CPR Feedback: The Good, The Bad and The Ugly

Mike McEvoy, PhD, NRP, RN, CCRN
EMS Coordinator – Saratoga County, NY
EMS Editor – Fire Engineering magazine
Professor Emeritus – Albany Medical College

www.mikemcevoy.com
Disclosures

• I don’t know how to play golf or ski
When I am not Fighting Fires, I am reading Fire Engineering

www.FireEngineering.com
Outline

• CPR 2010: that was then, this is now…
• Show me the money: is there proof?
• What matters?
• Why measure?
• How to assess quality CPR
• Unique hospital issues
• Future solutions
Adult Chain of Survival: 2010

1. Immediate recognition and activation of emergency response system
2. Early CPR with emphasis on chest compressions
3. Rapid defibrillation
4. Effective ALS
5. Integrated post-cardiac arrest care
CPR Sequence

**Change**

- A-B-C to C-A-B
- Initiate chest compressions before ventilations

**Why?**

- **Reduce delay to compressions**
- Can be started immediately
- Emphasizes importance of chest compressions
So, What Matters in CPR?

And how should we assess effectiveness?
### Chest Compressions

<table>
<thead>
<tr>
<th>2010</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>• &gt; 50 mm (≥ 2”)</td>
<td>• 38 – 51 mm (1.5 – 2”)</td>
</tr>
<tr>
<td>• At least 100 per minute</td>
<td>• 100 per minute</td>
</tr>
</tbody>
</table>

#### Most Common Errors:

1. Too slow
2. Not deep enough
3. Prolonged interruptions
4. Leaning
Chest Compressions

• ROC: survival associated with ↑ depth
• Abella et al: 100-120/min = ↑ survival
• Recommendations are LOE 4 & 5 (just do it, because we like it)
• In truth:
  – Ideal actual depth of CPR unknown
    • Probably lies near 50 mm
  – Best rate for CPR unknown
    • Is likely about 100/min
CPR Rate vs. ROSC


p < 0.0083
Probability of ROSC

One Day Survival

Survival to Discharge

Effective CPR?

• How do you measure the effectiveness of CPR?
  – End tidal carbon dioxide
  – Feedback devices
Waveform Capnography
Attaches to ET tube, measures CO₂
Oxygen $\rightarrow$ Lungs $\rightarrow$ alveoli $\rightarrow$ blood

Muscles + Organs

Cells

Oxygen + Glucose

$\text{CO}_2$

Breath

ENERGY

Blood
Measuring Exhaled CO₂

Colorimetric

Capnometry

Capnography
Measuring Exhaled \( \text{CO}_2 \)

- Colorimetric
- Capnometry
- Capnography
Measuring Exhaled CO₂

Colorimetric

Capnometry

Capnography
Carbon Dioxide (CO$_2$) Production
What If...
But, with High-Quality CPR...
Meet Howard Snitzer

- 54-years old, collapsed Jan 5, 2011 outside Don’s Foods in Goodhue, MN (pop. 900)
- 2 dozen rescuers took turns providing CPR for 96 minutes
- 6 shocks with first responder AED, 6 more shocks by Mayo Clinic Air Flight Medics
- Transported to Mayo Clinic Cardiac Cath Lab
Why Not Quit?

- Thrombectomy, stent to LAD
- 10 days inpatient
- “The capnography told us not to give up”
- $\text{EtCO}_2$ averaged 35 (range 32 – 37)
So What’s the Goal During CPR?

- Try to maintain a minimum EtCO₂ of 10 mmHg (1.4 kPa)
- Push
  - HARD (≥ 2” or 5 cm)
  - FAST (at least 100)
- Change rescuer
  - Every 2 minutes
Guidelines 2010

• Continuous quantitative waveform capnography recommended for intubated patients throughout peri-arrest period. In adults:
  1. Confirm ETT placement
  2. Monitor CPR quality
  3. Detect ROSC with EtCO$_2$ values
Guidelines 2005

EtCO$_2$ recommended to confirm ET tube placement
EtCO₂ detects ROSC

- 90 pre-hospital intubated arrest patients
- 16 survivors
- 13 survivors: rapid rise in exhaled CO₂ was the earliest indicator of ROSC
  - Before pulse or blood pressure were palpable


Capnography = Results, not process
CPR is Complicated!
Hospital Issues:

1. Bed Height
   - Optimal = bed at knee level of person administering chest compressions

2. Air Mattresses
   - No need to deflate mattress for CPR
     Perkins et al, Inten Care Med. 2003;29:2330-2335

3. Backboards
   - No evidence of benefit with backboard
     Perkins et al, Inten Care Med. 2003;29:2330-2335
CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system

Benjamin S. Abella, Dana P. Edelson, Salem Kim, Elizabeth Retzer, Helge Myklebust, Anne M. Barry, Nicholas O’Hearn, Terry L. Vanden Hoek, Lance B. Becker

In-Hospital Arrests, Dec 2004 – Dec 2005
Audiovisual CPR Feedback

- Incorporated into monitor/defibrillator
- Real time
- Accelerometer-based
Handheld Feedback Device


Handheld accelerometer-based audiovisual device

Original Contribution

Cardiopulmonary resuscitation feedback improves the quality of chest compression provided by hospital health care professionals

Charles N. Pozner MD, Adam Almozlin, Jonathan Elmer, Stephen Poole, De'Ann McNamara RN, David Barash MD

aSTRATUS Center for Medical Simulation, Brigham and Women’s Hospital, Boston, MA 02115, USA
bConcord Health care Strategies, LLC, Concord, MA, USA

Handheld accelerometer-based audiovisual device
Generation of Feedback
Post Code Reviews

Device Type: LIFEPAK 15
CPR Annotations Edited: Yes
Device Configuration: 05355ROK02000V
Duration: 00:50:22
Incident ID: 2010070813303100-MEDIC 23
Statistical Parameters: 1000-0300-3000-05

Compressions Ratio (/total time)

Compression Rate

Compressions/minute

10:22 / 10:55 = 95%

110/minute

104/minute

Initial Rhythm

× 0.25 mm/sec

(Code Stat ™)
EMS Feedback = ROSC

- FDNY uses audio-visual feedback
- Deactivated audio feedback for 1 week
- ROSC \(\downarrow\) 20%

NY State EMS Council Report Jan 2012
But Hospitals ≠ EMS

• How effective are feedback systems?
We have a problem:

Clinical paper

Compression feedback devices over estimate chest compression depth when performed on a bed

Gavin D. Perkins\textsuperscript{a, b, *}, Laura Kocierz\textsuperscript{c}, Samuel S. Burton\textsuperscript{c}, Robert A. McCulloch\textsuperscript{c}, Robin P. Davies\textsuperscript{b}
Accelerometer CPR Depth

Perkins et al. Resuscitation 2009;80:79-82
The Mattress Issue:

- Mattress compression = 35 – 40% of total compression depth
- Accelerometer feedback devices fail to account for mattress compression
- Use of a backboard fails to compensate for mattress compression

Perkins et al. Resuscitation 2009;80:79-82
CPR on Mattress
CPR with a Backboard
The Solution:

Directly measure the true compression depth.
Triaxial Field Induction

- Two end points
- Direct measurement of distance (magnetic)
- Discrimination of X, Y, Z
FIGURE 4. Schematic of average chest compression depth achieved by participants using either TFI (Group 1) or ACC (Group 2).

Summary

- Compressions are key to outcomes
  - Most common errors: depth and speed
- Need to assess effectiveness of CPR
  - It improves survival
  - Future hospital requirement
- Current tools: EtCO₂ and ACC
  - CO₂ delayed
  - ACC inaccurate
- Future: TFI
  - Very promising