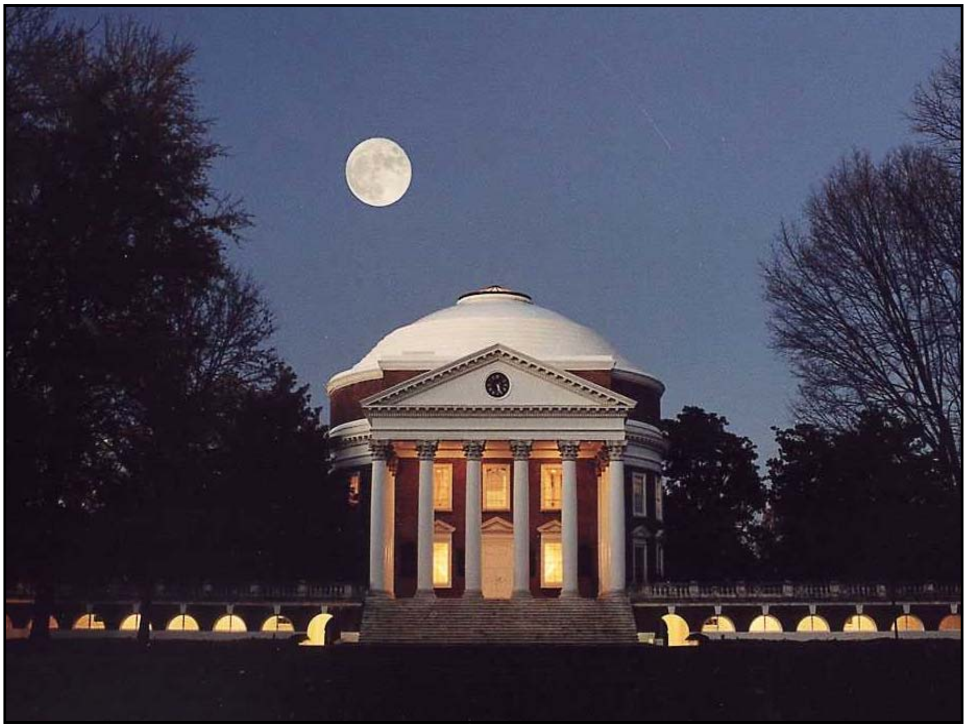
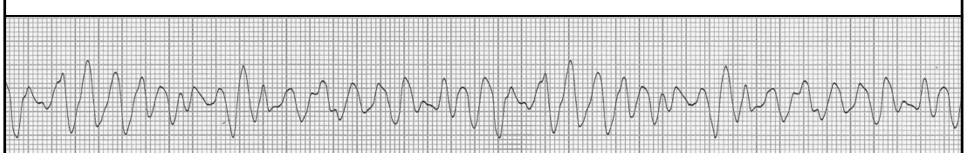


What Works (& Doesn’t Work) in Cardiac Arrest Resuscitation



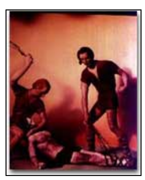
William J Brady, MD
Departments of Emergency Medicine & Medicine
University of Virginia

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

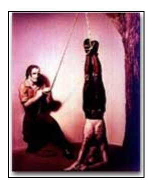


Middle Ages
The Flagellation Method

1530
The Bellows Method

1700
The Fumigation Method

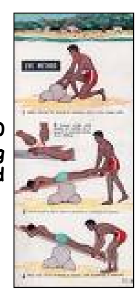
1750
The Barrel Roll Method



1775
The Inversion Method

1825
The Russian "Snow Packing" Method

1840
The Trotting Horse Method



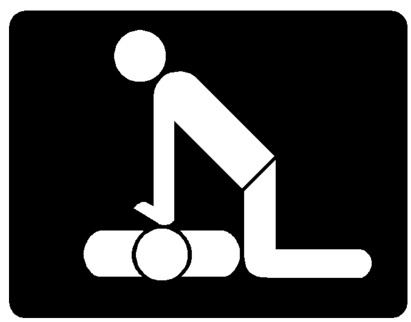
1930
The Rocking Method

The History of CPR - http://www.cprmatters.com/cpr-history.html

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

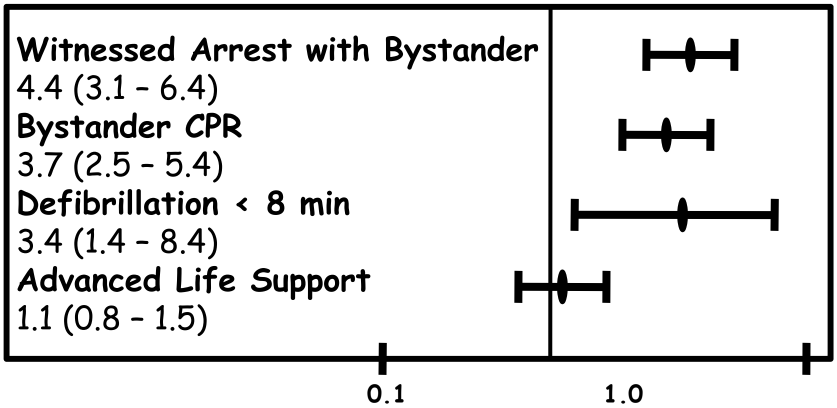
Today….



- 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 <u>early</u>
  - Cardio-active medication administration
- Limit interruptions in chest compressions

Relative Importance of Interventions in Cardiac Arrest

Adjusted Odds Ratio



Stiell NEJM 2005

Interventions in Cardiac Arrest

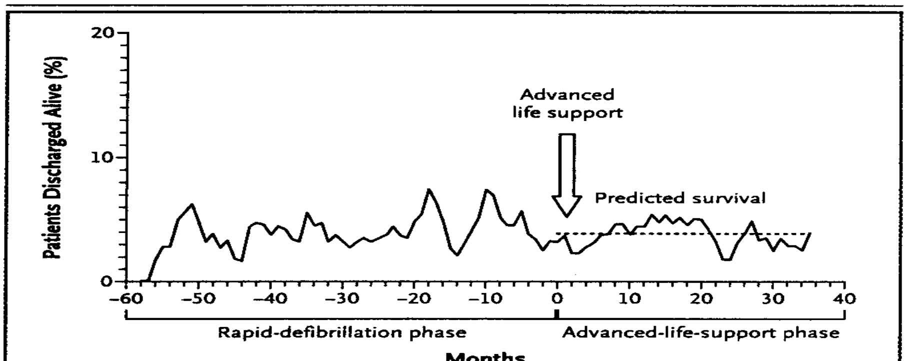


Figure 2. Actual versus Predicted Interrupted-Time-Series Model for Survival to Discharge for 100 Consecutive Months, from the Rapid-Defibrillation Phase to the Advanced-Life-Support Phase.
The solid line represents actual survival, and the dotted line represents predicted survival based on the rapid-defibrillation phase.

Stiell NEJM 2004

AHA Guidelines 2010

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

John M. Field, Mary Fran Hazinski, Michael R. Sayre, Leon Chameides, Stephen M. Schexnayder, Robin Hemphill, Ricardo A. Samson, John Kattwinkel, Robert A. Berg, Farhan Bhanji, Diana M. Cave, Edward C. Jauch, Peter J. Kudenchuk, Robert W. Neumar, Mary Ann Peberdy, Jeffrey M. Perlman, Elizabeth Sinz, Andrew H. Travers, Marc D. Berg, John E. Billi, Brian Eigel, Robert W. Hickey, Monica E. Kleinman, Mark S. Link, Laurie J. Morrison, Robert E. O'Connor, Michael Shuster, Clifton W. Callaway, Brett Cucchiara, Jeffrey D. Ferguson, Thomas D. Rea and Terry L. Vanden Hoek

Circulation 2010;122;S640-S656
DOI: 10.1161/CIRCULATIONAHA.110.970889
Circulation is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 72514

- 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

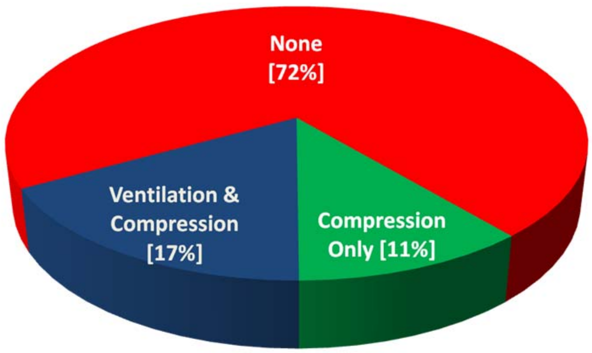
CPR vs Nothing

Rea et al, Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001;104:2513-6.

- 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

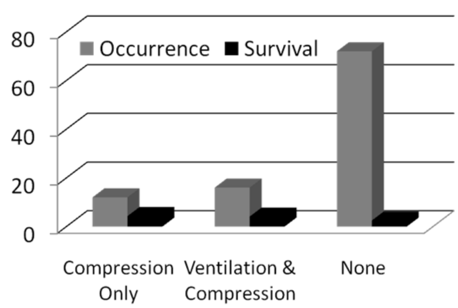
No ventilation benefit

SOS-KANTO Study Group. *Lancet* 2007;369:920

CPR

Nothing vs Traditional vs Compression - only

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



Intervention	Occurrence	Survival
Compression Only	544 (12%)	4.3%
Ventilation & Compression	783 (16%)	4.1%
None	3550 (72%)	2.5%

14

Ewy GA. *Circulation* 2007;116:2894

Traditional vs Compression-only

Hallstrom A et al, Cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation. NEJM 2000;342:1546-53.

- 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

Iwami et al, Circulation 2007;116:2900.

Early
Compressions > Ventilations
Late
Ventilations more important

- 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?

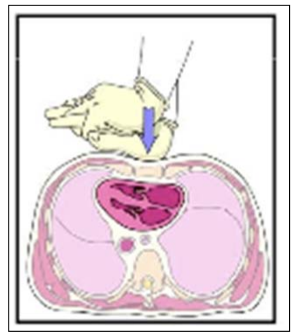
- Out-of-hospital cardiac arrest # 95,072 in Japan
- Comparison of bystander +/- ALS care
  - Bystander CPR (B-CPR)
  - ALS by EMS & MDs
- 8.1% alive @ 30 days with 2.8% with good neuro status
- Adjusted odds ratios for survival with good neuro status, as compared to EMS without B-CPR
  - EMS with B-CPR: 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

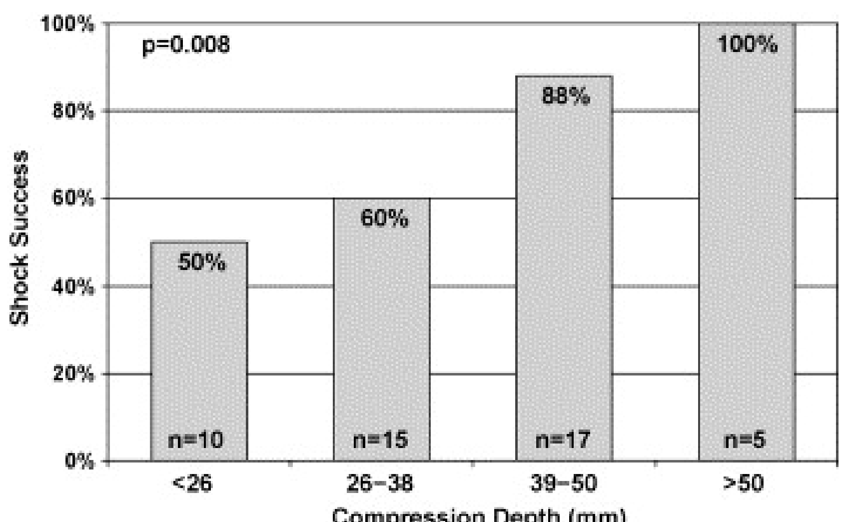
Compression Depth

- Deeper compressions depths eject more blood per compression
- Improved perfusion
- Better outcomes



PUSH HARD & DEEP!

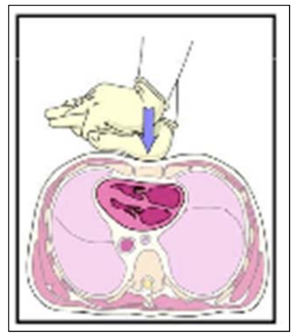
Deeper compressions are significantly associated with ROSC



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'Hearn, RN, MSN; Herbert N. Wigder, MD; Paul Hoffman, CRT; Kathleen Tynus, MD; Terry L. Vanden Hoek, MD; Lance B. Becker, MD

PUSH FAST!

Higher chest compression rates were significantly correlated with initial ROSC

Background—Recent data high[illegible] between [illegible] cardiopulmonary resuscitation (CPR) and survival after cardiac arrest; however, the quality of CPR as actually performed by trained healthcare providers is largely unknown. We sought to measure in-hospital chest compression rates and to determine compliance with published international [illegible].

Methods and Results—We developed and validated a handheld recording device to measure chest compression rate as a surrogate for CPR quality. A prospective observational study of adult cardiac arrests was performed at 3 hospitals from April 2002 to [illegible]. Resuscitations were witnessed by trained observers using a customized personal digital assistant programmed to store the exact time of each chest compression, allowing offline calculation of compression rates at serial time points. In 97 arrests, data from [illegible] during which chest compressions were delivered were analyzed in 30-second time segments. In 36.9% of the total number of segments, compression rates were <80 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

VERY IMPORTANT

DO NOT STOP

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

Quality of Cardiopulmonary Resuscitation During Out-of-Hospital Cardiac Arrest

Lars Wik, MD, PhD
Jo Kramer-Johansen, MD
Helge Myklebust, BEng
Hallstein Sørebø, MD
Leif Svensson, MD
Bob Fellows, MD
Petter Andreas Steen, MD, PhD

Context Cardiopulmonary resuscitation (CPR) guidelines recommend target values for compressions, ventilations, and CPR-free intervals allowed for rhythm analysis and defibrillation. There is little information on adherence to these guidelines during advanced cardiac life support in the field.

Objective To measure the quality of out-of-hospital CPR performed by ambulance personnel, as measured by adherence to CPR guidelines.

Design and Setting Case series of 176 adult patients with out-of-hospital cardiac arrest treated by paramedics and nurse anesthetists in Stockholm, Sweden, London, England, and Akershus, Norway, between March 2002 and October 2003. The defibrillators recorded chest compressions via a sternal pad fitted with an accelerometer and ventilations by changes in thoracic impedance between the defibrillator pads, in addition to standard event and electrocardiographic recordings.

Main Outcome Measure Adherence to international guidelines for CPR.

Results Chest compressions were not given 48% (95% CI, 45%-51%) of the time ... subtracting the time necessary for electrocardiographic analysis and defibrillation. Combining these data with mean compression rate of 121/min (95% CI, 118-124/min) ... (95% CI, 61-67/min). Mean compression depth was 34 mm (95% CI, 33-35 mm), 28% (95% ... compressions had a depth of 38 mm to 51 mm (guidelines recommendation), and the compression part of the duty cycle was 42% (95% CI, 41%-42%). A mean of 11 (95% CI, 11-12) ventilations were given per minute. Sixty-one patients (35%) had return of spontaneous circulation, and 5 of 6 patients discharged alive from the hospital had normal neurological outcomes.

Conclusions In this study of CPR during out-of-hospital cardiac arrest, chest compressions were not delivered half of the time, and most compressions were too shallow. Electrocardiographic analysis and defibrillation accounted for only small parts of intervals without chest compressions.

JAMA. 2005;293:299-304 www.jama.com

SINCE THE FIRST STANDARDS AND guidelines for cardiopulmonary resuscitation (CPR) were published 30 years ago[1] (with the latest update in 2000[2,3]) health care professionals ... have been trained accordingly around the world. The importance of CPR, defined as chest compressions and ventilation, for survival of cardiac arrest patients has been demonstrated,[4] and there are indications that the quality of CPR performance influences the outcome.[5-7]

When tested on mannequins, CPR quality performed by lay rescuers and health care professionals tends to deteriorate significantly within a few months after training,[8-10] but little is known about the quality of clinical performance on pa-

Chest compressions were not delivered half of the time, and most compressions were too shallow.

Quality of Cardiopulmonary Resuscitation During In-Hospital Cardiac Arrest

Benjamin S. Abella, MD, MPhil
Jason P. Alvarado, BA
Helge Myklebust, BEng
Dana P. Edelson, MD
Anne Barry, RN, MBA
Nicholas O'Hearn, RN, MSN
Terry L. Vanden Hoek, MD
Lance B. Becker, MD

Context The survival benefit of well-performed cardiopulmonary resuscitation (CPR) is well-documented, but little objective data exist regarding actual CPR quality during cardiac arrest. Recent studies have challenged the notion that CPR is uniformly performed according to established international guidelines.

Objectives To measure multiple parameters of in-hospital CPR quality and to determine compliance with published American Heart Association and international guidelines.

Design and Setting A prospective observational study of 67 patients who experienced in-hospital cardiac arrest at the University of Chicago Hospitals, Chicago, Ill, between December 11, 2002, and April 5, 2004. Using a monitor/defibrillator with novel additional sensing capabilities, the parameters of CPR quality including chest compression rate, compression depth, ventilation rate, and the fraction of arrest time without chest compressions (no-flow fraction) were recorded.

Main Outcome Measure Adherence to American Heart Association and international ...

Results Analysis of the first 5 minutes of each resuscitation by 30-second segments ... segments. Compression depth was too shallow (defined as <38 mm) for 37.4% of compressions ... a rate of more ... 0.24 (0.18). A 10-second pause each minute of arrest would yield a no-flow fraction of 0.17. A total of 27 patients (40.3%) achieved return of spontaneous circulation and 7 (10.4%) were discharged from the hospital.

Conclusions In this study of in-hospital cardiac arrest, the quality of multiple parameters of CPR was inconsistent and often did not meet published guideline recommendations, even when performed by well-trained hospital staff. The importance of high-quality CPR suggests the need for rescuer feedback and monitoring of CPR quality during resuscitation efforts.

JAMA. 2005;293:305-310 www.jama.com

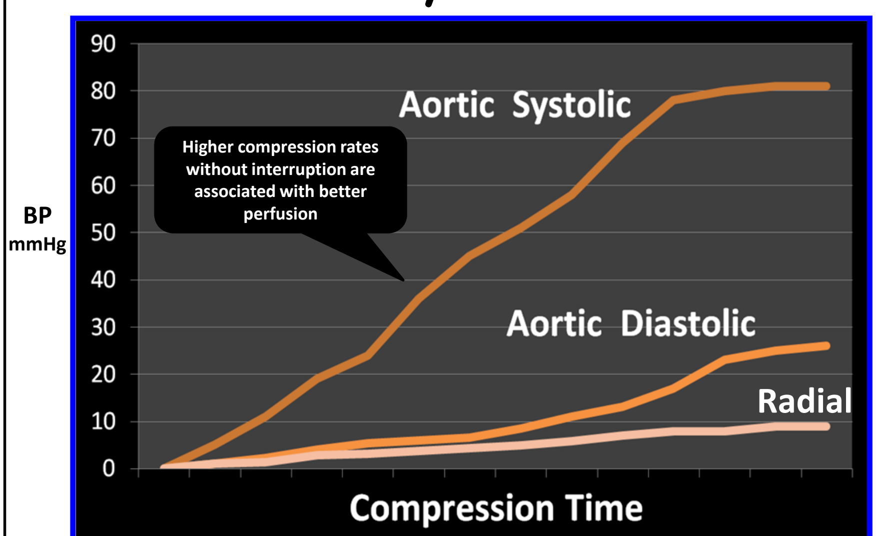
SURVIVAL FROM CARDIAC ARREST remains low despite the introduction of cardiopulmonary resuscitation ... years ago ... significant survival benefit in both animal and human ... ruptions in CPR or failure to provide compressions during cardiac arrest ("no-flow time") have been noted to have a negative impact on survival in animal studies.[7] Consensus guidelines clearly define how CPR is to be performed,[9] but the parameters of CPR in actual practice are not routinely measured, nor is the quality known.

Again, chest compressions were not delivered more than half of the time and most compressions were too shallow.

Compression Interruptions

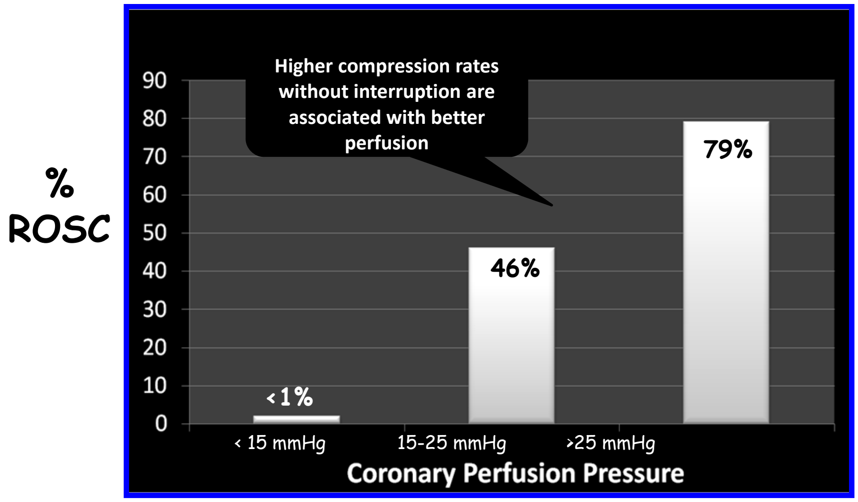
- Interruptions are bad!
- We want to strive towards a significant reduction in compression interruptions
- Avoid *resuscitatus interruptus*

ROSC & Coronary Perfusion Pressure



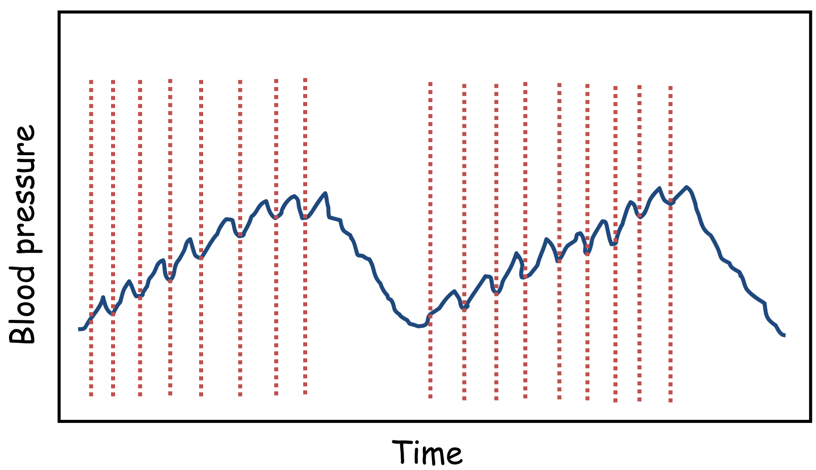
Ewy G, Circulation 2005

ROSC & Coronary Perfusion Pressure



Paradis JAMA 1990

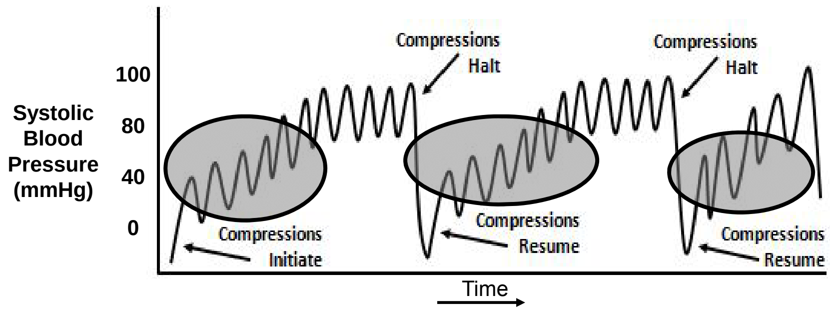
Standard CPR



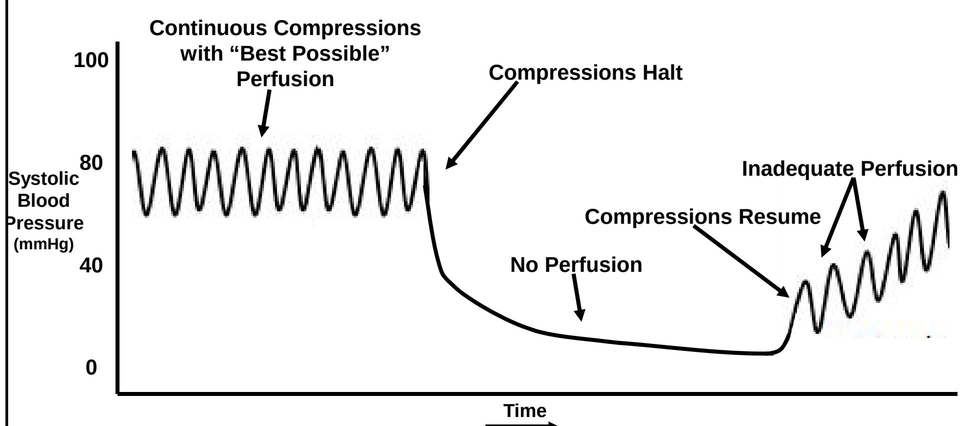
= chest compression

Berg et al, 2001

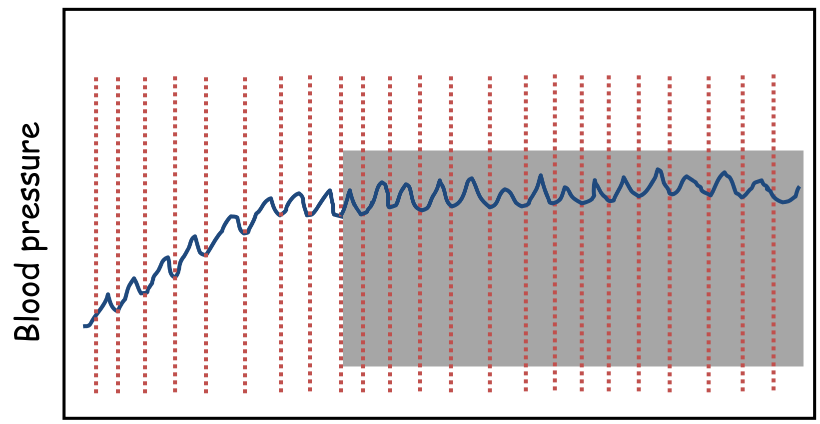
Inadequate Perfusion During Cardiac Arrest as Chest Compressions Resume After Interruption



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

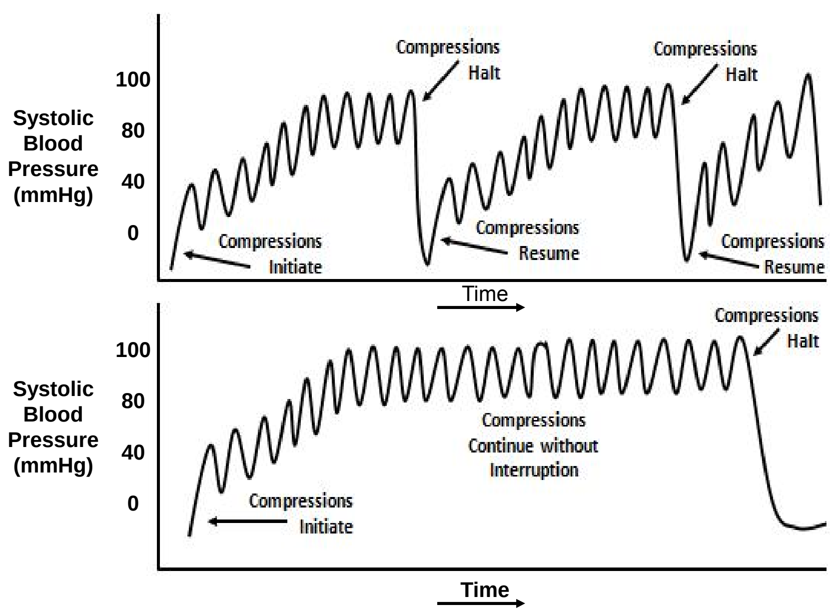


Compression Only



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

- #1029 VF victims
- Increasing CCF associated with better outcome
- Depth & rate were inversely related
- Higher rates of ROSC
  - Increased rate
  - Increased depth

Stiell et al, Crit Care Med, epub Jan 2012

- #2103 non-VF/VT victims
- Increasing CCF associated with better outcome
- Adjusted OR for ROSC for each CCF category
  - 41-60% -- 1.14
  - 61-80% -- 1.42
  - 81-100% - 1.48

Vaillancourt et al, Resuscitation, 2011;82:1501-7

- <u>Bottom line</u> = improved outcome / more compressions

CPR Devices

Surprisingly Equivocal Outcomes

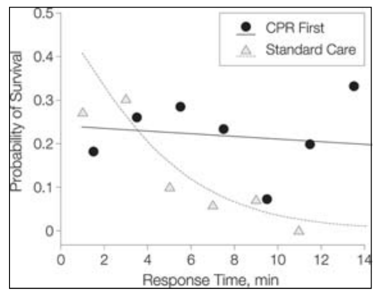
Defibrillation

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?

Hayakawa et al, Am J Emerg Med 2009

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?

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 SEPTEMBER 1, 2011 VOL. 365 NO. 9

Early versus Later Rhythm Analysis in Patients with Out-of-Hospital Cardiac Arrest

Ian G. Stiell, M.D., Graham Nichol, M.D., M.P.H., Brian G. Leroux, Ph.D., Thomas D. Rea, M.D., M.P.H., Joseph P. Ornato, M.D., Judy Powell, B.S.N., James Christenson, M.D., Clifton W. Callaway, M.D., Ph.D., Peter J. Kudenchuk, M.D., Tom P. Aufderheide, M.D., Ahamed H. Idris, M.D., Mohamud R. Daya, M.D., Henry E. Wang, M.D., Laurie J. Morrison, M.D., Daniel Davis, M.D., Douglas Andrusiek, M.Sc., Shannon Stephens, E.M.T.-P., Sheldon Cheskes, M.D., Robert H. Schmicker, M.S., Ray Fowler, M.D., Christian Vaillancourt, M.D., David Hostler, Ph.D., E.M.T.-P., Dana Zive, M.P.H., Ronald G. Pirrallo, M.D., M.H.S.A., Gary M. Vilke, M.D., George Sopko, M.D., and Myron Weisfeldt, M.D., for the ROC Investigators*

- 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 <u>single</u> 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

N	Waveform Energy	VF Termination 1st shock	VF Termination 2nd shock	VF Termination 3rd shock
54	Biphasic 150J, 150J, 150J	96%	96%	98%
48	Monophasic 200J, 300J, 360J	54%	60%	67%

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

    No compressions for 14.8 sec
  - "Interrupted" method (AHA)
    - Rhythm check w/o compressions
    - If shockable, resume compression & charge
    - Then halt & shock

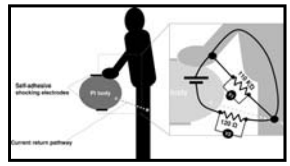
    No compressions for 11.5 sec
  - "Anticipatory" charging
    - Charge defibrillator prior to rhythm check
    - Rhythm check w/o compressions
    - If shockable, shock
    - "Dump" charge if no shock

    No compressions for 3.9 sec

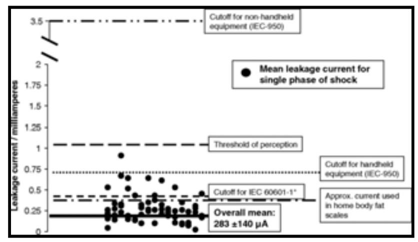
Edelson et al, Resuscitation 2010.

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

48

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

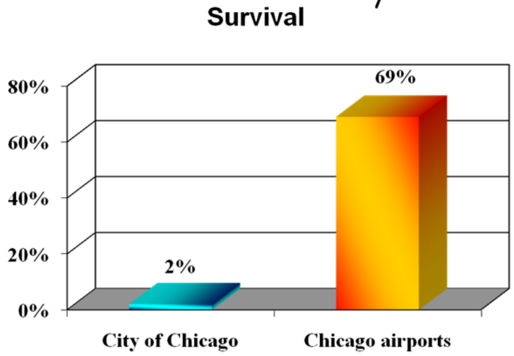
- Out-of-hospital / Netherlands / 2006-2009
- Time to first shock / outcome with neurologic status
- 2833 consecutive cardiac arrest patients
  - AED on-site #128
  - AED distant #478
  - EMS Response #2227

Strategy	Time to Shock (min)	Survival (%)	Odds Ratio (CI)
AED on site	4.1	49.6	2.72 (1.77-4.18)
AED distant	8.5	14.2	1.07 (0.82-1.39)
Response	11.0	5.6	-------------------------

Berdowski et al, Circulation 2011;124:2225

Chicago Airports AED Program

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



16 arrests

VF 13 | Non-VF 3

Survival 9 (69%) | Survival 0 (0%)

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

Caffrey et al, NEJM 2002

Las Vegas Gaming Casinos

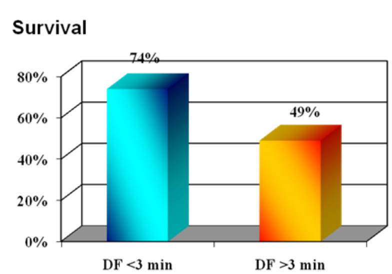
Valenzuela TD et al, NEJM 2000

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

105 VF arrests

Survival to discharge 56 (53%)

- 86% witnessed arrest
- Collapse to DF -- 4.4 min
- Collapse to EMS -- 9.8 min



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 12, 2004 VOL. 351 NO. 7

Public-Access Defibrillation and Survival after Out-of-Hospital Cardiac Arrest

The Public Access Defibrillation Trial Investigators*

- 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
- **Mosesso et al, Ann Emerg Med 1998**
  - Suburban // PD first-responders
  - Increased rate of VF survival
- **Forrer et al, Resuscitation 2002**
  - Suburban // PD with AED
  - Cost-effective intervention

Airway Management

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

	O_2 Sat	pCO_2	pH
Compressions & Ventilations	92±1*	25±2	7.49±.02
Compressions Only	76±6*	37±5	7.41±.03

* $p<0.01$

Berg, *Circulation* 1997

Noncardiac-based Cardiac Arrest Arterial Blood Gas

after 7 min of CPR with asphyxia

	O_2 Sat	pCO_2	pH
Compressions & Ventilations	87±6*	45±8*	7.20±.02*
Compressions Only	17±5	97±5	7.01±.06

* 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

Outcome	RR [95 CI)
ROSC	0.61 [0.54-0.69]
Neuro Status	0.47 [0.38-0.57]

- Invasive airways were <u>not</u> 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

Early vs Late Airway

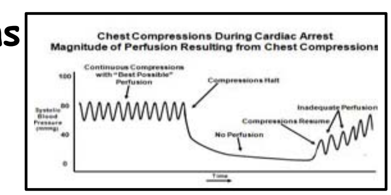
Event	Occurrence	Adjusted Odds Ratio
ROSC	50.3% (49.7-51.0)	0.96 (0.91 – 1.01)
Survival to 24 hr	33.7% (33.1-34.3)	0.94 (0.89 – 0.99)
Survival to D/C	15.3% (14.9-15.8)	Unable to analyze

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

Wong, 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



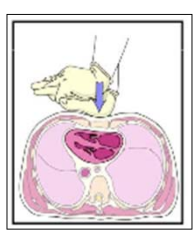
Wang et al, Ann Emerg Med, 2009;54:645

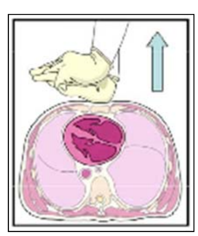
Chest Compression Interruptions
Due to Intubation -- "Minimally Interrupted" CPR

- 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

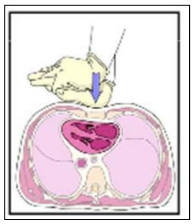
Bobrow et al Ann Emerg Med 2009;54:656

Please Avoid
"Death by Hyperventilation"

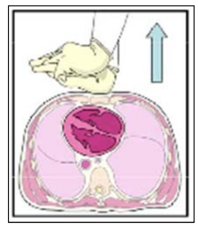




Compressions & Blood Flow

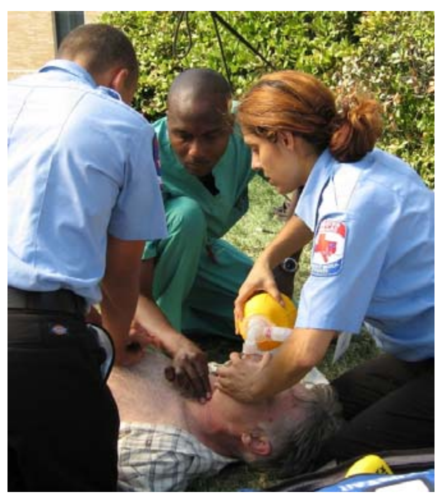


- Cardiac Pump Theory
  - "Compressive" approach
  - Heart is "squeezed" between the breastbone & spine



- 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%

Reades R et al, *Ann Emerg Med* 2011;58:509.

Medications in Cardiac Arrest?

Olasveegen et al, Intravenous drug administration during out-of-hospital cardiac arrest: A randomized trial. JAMA 2009;302:2222.

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

- Out-of-hospital cardiac arrest (#1183) – 5 years in Oslo, Norway
- ALS therapy with & without IV medications

Therapy	ROSC *	Survival to D/C	1 Year Survival	Neuro Status
With IV (#418)	32.0	10.5	10.0	9.8
Without IV (#433)	21.0	9.2	8.0	8.1

* $P < 0.001$

- 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

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

Mitchell RG, Brady W, Guly UM, Pirallo RG, Robertson CE: Comparison of two emergency response systems and their effect on survival from out of hospital cardiac arrest. Resuscitation 1997;35:225-9.

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%

vs.

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%

?? Impact of Medications in Cardiac Arrest Resuscitation ??

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Vasopressor Therapy

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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

	ROSC	Survival to D/C*
Epinephrine	64 (23.5%)	11 (4.0%)
Placebo	22 (8.4%)	5 (1.9%)

- 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
- Wenzel V et al, NEJM 2004 – out-of-hospital
  - No difference in VT/VF & PEA outcomes
- Gueugniaud et al, NEJM 2008 – out-of-hospital
  - 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

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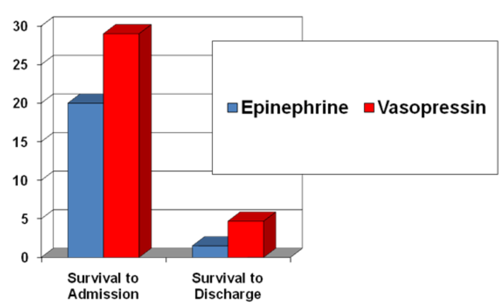
Vasopressor Therapy in Cardiac Arrest

Wenzel V et al, NEJM 2004

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



- Increased effectiveness for epinephrine as 2nd line agent

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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

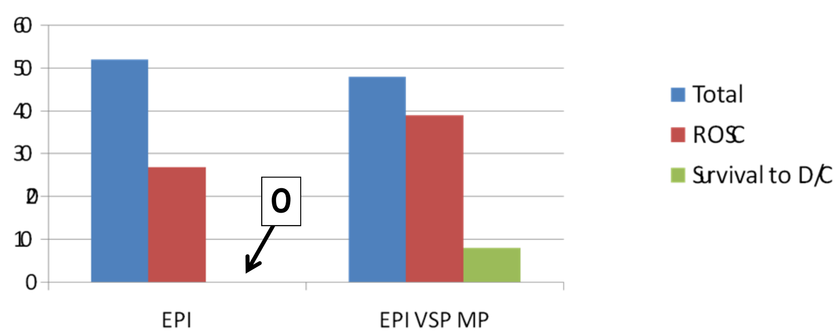
Gueugniaud et al, NEJM 2008

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

Mentzelopoulos et al. Arch Int Med 2009

Vasopressin vs Epinephrine with Steroids in Cardiac Arrest



- **Resuscitation & hospital D/C rates were higher in the steroid group**
- **Hemodynamics , CVO_2 saturation, & organ failure-free days – improved in steroid group**

Mentzelopoulos et al. Arch Int Med 2009

Anti-Arrhythmic Therapy

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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

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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*

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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 <u>hospital admission</u> 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

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Magnesium

- 13 studies demonstrating no benefit

<u>*MAGIC Trail -- representative*</u>

- 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

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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 / transufusion
  - Known hypocalcemia

Stueven HA et al: Lack of effectiveness of calcium chloride in refractory asystole. *Ann Emerg Med.* 1985;14 :630

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Fibrinolytic Therapy

- Very limited impact
- Poor outcomes
- Indications?
  - All patients vs certain subsets
  - "Niches"
    - Witnessed arrest
    - Pulmonary embolism

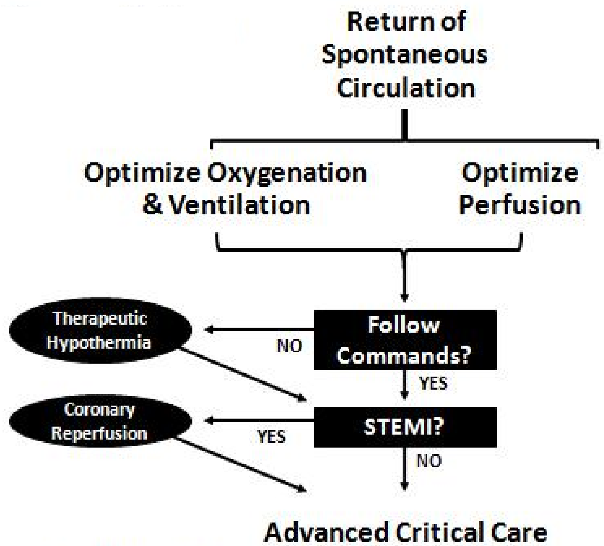
Bottiger ,N Engl J Med 2008

Post-Resuscitation Care

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



AHA Guidelines 2010

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

714 survivors — 235 excluded (non-cardiac)

435 to catheterization

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

Overall 51% survival with PCI vs 31% survival without PCI

Dumas et al, Cardiovasc Interv 2010

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"*

Garot Pvet al *Circulation* 2007 | Knafelj et al *Resuscitation* 2007 | Richling et al *Am J Emerg Med.* 2007

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

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"Putting It All Together"

"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

survival-to-hospital discharge	before MICR training	after MICR training
All	1.8% (4/218)	5.4% (36/668)
witnessed VF	4.7% (2/43)	17.6% (23/131)

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 cardio-cerebral 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

Kellum et al, Ann Emerg Med 2008

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

Kellum et al, Ann Emerg Med 2008

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%

Mosier et al, Acad Emerg Med 2010

Cardiocerebral Resuscitation

- Age-based subgroup survival

Age Group (yr)	ACLS (%)	CCR (%)
< 40	3.7	18.8
40-49	4.1	14.4
50-59	4.9	11.9
60-69	6.0	10.2
70-79	4.2	6.3
> 80	1.9	4.6

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.....

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

Cheng-lu et al, AJEM 2012;30:784.

Identifying Non-Cardiac Cardiac Arrest

- Difficult to identify non-cardiac causes
  - 31% of 3068 arrest victims had non-cardiac cause Dumas et al, Resuscitation 2012;83:134
  - 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 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

wjbrady@virginia.edu