Resuscitation Arsenal

- Therapeutic hypothermia
- Transcutaneous pacing
- Sodium bicarbonate Rx
- Calcium, Magnesium
- Fluids and Pressors
- Antiarrhythmic Rx
- Epi/Vasopressin
- $O_2$/intubation
- Shock
- CPR
CPR Prior to Shock
Out-of-hospital VF Analysis of Survival $n=1117$

- 22% improved survival
  - $p=0.04$

1990-93
- "Shock first"
  - 24.3%
  - 155/639

1994-96
- "CPR first"
  - 29.7%
  - 142/478

Cobb LA et al. JAMA 1999;281:1182-88
Compression
- Increased intrathoracic pressure
- Ejects blood from heart and lungs
- “Good” compression increases forward output and BP

Decompression (recoil)
- Decreased intrathoracic pressure
- Refilling of heart and lungs
- “Good” recoil → ↑ vacuum → ↑ refilling → ↑ forward output
Hemodynamics of CPR

Compression ("systole")

Decompression ("diastole")

Aorta

Organ perfusion

Heart + organ perfusion

Extrathoracic veins (U)

Left ventricle

Right atrium

“The adult sternum should be depressed at least 2 inches (5 cm) with chest compression and chest recoil/relaxation times approximately equal (…duty cycle of 50%) … at a rate of at least 100 compressions/minute.”
How well do we do?
Does perception = performance?

• Aufderheide et al: direct observation of duty cycle and compression depth/recoil is << than EMTs’ perception (Resuscitation. 2005;64(3):353-62).

• Wik et al: compression rate/depth << AHA guidelines and no flow times (neither pulse or CPR) was ~ 50% (JAMA. 2005;293(3):299-304).

• Is there a better way than the current standard of practice? If there is, what should it emphasize?
Clinical and hemodynamic comparison of 15:2 and 30:2 compression-to-ventilation ratios for cardiopulmonary resuscitation*

Demetris Yannopoulos, MD; Tom P. Aufderheide, MD; Andrea Gabrielli, MD; David G. Beiser, MD; Scott H. McKnite, BS; Ronald G. Pirrallo, MD, MHSA; Jane Wigginton, MD; Lance Becker, MD; Terry Vanden Hoek, MD; Wanchun Tang, MD; Vinay M. Nadkarni, MD; John P. Klein, PhD; Ahamed H. Idris, MD; Keith G. Lurie, MD

Increasing C:V ratio to 30:2 . . .

- Increased CO 35%
- Doubled common carotid artery blood flow
- No negative effects on oxygenation/pH balance
- No worsening of CPR quality
- No difference in rescuer fatigue or discomfort
CPR MATH

30 cc @ 100 cc/min
2 breaths
Rhythm/vitals analysis/shock ~10 secs

150 compressions (90 secs)/2 min
Avg compression rate = 75/min
CPR fraction* = 90 secs/120 secs (75%)

150 compressions (90 secs)/~130 secs
Avg compression rate = 69/min
CPR fraction = 90 secs/130 secs (69%)

*Proportion of resuscitation time devoted to chest compressions in absence of spontaneous circulation
**CPR MATH**

- **200 cc @100/min**
- **Asynchronous** 1 breath/10 cc
- **Rhythm/vitals analysis/shock** \(\sim 7\) secs

**200 compressions (120 secs)/2 min**
- Avg compression rate = 100/min
- CPR fraction* = 120 secs/120 secs (100%)

**200 compressions (120 secs)/\sim 127\) secs**
- Avg compression rate = 94/min
- CPR fraction = 120 secs/127 secs (94%)

*Proportion of resuscitation time devoted to chest compressions in absence of spontaneous circulation*
Diagram showing ECG and CC traces with labels indicating pre-shock pause and shock times:

(A) 5 sec
- ECG
- Pre-shock pause
- Shock

(B) 8 sec
- ECG
- Pre-shock pause

16 sec
Perishock Pause
An Independent Predictor of Survival From Out-of-Hospital Shockable Cardiac Arrest

on behalf of the Resuscitation Outcomes Consortium (ROC) Investigators

- n = 815 VF arrest
- 1st-11 shocks
- 3756 shocks analyzed
- Longest pre, post, peri-shock pauses
- Survival outcome

ECG Pads

12.3"

Impedance

10"

2.3"

Pre-Shock Pause

Post-Shock Pause

Time (Seconds)

625
630
635
640
645
650

Shock Pauses and Cardiac Arrest Survival

Survival to hospital discharge (% patients)

- Preshock Pause
  - <10: 35%
  - ≥20: 32%
- Post Shock Pause
  - <10: 25%
  - ≥20: 23%
- Perishock Pause
  - <20: 33%
  - ≥40: 20%

OR: 0.47 (0.27, 0.82)

p-values: 0.02, 0.06, 0.01

Maximum Pause in Chest Compressions (secs)

Does rate matter?

• The likelihood of ROSC increases significantly with higher mean compression rate

• Abella et al. Circulation 2005;111:428-34. A study of hospitalized patients in which 75% of patients achieved ROSC with compression rate of $\geq 90$ vs 42% for rate $\leq 72$
Impact of Chest Compression Rate on Outcome

n = 97 patients in-hospital cardiac arrest

ROSC
mean rate 90 ± 17  \( \rightarrow p = 0.0033 \)  mean rate 79 ± 18

Quartile 1 (n=24)
95.5-138.7 cpm
75%  25%

Quartile 2 (n=25)
87.1-94.8 cpm
76%  24%

Quartile 3 (n=24)
72.4-87.1 cpm
58%  42%

Quartile 4 (n=24)
40.3-72 cpm
42%  58%

* p < 0.0083

*ROSC = detectable pulse and perfusing rhythm for ≥ 5 min

The components of CPR

- Better compressions lead to better organ perfusion.
- At least 2 inches is key.
- Recoil is just as important as compression
Compression

- Increased intrathoracic pressure
- Ejects blood from heart and lungs
- “Good” compression increases forward output and BP
- Tissue perfusion

Decompression (recoil)

- Decreased intrathoracic pressure
- Refilling of heart and lungs
- “Good” recoil → ↑ vacuum → ↑ refilling → ↑ forward output
- Coronary and tissue perfusion
Coronary Perfusion is Key to ROSC

- Compression leads to forward flow.
- Decompression primes the pump for forward flow.
- Decompression also leads to heart perfusion and in so doing it increases the likelihood of successful defibrillation.
- Successful defibrillation appears to require a CorPP of 15 mmHg.
Hemodynamics of CPR

Compression ("systole")

Decompression ("diastole")

RT ATRIUM

Aorta

Orgn perfusion

Heart + organ perfusion

LEFT VENTRICLE

EXTRATHORAIC VEINS (IJ)

Saving the Heart: CPP and ROSC in Human CPR

n=100 patients with cardiac arrest

% Patients with ROSC

100%
80%
57%
50%
40-45
36%
25-39
20-24
15-19
0-14

Max coronary perfusion pressure (mm Hg)

CorPP = Aorta – RA pressure gradient during relaxation (diastolic) phase of precordial compression

*CorPP = Aorta – RA pressure gradient during relaxation (diastolic) phase of precordial compression

Recoil/Decompression

• If decompression is incomplete, compression is not as effective due to inadequate blood volume in the heart and lungs.

• Even limited periods of incomplete decompression can have lingering effects on heart and brain/organ perfusion.

• Yannopoulos et al showed that even 75% recoil (vs 100%) doesn’t generate sufficient coronary or cerebral perfusion pressures to achieve ROSC.
Effects of incomplete chest wall decompression during cardiopulmonary resuscitation on coronary and cerebral perfusion pressures in a porcine model of cardiac arrest

Demetris Yannopoulos, Scott McKnite, Tom P. Aufderheide, Gardar Sigurdsson, Ronald G. Pirrallo, David Benditt, Keith G. Lurie

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b Cardiac Arrhythmia Center, University of Minnesota, Minneapolis, MN, USA
c Department of Emergency Medicine of Hennepin County Medical Center, Minneapolis, MN, USA
d Medical College of Wisconsin, Milwaukee, WI 53226, USA

- n=9 instrumented swine
- 6 minutes untreated VF → standard CPR* × 3 min → CPR with 75% recoil (residual 1.2 cm sternal compression @ end decompression) x 1 min → standard CPR* × 1 min → defib × 3 → ACLS

*Standard CPR = CC @100/min, 50% duty cycle, 5 cm depth, full (100%) recoil, 15:2 ratio
Effect of Incomplete Chest Decompression On Coronary and Cerebral Perfusion Pressures

n=9 instrumented swine → std CPR (100% recoil) x 3’ → CPR (75% recoil) x 1’

Critical pressure for ROSC (15 mm Hg)

Coronary Perfusion Pressure*  *(Ao Diastolic-RAP)

Mean Cerebral Perfusion Pressure†
†(MAP – mean ICP pressure)

* p<0.05
† p<0.05

Do pauses in compression matter?

- Yes!
- The longer the pauses preceding or following defibrillation, the lower the chance of ROSC.
- Pauses of 20 seconds or greater increase no ROSC/death.
Adverse Outcomes of Interrupted Precordial Compression During Automated Defibrillation

Ting Yu, MD; Max Harry Weil, MD, PhD; Wanchun Tang, MD; Shijie Sun, MD; Kada Klouche, MD; Heitor Povoas, MD; Joe Bisera, MSEE

- 20 instrumented swine
- 7 minutes of unsupported VF

\[ \text{CPR + AED} \]

“Hands-off” interval prior to each shock
(mimicking analysis and charge interval of AEDs (10-19secs))

3 secs  10 secs  15 secs  20 secs
Effect of Interrupted Precordial Compression on Resuscitation Outcome

Successfully Resuscitated

- 100% at 3 seconds
- 80% at 10 seconds
- 40% at 15 seconds

n=5 per group
The Price of CPR Pauses

- 30 compressions
- CPR “systole”
- CPR “diastole”
- Paused CPR
- Aorta
- RA
- 16 secs
- 3 secs
Effect on Medication

• Perfusion circulates medication.

• Good CPR decreases up to two-fold the amount of time required for epinephrine reach peak concentration.

• Epinephrine without good CPR will not increase CorPP or CNS blood flow.
The Quality of CPR

Are compression/recoil equally important?

Do length/frequency of pauses matter?

Is compression rate important?

Does CPR improve ALS?

Is there a better way?

HPCPR
High Performance CPR

• Science demonstrates that ROSC increases when CPR is performed according to guidelines.

• HPCPR emphasizes minimal pauses, full compression recoil, adequate compression depth and optimal compression rate.
High Performance CPR: 10 Components

1. EMTs own CPR
2. Minimize interruptions in CPR at all times
3. Ensure proper compression depth (>2 inches)
4. Ensure full chest recoil
5. Ensure proper compression rate (100-120/min)
6. Rotate Compressors every 2 minutes
7. Hover hands over chest during shock administration and be ready to compress as soon as pt is cleared
8. Intubate or place advanced AW with ongoing CPR
9. Place IV or IO with ongoing CPR
10. Coordination and teamwork between BLS and ALS
Common CPR Quality Issues

- Frequent and prolonged pauses
- Excessive ventilation very common
- Shallow compressions
- Too slow/fast compressions
- Incomplete recoil
“Definition” High-Quality CPR

Target CPR performance metrics:

- Chest Compression FRACTION (CCF) > 80%
- Compression RATE of 100 to 120/min
- Compression DEPTH > 50 with ZERO leaning
  - Children > 1/3 AP chest in children
- Avoid EXCESSIVE VENTILATION
  - minimal chest rise
  - RATE < 12 breaths/minute)

Meaney, et al. (2013) Circulation
5-Components

- Choreography
- Training
- CPR Monitoring/Feedback (Real-Time/Post-Event)
- Provider Debriefing
- Data Collection/QI
Choreography/Team Resuscitation

- Avoid unnecessary pulse checks
- Minimize pauses
- Avoid rescuer fatigue/no leaning
- Regulate compression rate
- Maximize compression depth
- Avoid hyperventilation
- Clear communication
4 Person Pit Crew Formation

Focus on Monitor

Defib, IV/IO Meds

Airway, Drug prep

Others need to help #1:
1. Make sure Chest Compressor can see monitor!!
2. Do not interrupt Chest Compressors - they need to focus on delivery of quality chest compressions.

Chest Compressors (switch every 2 min)!!

Second compressor, IV Prep and watch monitor
# CPR Quality Checklist

**Record/Incident Number:**

**Date:**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>Could Improve</th>
<th>No</th>
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<tbody>
<tr>
<td>Was a team leader identified?</td>
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<td>Was CPR initiated within 10 seconds of arrival?</td>
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<td>Was defibrillator applied efficiently?</td>
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<td>Were compression pauses minimized?</td>
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<td>Were compressions of adequate depth?</td>
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<td>Were peri-shock pauses minimized?</td>
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<tr>
<td>Was ventilation rate &lt;10/min?</td>
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<tr>
<td>Was there clear communication? If not – explain in Observations</td>
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**Observations:**
Conclusions

1. Everyone in VF Survives
2. Eliminating / Minimizing pauses in CPR saves lives
3. Recoil is just as important as compressions
4. Compression depth should be 2” in adults
5. Procedures should be done while CPR is ongoing
6. CPR is a BLS skill
Everybody in VF survives