
  – Cardio-active medication administration
• Limit interruptions in chest compressions
### Relative Importance of Interventions in Cardiac Arrest

**Adjusted Odds Ratio**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Witnessed Arrest with Bystander</td>
<td>4.4 (3.1 - 6.4)</td>
</tr>
<tr>
<td>Bystander CPR</td>
<td>3.7 (2.5 - 5.4)</td>
</tr>
<tr>
<td>Defibrillation &lt; 8 min</td>
<td>3.4 (1.4 - 8.4)</td>
</tr>
<tr>
<td>Advanced Life Support</td>
<td>1.1 (0.8 - 1.5)</td>
</tr>
</tbody>
</table>

**Stiell NEJM 2005**

### Interventions in Cardiac Arrest

**Figure 2.** Actual versus Predicted Interrupted-Time-Series Model for Survival to Discharge for 100 Consecutive Months, from the Rapid-Defibrillation Phase to the Advanced-Life-Support Phase.

The solid line represents actual survival, and the dotted line represents predicted survival based on the rapid-defibrillation phase.

**Stiell NEJM 2004**
AHA Guidelines 2010

Part 1: Executive Summary: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Circulation 2010:122:S640-S656
DOI: 10.1161/CIRCULATIONAHA.110.970889
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

- Immediate recognition of cardiac arrest and activation of the emergency response system
- Early CPR with an emphasis on chest compressions
- Rapid defibrillation
- Effective advanced life support
- Integrated post–cardiac arrest care

Cardiopulmonary Resuscitation
**Cardiopulmonary Resuscitation**

- **EXTREMELY** important intervention
- More so than previously thought
- Multiple techniques
  - Traditional CPR
  - Compression-only
- High-quality compressions
  - Rate of 100/minute
  - Minimize interruptions

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**CPR vs Nothing**


- Out-of-hospital cardiac arrest (#7265)
- Three groups
  - No CPR -- 44.1%
  - Dispatcher-assisted - 25.7%
  - Bystander CPR - 30.2%
- Overall Survival 15.3%
- Compared to no CPR, adjusted ORs of survival...
  - Dispatcher-assisted -- 1.45 (95% CI 1.21, 1.73)
  - Bystander -- 1.69 (95% CI 1.42, 2.01)
CPR

Nothing vs Traditional vs Compression - only

Japan
Urban setting
Outpatient cardiac arrest
Survival
5% "CR" vs 2.2% none
No ventilation benefit


CPR

Nothing vs Traditional vs Compression - only

- United States
- Urban setting
- Outpatient cardiac arrest
- No ventilation benefit

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Occurrence</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Only</td>
<td>544 (12%)</td>
<td>4.3%</td>
</tr>
<tr>
<td>Ventilation &amp; Compression</td>
<td>783 (16%)</td>
<td>4.1%</td>
</tr>
<tr>
<td>None</td>
<td>3550 (72%)</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Ewy GA. *Circulation* 2007;116:2894
Traditional vs Compression-only


- Out-of-hospital cardiac arrest (#520)
- Compression Only-CPR vs Traditional CPR
  - Dispatcher-assisted
  - CO-CPR: #241, 81% “successful”
  - T-CPR: #279, 62% “successful”
  - 1.4 minutes less time for CO-CPR
- Survival
  - CO-CPR: 14.6%
  - T-CPR: 10.4%

Traditional vs Compression-only

Early & Late in Resuscitation


- Prehospital arrest (#4902)
- Comparison
  - Compressions in early arrest (#544) - any form of CPR with compressions
  - Traditional CPR in prolonged arrest (#783)
- Outcome: 1 yr survival & good neuro status
- Outcomes:
  - Short duration (< 15 min)
    None - 2.5%
    Compressions - 4.3%, OR 1.72
    Traditional - 4.1%; OR 1.57
  - Prolonged duration (> 15 min)
    None - 0.3%
    Compressions - 0
    Traditional - 2.2%
The Value of CPR

Basic vs Advanced Care?

- Out-of-hospital cardiac arrest # 95,072 in Japan
- Comparison of bystander +/- ALS care
  - Bystander CPR (B-CPR)
  - ALS by EMS & MDs
- 8.1% alive @ 30 days with 2.8% with good neuro status
- Adjusted odds ratios for survival with good neuro status, as compared to EMS without B-CPR
  - EMS with B-CPR: 2.23, (95CI: 0.05 to 2.42; P < 0.01)
  - MD without B-CPR: 1.18, (95CI: 0.86 to 1.61; P = 0.32)
  - MD with B-CPR: 2.8, (95CI: 2.28 to 3.43; P < 0.01)
- Bystander CPR most significant factor in survival with good neuro status

Yasunaga H et al, Crit Care 2010:14:R199

PUSH HARD, DEEP, & FAST
Compression Depth

• Deeper compressions depths eject more blood per compression

• Improved perfusion

• Better outcomes

PUSH HARD & DEEP!
Deeper compressions are significantly associated with ROSC

Edelson et al., Resuscitation 2006:71:137
Compression Rate

- More rapid rates of compression increase cardiac output
- Improved perfusion
- Better outcomes
- Difficult to attain

Chest Compression Rates During Cardiopulmonary Resuscitation Are Suboptimal
A Prospective Study During In-Hospital Cardiac Arrest

Benjamin S. Abella, MD, MPhil; Nathan Sandbo, MD; Peter Vassilatos, MS; Jason P. Alvarado, BA; Nicholas O’Hea, RN, MSN; Herbert N. Wigder, MD; Paul Hoffman, CRT; Kathleen Tynus, MD; Tony L. Vanden Hoek, MD; Lancer R. Becker, MD

**Background**—Recent data highligh7 a new recommendation for cardiac resuscitation (CPR) and survival after cardiac arrest; however, evidence linking CPR technique to successful outcomes by healthcare providers is largely unknown. We sought to measure in-hospital chest compression rates and to determine compliance with published recommendations.

**Methods**—We conducted a prospective cohort study of patients receiving CPR in hospitals from April 2002 to June 2003. Compression rates were measured using a chest compression monitor, or a portable, digital assistant programmed to store the exact time of chest compression, allowing offline calculation of compression rates at, or near, the time point. All patients received CPR in the hospital. Rates were analyzed in 3-second time segments. In 93% of the total number of segments, compression rates were >90 compressions per minute (cpm), and 21.7% had rates <70 cpm. Higher chest compression rates were significantly correlated with initial return of spontaneous circulation (mean chest compression rates for initial survivors and nonsurvivors, 90±17 and 79±18 cpm, respectively; P=0.0033).

**Conclusions**—In-hospital chest compression rates were below published resuscitation recommendations, and suboptimal compression rates in our study correlated with poor return of spontaneous circulation. CPR quality is likely a critical determinant of survival after cardiac arrest, suggesting the need for routine measurement, monitoring, and feedback systems during actual resuscitation. (Circulation. 2005;111:428-434.)

**Key Words:** cardiopulmonary resuscitation ■ death, sudden ■ heart arrest

PUSH FAST!

Higher chest compression rates were significantly correlated with initial ROSC.
Compression Interruptions

• Interruptions halt all perfusion
• Magnitude of interruptions
  – ~30 sec - pulse check
  – ~20 sec - rhythm check
  – ~240 sec - placement of invasive airway
  – ~15 sec - defibrillation
• Sobering facts
  – Each 10 sec of no compressions reduces survival by 5%
  – Resumption of CNS perfusion after compressions requires 40-45 sec
Chest compressions were not delivered half of the time, and most compressions were too shallow.
Compression Interruptions

- Interruptions are bad!

- We want to strive towards a significant reduction in compression interruptions

- Avoid *resuscitatus interruptus*

ROSC & Coronary Perfusion Pressure

Ewy G, Circulation 2005
ROSC & Coronary Perfusion Pressure

Paradis JAMA 1990

Higher compression rates without interruption are associated with better perfusion.

Standard CPR

Berg et al, 2001

Blood pressure

Time

= chest compression
Inadequate Perfusion During Cardiac Arrest as Chest Compressions Resume After Interruption

Chest Compressions During Cardiac Arrest
Magnitude of Perfusion Resulting from Chest Compressions
Compression Only

Blood pressure

Time

= chest compression

Berg et al, 2001

Perfusion During Cardiac Arrest with Chest Compress
Continuous Chest Compressions

Chest Compression Fraction

- Out-of-hospital cardiac arrest
- Chest compression fraction = proportion of CPR time spent providing compressions

<table>
<thead>
<tr>
<th>#1029 VF victims</th>
<th>#2103 non-VF/VT victims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing CCF associated with better outcome</td>
<td>Increasing CCF associated with better outcome</td>
</tr>
<tr>
<td>Depth &amp; rate were inversely related</td>
<td>Adjusted OR for ROSC for each CCF category</td>
</tr>
<tr>
<td>Higher rates of ROSC</td>
<td>41-60% -- 1.14</td>
</tr>
<tr>
<td></td>
<td>61-80% -- 1.42</td>
</tr>
<tr>
<td></td>
<td>81-100% -- 1.48</td>
</tr>
<tr>
<td></td>
<td>Vaillancourt et al, Resuscitation, 2011;82:1501-7</td>
</tr>
<tr>
<td></td>
<td>Stiell et al, Crit Care Med, epub Jan 2012</td>
</tr>
</tbody>
</table>

- Bottom line = improved outcome / more compressions

CPR Devices

Surprisingly Equivocal Outcomes
Defibrillation

- Only for pulseless VT & VF
- Shock as soon as possible
- One shock vs “stacked shocks”
- Device-specific maximal energy
- Limit interruptions in chest compressions
- Automatic external defibrillators
Defibrillation
When should we shock?

- Controversial -- when should we shock pulseless VT & VF?
- Compressions, shock, or what?


Immediate Shock vs CPR?

Pro - delay to defibrillation
- Investigate impact of CPR prior to 1st shock
- Retrospective analysis
  - Witnessed out-of-hospital VF cardiac arrest
  - Compared 2 approaches
    - Mandated EMS approval for shock (CPR 1st) -- #143
    - Immediate shock -- #100
- CPR 1st group
  - More CPR prior to 1st shock
  - Higher rate of favorable neurologic outcome at 30 days (28% vs 14%) & 1 year (26% vs 11%)

Additional 2 of 3 papers supportive of "delayed" defibrillation
Immediate Shock vs CPR?

Simpson et al, Resuscitation 2010

Con - delay to defibrillation

• Systematic review / meta-analysis – 3 trials
• Results..... response time < 5 min & > 5 min
  – No benefit to providing CPR before defibrillation vs. immediate defibrillation
  – No harm to performance of CPR before defibrillation

Compressions or Defibrillation First?

9933 out-of-hospital cardiac arrest patients
5290 early / 4643 late rhythm analysis
Subsequent defibrillation as appropriate
Outcome – survival to D/C with intact neuro status
273 (5.9%) / 310 (5.9%) reached study endpoint
No outcome difference
Immediate Shock vs CPR?

• What should we do?

• AHA has reduced the strength of its recommendation of shock first in delayed response / prolonged down times

“Note that EMS [and hospital] systems exercise operational & medical judgment in determining the time of first defibrillation”

Defibrillation

# Shocks & Energy

• Initial delivery of single shock
  – Followed by immediate CPR

• Energy issues
  – Device specific recommendations
  – If in doubt, device-specific MAXIMUM
First Shock Efficacy  
(Termination of VF)

Stacked shock approach with biphasic energy

No increased chance of successful defibrillation with biphasic energy

<table>
<thead>
<tr>
<th>N</th>
<th>Waveform Energy</th>
<th>VF Termination 1st shock</th>
<th>VF Termination 2nd shock</th>
<th>VF Termination 3rd shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Biphasic 150J, 150J, 150J</td>
<td>96%</td>
<td>96%</td>
<td>98%</td>
</tr>
<tr>
<td>48</td>
<td>Monophasic 200J, 300J, 360J</td>
<td>54%</td>
<td>60%</td>
<td>67%</td>
</tr>
</tbody>
</table>

Martens 2001

Chest Compression Interruptions

Due to Electrical Charging for Electrical Defibrillation

- Inpatient setting -- 562 shocks in 244 cardiac arrests
- Three methods of defibrillator charging
  - "Halted" method
    - Rhythm check w/o compressions
    - If shockable, charge & shock
  - "Interrupted" method (AHA)
    - Rhythm check w/o compressions
    - If shockable, resume compression & charge
    - Then halt & shock
  - "Anticipatory" charging
    - Charge defibrillator prior to rhythm check
    - Rhythm check w/o compressions
    - If shockable, shock
    - "Dump" charge if no shock

Edelson et al, Resuscitation 2010.
Chest Compression Interruptions
Due to Electrical Defibrillation

• *I'm clear, you're clear, we're all clear!*
  – Does it really matter?

• 39 patients / 43 shocks
  – Elective cardioversion
  – Simulated CPR contact
  – Standard gloves worn / self-adhesive pads

• No issue for rescuer
  – No perceptible shock
  – Average leakage current very low

Lloyd MS et al, Circulation 2008;117:2510

Automatic External Defibrillator
Automatic External Defibrillator

- Portable, automatic defibrillator
- Easy to use
- Safe to use
- Can be life saving
- Markedly reduce the time to defibrillation
- Used in conjunction with CPR

AED vs Standard Response

Time to Shock / Outcome

- Time to first shock / outcome with neurologic status
- 2833 consecutive cardiac arrest patients
  - AED on-site #128
  - AED distant #478
  - EMS Response #2227

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Time to Shock (min)</th>
<th>Survival (%)</th>
<th>Odds Ratio (CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AED on site</td>
<td>4.1</td>
<td>49.6</td>
<td>2.72 (1.77-4.18)</td>
</tr>
<tr>
<td>AED distant</td>
<td>8.5</td>
<td>14.2</td>
<td>1.07 (0.82-1.39)</td>
</tr>
<tr>
<td>Response</td>
<td>11.0</td>
<td>5.6</td>
<td>-----------------</td>
</tr>
</tbody>
</table>

Berdowski et al, Circulation 2011;124:2225
Chicago Airports AED Program

- 33 AEDs at O’Hare
- 7 AEDs at Midway

Survival
- VF: 13 (69%)
- Non-VF: 3 (0%)

- Replicated at other airports
  - Logan 21% survival
  - LAX 26% survival

Las Vegas Gaming Casinos
Valenzuela TD et al, NEJM 2000

- < 3 min to DF AED placement
- Security officers
- DF first, then CPR

Survival to discharge
- 105 VF arrests
- 86% witnessed arrest
- Collapse to DF -- 4.4 min
- Collapse to EMS -- 9.8 min

Survival
- 56 (53%)
Prospective / multicenter clinical trial
Randomly assigned community units
- Lay volunteers trained in CPR vs CPR / AED
Primary outcome -- survival to discharge
Survival
- CPR / AED -- 30 among 128 (23%)
- CPR only – 15 among 107 (14%)
No inappropriate shocks

Targeted First Responder
Police Application

- Myerburg et al, Circulation 2002
  - Urban // suburban PD
  - Reduced time to Rx / improved outcome in VF
  - Suburban // PD first-responders
  - Increased rate of VF survival
- Forrer et al, Resuscitation 2002
  - Suburban // PD with AED
  - Cost-effective intervention
Airway Management

• Once thought to be a primary intervention of significant importance
• Now known to be of less value
  – Particularly early in resuscitation
  – Impact is not negative
  – But distractions / interruptions are negative
Airway Management

- Options
  - None
  - 100% face mask / oral airway
  - Bag-mask ventilations
  - Supra-glottic airways
  - Endotracheal intubation
  - Surgical airways

- Less value early in cardiac-based cardiac arrest
- More value in non-cardiac-based cardiac arrest
- In either instance, do not allow interruptions in compressions due to airway placement

Cardiac-based Cardiac Arrest
Arterial Blood Gas
after 7 min of CPR for VF

<table>
<thead>
<tr>
<th></th>
<th>$O_2$ Sat</th>
<th>pCO$_2$</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressions &amp; Ventilations</td>
<td>92±1*</td>
<td>25±2</td>
<td>7.49±.02</td>
</tr>
<tr>
<td>Compressions Only</td>
<td>76±6*</td>
<td>37±5</td>
<td>7.41±.03</td>
</tr>
</tbody>
</table>

* p<0.01

Berg, *Circulation* 1997
Noncardiac-based Cardiac Arrest
Arterial Blood Gas
after 7 min of CPR with asphyxia

<table>
<thead>
<tr>
<th></th>
<th>O\textsubscript{2} Sat</th>
<th>pCO\textsubscript{2}</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressions &amp; Ventilations</td>
<td>87±6*</td>
<td>45±8*</td>
<td>7.20±.02*</td>
</tr>
<tr>
<td>Compressions Only</td>
<td>17±5</td>
<td>97±5</td>
<td>7.01±.06</td>
</tr>
</tbody>
</table>

* p<0.001

Berg, Circulation 1997

Placement of Invasive Airway
Prehospital Endotracheal Intubation

- Utstein registry (2007) -- #109,461
- Considered ROSC @ event & neuro status @ 1 month

<table>
<thead>
<tr>
<th>Outcome</th>
<th>RR [95 CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC</td>
<td>0.61 [0.54-0.69]</td>
</tr>
<tr>
<td>Neuro Status</td>
<td>0.47 [0.38-0.57]</td>
</tr>
</tbody>
</table>

- Invasive airways were not associated with good outcome

ICEM 2010, Singapore
Placement of Invasive Airway Hospitalized Patients #25,006

- Invasive airway placement
  - After onset & during event
  - Considered time from onset to airway placement
  - 40,772 (62%) patients with airway placement after ROSC (excluded)
  - Mean time to placement 5.9 minutes

- Outcomes
  - No increase in ROSC
  - MINIMAL increase in 24 hr survival
  - Analysis not possible for survival to D/C & neuro outcome

<table>
<thead>
<tr>
<th>Event</th>
<th>Occurrence</th>
<th>Adjusted Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC</td>
<td>50.3% (49.7-51.0)</td>
<td>0.96 (0.91 – 1.01)</td>
</tr>
<tr>
<td>Survival to 24 hr</td>
<td>33.7% (33.1-34.3)</td>
<td>0.94 (0.89 – 0.99)</td>
</tr>
<tr>
<td>Survival to D/C</td>
<td>15.3% (14.9-15.8)</td>
<td>Unable to analyze</td>
</tr>
</tbody>
</table>

Wang, Resuscitation, 2010;81:182

Chest Compression Interruptions Due to Endotracheal Intubation

- Out-of-hospital cardiac arrest -- #100
- Endotracheal intubation interruptions
  - Average 2 interruptions per arrest
  - Range 1-9 interruptions
  - Average single interruption – 47 sec
  - Total interruptions – 221 sec
  - ~25% CPR interruptions

Chest Compression Interruptions
Due to Intubation -- “Minimally Interrupted” CPR

• Compared passive oxygen “flow” vs. BVM ventilation
• 1,019 out-of-hospital cardiac arrest events
  – 459 passive oxygen & 560 BVM ventilation
• Among witnessed arrests with VT/VF
  – Passive oxygen - 38% neuro-intact survival
  – BVM ventilation - 26% neuro-intact survival
• Similar outcomes in unwitnessed & nonshockable rhythms
• Theorized...fewer compression interruptions improved outcome


Please Avoid
"Death by Hyperventilation"
Compressions & Blood Flow

- **Cardiac Pump Theory**
  - “Compressive” approach
  - Heart is “squeezed” between the breastbone & spine

- **Thoracic Pump Theory**
  - “Pressure” approach
  - Chest acts like a bellows
  - Compressions increase pressure & produce cardiac output
  - Release decreases pressure, allowing the heart to refill (preload)

Hyperventilation-Induced Hypotension During CPR

- Observational study n=21 (Milwaukee)
- Ventilation rates were too high
- Reproduced in pig lab
- Excessive vent rates produce
  - Increased positive intrathoracic pressure
  - Decreased coronary perfusion
  - Decreased survival rates

Aufderheide, *Circulation* 2004
Impedance Threshold Devices

Equivocal Outcomes

Vascular Access
Vascular Access in Cardiac Arrest

- Access options
  - None
  - Peripheral: IV vs IO
  - Central
- Time of placement of vascular access
  - Early
  - Not early
- Impact of interruptions

Vascular Access in Cardiac Arrest

- Peripheral venous access
  - Preferred approach
- Intra-osseus access
  - Very acceptable alternative
  - At times, preferred technique
- Central venous access
  - Rarely the access of initial choice
  - Reasonable in certain circumstances
    - Large volume resuscitation
    - Placement after resuscitation
**Vascular Access in Cardiac Arrest**

- IO vs IV access
- Prehospital setting – nontraumatic arrest
- Randomized to: tibial IO vs humeral IO vs IV
- Outcome – rate of first-success placement
- 182 patients: 64 (tibial IO), 51 (humeral IO), 67 (peripheral IV)
- First-success placement
  - Tibial IO – 91%
  - Humeral IO – 51%
  - Peripheral IV – 43%


**Medications in Cardiac Arrest?**


Explored the “removal of intravenous drug administration from an ALS protocol” & its impact on survival

<table>
<thead>
<tr>
<th>Therapy</th>
<th>ROSC *</th>
<th>Survival to D/C</th>
<th>1 Year Survival</th>
<th>Neuro Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>With IV (418)</td>
<td>32.0</td>
<td>10.5</td>
<td>10.0</td>
<td>9.8</td>
</tr>
<tr>
<td>Without IV (433)</td>
<td>21.0</td>
<td>9.2</td>
<td>8.0</td>
<td>8.1</td>
</tr>
</tbody>
</table>

- Outcome: survival to event, discharge, & 1 year; also considered impact on CPR & ultimate neuro status
- Impact on CPR -- negligible
- Adjusted odds ratio for survival as a function of medication use -- 1.15; 95CI, 0.69-1.91

**Adjusted odds ratio for survival: IV Therapy 1.15 (0.69 – 1.91)**
Medication Administration

• Range of agents
  – Vasopressors
  – Anti-arrhythmic agents
  – Buffers
  – Electrolytes
  – Fibrinolytic agents
• Benefit is modest at best
• Some benefit in selected patients
Medications in Cardiac Arrest

Milwaukee
- ALS unit
- Standard "North American" ACLS Rx
- Witnessed – 25%
- Bystander CPR – 27.1%
- Initial rhythms – more PEA / asystole
- Survival to D/C – 7.2%

Edinburgh
- ALS unit
- Resuscitation Rx [BLS, Defib, Airway, IVF]
- Witnessed – 65.7%
- Bystander CPR – 42.3%
- Initial rhythms – more VF
- Survival to D/C – 12.4%

VS.

?? Impact of Medications in Cardiac Arrest Resuscitation ??

Vasopressor Therapy
Bolus Vasopressor Therapy

-- Epinephrine --
-- Vasopressin --

Epinephrine
Jacobs et al, Resuscitation 2011;82:1138

• Out-of-hospital cardiac arrest
  – Epinephrine (1:1000) 1 mg vs placebo
  – Therapy per ALS guidelines
  – Matched for demographics & resuscitation RX

• 4103 patients – 534 analyzed: 272 EPI vs 262 Placebo

<table>
<thead>
<tr>
<th></th>
<th>ROSC</th>
<th>Survival to D/C*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephrine</td>
<td>64 (23.5%)</td>
<td>11 (4.0%)</td>
</tr>
<tr>
<td>Placebo</td>
<td>22 (8.4%)</td>
<td>5 (1.9%)</td>
</tr>
</tbody>
</table>

• Conclusion: EPI does not alter outcome

* OR = 2.2; 95 CI 0.7 – 6.3
Vasopressor Therapy in Cardiac Arrest -- Vasopressin

- Stiell et al, Lancet 2001 -- inpatient
  - No difference in survival & neurologic function

  - No difference in VT/VF & PEA outcomes

  - No difference in survival to D/C & neurologic outcome

- All with more frequent ROSC at event

Vasopressor Therapy in Cardiac Arrest

Stiell et al, Lancet 2001

- Prospective, randomized, triple-blinded study
- Inpatient cardiac arrest victims
  - Vasopressin 40 U vs epinephrine 1 mg
  - Outcome: survival to hospital discharge & neurologic status
- 200 patients: 104 vasopressin & 96 epinephrine
- No difference:
  - Survival
  - Neurologic function
Vasopressor Therapy in Cardiac Arrest
Wenzel V et al, NEJM 2004

• Randomized trial
• Prehospital cardiac arrest
  – Vasopressin vs epinephrine
  – Additional epinephrine as needed
  – Primary end point -- survival to admission / discharge
• 1219 patients

Vasopressor Therapy in Cardiac Arrest
Wenzel V et al, NEJM 2004

• No significant differences in VF & PEA
• Aystole – improved outcome

• Increased effectiveness for epinephrine as 2nd line agent
Vasopressin vs Epinephrine in Cardiac Arrest

• Out-of-hospital cardiac arrest victims
• Random assignment
• Interventions
  EPI 1 mg/VSP 40 IU
  EPI 1 mg
  Placebo
  Similar subsequent agents / doses

Gueugniaud et al, NEJM 2008

Vasopressin vs Epinephrine in Cardiac Arrest

• 1442 patients EPI + VP vs 1452 patients EPI
• 80% of patients with asystole
• No significant difference
  – Survival to hospital admission
  – ROSC
  – Survival to hospital discharge
  – 1-year survival
  – Neurologic outcome

Gueugniaud et al, NEJM 2008
Vasopressin vs Epinephrine with Steroids in Cardiac Arrest

• Inpatient cardiac arrest – #100
• Interventions / CPR cycle
  – Saline + EPI (1 mg) -- [#52]
  – VSP (20 IU) + EPI (1 mg) + methylprednisolone (40 mg) -- [#48]
  – Post-resuscitation shock – hydrocortisone 300mg daily 7 days
• Single-enter, prospective, randomized, double-blind, placebo-controlled, parallel-group trial
• End points: ROSC & survival to D/C

Vasopressin vs Epinephrine with Steroids in Cardiac Arrest

• Resuscitation & hospital D/C rates were higher in the steroid group
• Hemodynamics, CVO₂ saturation, & organ failure-free days – improved in steroid group

Mentzelopoulos et al. Arch Int Med 2009
Bolus Anti-arrhythmic Therapy

-- Lidocaine --
-- Amiodarone --
-- Magnesium --
-- Procainamide --
**Lidocaine**

- No evidence of beneficial impact
  - Despite decades of recommended use
  - Millions of treated patients
- Now considered an “acceptable alternative”

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**Amiodarone**

- Kudenchuk et al, NEJM 1999 - out-of-hospital
  - vs placebo
  - Pulseless VT / VF
  - No significant difference for survival to hospital discharge
- Dorian P et al, NEJM 2002
  - vs lidocaine
  - Pulseless VT / VF
  - No significant difference for survival to hospital discharge
- Both with higher rates of ROSC & survival to hospital admission
AMIODARONE (vs placebo)  
Kudenchuk et al, NEJM 1999

• Prehospital study of patients with shock-resistant VT / VF  
• Therapy  
  – 3 shocks, ETT, 1 mg epinephrine  
  – 300 mg amiodarone (246 patients) or placebo (258 patients)  
• Subsequent treatment per standard ACLS  
• Results  
  – Amiodarone patients -- higher survival to admission (44% vs. 34%)  
  – No significant difference for survival to hospital discharge

AMIODARONE (vs lidocaine)  
Dorian P et al, NEJM 2002

• Prehospital trial  
  – comparing amiodarone with lidocaine  
  – 347 patients with refractory VF / VT  

• 11% improvement in survival to hospital admission for amiodarone patients  

• Less post-countershock asystole in amiodarone group (18% vs 29%)  

• NOTE: designed to ID difference for survival to hosp admit / not survival to hosp d/c
Magnesium

- 13 studies demonstrating no benefit

  MAGIC Trail -- representative
  - Prospective, randomized, placebo-controlled, double-blinded clinical trial
  - Magnesium sulfate 5 g vs placebo as first line Rx for pre-hospital cardiac arrest
  - No improvement in ROSC or survival to hospital discharge

- Consider "niche" application -- potential uses
  - Long QT - related polymorphic VT
  - Toxemia
  - Hyperkalemia

Atropine

- Cardiac arrest
  - No value in PEA / asystolic arrest
  - Removed from G2010

- Compromising bradycardia
  - Indications unchanged
  - Use early with appropriate doses
Calcium

• Routine administration of calcium does not improve outcome of cardiac arrest.
• “Niche” application -- potential uses
  – Hyperkalemia
  – Certain ingestions
  – Massive blood loss / transfusion
  – Known hypocalcemia


Fibrinolytic Therapy

• Very limited impact
• Poor outcomes
• Indications?
  – All patients vs certain subsets
  – “Niches”
    • Witnessed arrest
    • Pulmonary embolism

Post-Resuscitation Care

• Important addition to cardiac arrest therapy
• General
  – Oxygenation & ventilation
  – Intravascular volume
  – Vasopressor & inotropic support
  – Avoid extremes: oxygen, temperature, etc
  – Seizure control
  – Et cetera......
• Specific
  – Therapeutic (induced) hypothermia
  – Coronary reperfusion
Post-Resuscitation Care

Therapeutic Hypothermia

- Hypothermia After Cardiac Arrest Study Group -- Austria
- 275 patients randomized: cooled patients to 32-34°C
- Mortality...
  - 41% (cooled)
  - 55% (non-cooled)
- Good neuro outcome...
  - 55% (cooled)
  - 39% (non-cooled)

NEJM 2002;346:549
Post-Resuscitation Care

Therapeutic Hypothermia

- Prospective study in Australia
- 77 patients randomized: cooled patients to 33°C
- Mortality...
  - 51% (cooled)
  - 68% (non-cooled)
- Good neuro outcome...
  - 49% (cooled)
  - 26% (non-cooled)

NEJM 2002;346:557

Post-Resuscitation Care

Therapeutic Hypothermia

- Meta-analysis: 4 randomized studies
- Number needed to treat to save one life = 7
- Number needed to treat to prevent 1 poor neurologic outcome = 5

Can J Emerg Med 2006;8:329
**Post-Resuscitation Care**

*Immediate Percutaneous Coronary Intervention*

- Prehospital cardiac arrest -- #714 survivors (Paris)
- Retrospective review
- Immediate PCI in ST elevation & non-ST elevation cases

<table>
<thead>
<tr>
<th>714 survivors</th>
<th>235 excluded (non-cardiac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>435 to catheterization</td>
<td>Overall 51% survival with PCI vs 31% survival without PCI</td>
</tr>
</tbody>
</table>

- 134 ST elevation:
  - 128 with at least 1 lesion: 74% with PCI, 54% survival
  - 176 with at least 1 lesion: 88% with PCI, 47% survival

- 301 no ST elevation:
  - 128 with at least 1 lesion: 74% with PCI, 54% survival
  - 176 with at least 1 lesion: 88% with PCI, 47% survival

*Dumas et al, Cardiovasc Interv 2010*

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**Post-Resuscitation Care**

*Emergent Reperfusion & Therapeutic Hypothermia*

- VT / VF survivors
- STEMI demonstrated on 12-lead ECG
- Fibrinolysis vs PCI +/- hypothermia
  - "Survival at 6 months was 54% with 46% demonstrating good neurologic function"
  - "...initially comatose patients survived 51% of hospitalizations with good neurological status in 29%"
  - "...55% of the TH group compared to non-TH group were discharged with good neurological outcome"

Post-Resuscitation Care
Emergent Reperfusion & Therapeutic Hypothermia

- Considered safety & feasibility of PCI with simultaneous TH
  - 90 cardiac arrest survivors: 20 with PCI during TH & 70 TH only
  - Outcomes: malignant dysrhythmia, adverse event, & mortality
- No difference in any outcome variable
- Very small study -- safely performed

Batista et al, Resuscitation 2010

Resuscitation Centers

- Emerging concept?
- Management of the resuscitated cardiac arrest patient
  - Focused
  - Multidisciplinary
  - Specialist-oriented
- Therapeutic hypothermia
- Early coronary angiography with PCI
- Aggressive critical care support
“Putting It All Together”

- Reorder the alphabet from ABCs to CABs
- Emphasis on the basic therapies
  - Chest compressions & Defibrillation
- Continued use of advanced therapies
  - Parenteral access
  - Airway management
  - Medications
- Limit therapy-based interruptions in chest compressions
Minimally Interrupted Cardiac Resuscitation by EMS for Out-of-Hospital Cardiac Arrest

<table>
<thead>
<tr>
<th>survival-to-hospital discharge</th>
<th>before MICR training</th>
<th>after MICR training</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>1.8% (4/218)</td>
<td>5.4% (36/668)</td>
</tr>
<tr>
<td>witnessed VF</td>
<td>4.7% (2/43)</td>
<td>17.6% (23/131)</td>
</tr>
</tbody>
</table>

Bobrow et al., JAMA 2008;299:1158

Cardiocerebral Resuscitation

- A “new” concept – 2003 Univ. of Arizona
  - Stressing beneficial Rx
  - Avoiding interruptions in compressions
  - De-emphasizing less beneficial Rx
  - Moving from “A-B-C” to “C-A-B”

- 3 major components
  [1] continuous chest compressions with no early ventilations pre- & post-shock
  [2] delayed endotracheal intubation
  [3] early use of epinephrine
Cardiocerebral Resuscitation

- Out-of-hospital cardiac arrest (#498)
- Comparison of standard Rx (#268) vs cardiocerebral resuscitation (#230)
- Cardio-cerebral resuscitation algorithm
  - Chest compressions for 2 minutes - then rhythm analysis
  - If "shockable" rhythm (pulseless VT or VF)
    • 1 defibrillation at maximal energy
    • 2 more cycles of compression with defibrillation
    • Oral airway with 100% oxygen by face mask
  - If "non-shockable" rhythm (asystole or PEA)
    • Invasive airway placement


Cardiocerebral Resuscitation

- Analysis of subgroups with neuro outcome
  - Witnessed vs unwitnessed
  - Shockable vs non-shockable initial rhythm
- Survivors
  - Unwitnessed & nonshockable - 0 / 167
  - Witnessed & nonshockable - 2 / 108
  - Witnessed & shockable - 60 / 181

Cardiocerebral Resuscitation

more evidence......

- Similar approach – no ETT until 3 cycles of chest compression
- Outcome: survival with neuro status
- #3515 prehospital patients
  - #2491 “standard” ACLS
  - #1024 “CCR”
- Overall survival – 5.8%

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Cardiocerebral Resuscitation

- Age-based subgroup survival

<table>
<thead>
<tr>
<th>Age Group (yr)</th>
<th>ACLS (%)</th>
<th>CCR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 40</td>
<td>3.7</td>
<td>18.8</td>
</tr>
<tr>
<td>40-49</td>
<td>4.1</td>
<td>14.4</td>
</tr>
<tr>
<td>50-59</td>
<td>4.9</td>
<td>11.9</td>
</tr>
<tr>
<td>60-69</td>
<td>6.0</td>
<td>10.2</td>
</tr>
<tr>
<td>70-79</td>
<td>4.2</td>
<td>6.3</td>
</tr>
<tr>
<td>&gt; 80</td>
<td>1.9</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Mosier et al, Acad Emerg Med 2010
**Cardiocerebral Resuscitation vs Standard CPR with ALS**

- Systematic review: CCR vs CPR with ALS
- 13 studies considered - as compared to CPR with ALS, CCR performed.....

<table>
<thead>
<tr>
<th>Outcome</th>
<th>CCR [AOR with 95CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients - Survival to D/C</td>
<td>1.45 [1.07-1.97]</td>
</tr>
<tr>
<td>All Patients - Neuro Intact Survival</td>
<td>1.25 [1.01-1.55]</td>
</tr>
<tr>
<td>Shockable Rhythm - Survival to D/C</td>
<td>2.03 [1.44-2.86]</td>
</tr>
<tr>
<td>Shockable Rhythm - Neuro Intact Survival</td>
<td>1.47 [0.91-2.36]</td>
</tr>
<tr>
<td>Non-cardiac Cause of Arrest - Survival to D/C</td>
<td>0.68 [0.33-1.39]</td>
</tr>
<tr>
<td>Non-cardiac Cause of Arrest - Neuro Intact Survival</td>
<td>0.63 [0.26-1.51]</td>
</tr>
</tbody>
</table>


**Identifying Non-Cardiac Cardiac Arrest**

- Difficult to identify non-cardiac causes
  - 31% of 3068 arrest victims had non-cardiac cause
  - Prediction model was difficult to construct
- Difficult to identify underlying cause in PEA
  - 18% had cause ID’ed with specific RX
    - 32% survival compared to 11% in general RX group
  - Trend towards better outcome in specific RX group

Dumas et al, Resuscitation 2012;83:134

Saarinen et al, Resuscitation epub 2011 Dec
Resuscitation in Cardiorespiratory Arrest

- Basic is awesome / advanced is good
- A change of the alphabet from "ABCs" to the "CABs"
- A phased approach with different priorities at different times
  - Maximize chest compressions
  - Limit interruptions
  - Prioritize other interventions
- Beware the exceptions to the CAB approach

Many Thanks

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