## Speaker disclosures

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- CR Bard
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**Medical Advisory Board:**
- CardioReady

**Equity:**
- Resuscor LLC
The AHA guidelines: an overview

Resuscitation guidelines are updated every 5 years
Collaboration of physicians, nurses and EMTs
Science recommendations from ILCOR
US guidelines (AHA) based on ILCOR science recs
**Cardiac arrest: introduction**

- **Chest Compression Rate**
  - **2015 (Updated):** In adult victims of cardiac arrest, it is reasonable for rescuers to perform chest compressions at a rate of 100 to 120/min.
  - **2010 (Old):** It is reasonable for lay rescuers and HCPs to perform chest compressions at a rate of at least 100/min.

**New upper limit to chest compression rate**

- Based on large OHCA studies showing worse outcomes
Chest compression depth

**Chest Compression Depth**

**2015 (Updated):** During manual CPR, rescuers should perform chest compressions to a depth of at least 2 inches (5 cm) for an average adult, while avoiding excessive chest compression depths (greater than 2.4 inches [6 cm]).

**2010 (Old):** The adult sternum should be depressed at least 2 inches (5 cm).

New upper limit to chest compression depth

Upper limit based on weak evidence; may be more academic than real-world
Mechanical CPR devices

Mechanical Chest Compression Devices

**2015 (Updated):** The evidence does not demonstrate a benefit with the use of mechanical piston devices for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest. However, such a device may be a reasonable alternative to conventional CPR in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (e.g., limited rescuers available, prolonged CPR, CPR during hypothermic cardiac arrest, CPR in a moving ambulance, CPR in the angiography suite, CPR during preparation for ECPR).

**2010 (Old):** Mechanical piston devices may be considered for use by properly trained personnel in specific settings for the treatment of adult cardiac arrest in circumstances (e.g.,

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Mechanical CPR and manual CPR are equivalent – no advantage to mechanical CPR
End-tidal carbon dioxide (ET-CO$_2$)

**ETCO$_2$ for Prediction of Failed Resuscitation**

2015 (New): In intubated patients, failure to achieve an ETCO$_2$ of greater than 10 mm Hg by waveform capnography after 20 minutes of CPR may be considered as one component of a multimodal approach to decide when to end resuscitative efforts but should not be used in isolation.

Why: Failure to achieve an ETCO$_2$ of 10 mm Hg by waveform capnography after 20 minutes of resuscitation has been associated with an extremely poor chance of ROSC and survival. However, the studies to date are limited in that they have potential confounders and have included relatively small numbers of patients, so it is inadvisable to rely solely on ETCO$_2$ in determining when to terminate resuscitation.

A role for end-tidal CO$_2$ in prognostication – less clear of a role to assess CPR effectiveness.
TTM: Target Temperature Management

**2015 (Updated):** All comatose (i.e., lacking meaningful response to verbal commands) adult patients with ROSC after cardiac arrest should have TTM, with a target temperature between 32°C and 36°C selected and achieved, then maintained constantly for at least 24 hours.

**2010 (Old):** Comatose (i.e., lacking of meaningful response to verbal commands) adult patients with ROSC after out-of-hospital VF cardiac arrest should be cooled to 32°C to 34°C for 12 to 24 hours. Induced hypothermia also may be considered for comatose adult patients with ROSC after IHCA of any initial rhythm or after OHCA with an initial rhythm of pulseless electrical activity or asystole.

Acceptable range of TTM target temp now expanded: 32°C-36°C

Goal should be specific within this range – selection tailored to patient
Newer trials evaluating TTM target

Targeted Temperature Management at 33°C versus 36°C after Cardiac Arrest
Niklas Nielsen, M.D., Ph.D., Jørn Wetterslev, M.D., Ph.D., Tobias Cronberg, M.D., Ph.D., David Erlinge, M.D., Ph.D., Yvan Gasche, M.D., Christian Hassager, M.D., D.M.Sc., 2013

Therapeutic Hypothermia after Out-of-Hospital Cardiac Arrest in Children
Frank W. Moler, M.D., Faye S. Silverstein, M.D., Richard Holubkov, Ph.D., 2015
Survival in the Nielsen et al trial

No difference in outcomes at either 33°C or 36°C
No differences in adverse effects between groups
Cardiac arrest: introduction

Pre-hospital TTM via cold fluids

2015 Recommendation—New
We recommend against the routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids (Class III: No Benefit, LOE A).

Cold fluids in the pre-hospital setting are not recommended – no RCT has shown benefit

Original Investigation
Effect of Prehospital Induction of Mild Hypothermia on Survival and Neurological Status Among Adults With Cardiac Arrest
A Randomized Clinical Trial

Francis Kim, MD; Graham Nichol, MD, MPH; Charles Maynard, PhD; Al Hallstrom, PhD; Peter J. Kudenchuk, MD; Thomas Rea, MD, MPH; Michael K. Copass, MD; David Carlbom, MD; Steven Deem, MD; W. T. Longstreth Jr, MD; Michele Olsufka, RN; Leonard A. Cobb, MD
Hope for prehospital TTM?

Newer technologies may change perspective

Intra-arrest TTM as a possible approach?
Fever after rewarming may require aggressive prevention to minimize neurologic injuries.
Post-TTM normothermia: the science

Prevalence and effect of fever on outcome following resuscitation from cardiac arrest

Kory Gebhardt\textsuperscript{a}, Francis X. Guyette\textsuperscript{b}, Ankur A. Doshi\textsuperscript{b}, Clifton W. Callaway\textsuperscript{b}, Jon C. Rittenberger\textsuperscript{b,\#}, The Post Cardiac Arrest Service\textsuperscript{bc}

Pyrexia and neurologic outcomes after therapeutic hypothermia for cardiac arrest

Marion Leary\textsuperscript{a,b,1}, Anne V. Grossestreuer\textsuperscript{a,1}, Stephen Iannacone\textsuperscript{a,1}, Mariana Gonzalez\textsuperscript{a,1}, Frances S. Shofer\textsuperscript{a,1}, Clare Povey\textsuperscript{c,1}, Gary Wendell\textsuperscript{c,1}, Susan E. Archer\textsuperscript{d,1}, David F. Galeski\textsuperscript{a,1}, Benjamin S. Abella\textsuperscript{a,b,\#,1}

\begin{itemize}
  \item [Naive] Both studies: fever may contribute to poor outcomes
  \item [Naive] 41\% with post-TTM pyrexia
  \item [Naive] Median temp 38.7\textdegree C
  \item [Naive] Above median: worse outcomes
\end{itemize}
Biology of prolonged temp control

Ongoing injury up to 72 hours supported by laboratory and clinical studies

Our TTM protocol specifies 24 hour period of “controlled normothermia” post-rewarming

Longer period of TTM?

Longer period of post-TTM normothermia?

Figure. Phases of post-cardiac arrest syndrome.

Neumar, 2008
Cardiac arrest: introduction

Post-arrest hemodynamic goals

Hemodynamic Goals After Resuscitation

2015 (New): It may be reasonable to avoid and immediately correct hypotension (systolic blood pressure less than 90 mm Hg, mean arterial pressure less than 65 mm Hg) during post-cardiac arrest care.

Avoiding hypotension during post-arrest critical care is important

Analogous to CVA hemodynamics
Post-arrest brain swelling

Elevated ICP in days following resuscitation from arrest
Higher mean arterial pressure with or without vasoactive agents is associated with increased survival and better neurological outcomes in comatose survivors of cardiac arrest.

2013

Higher mean arterial pressure associated with improved outcome

Goal MAP unclear

>65 mm Hg per AHA guidelines but this study suggests >80 mm Hg
Problem with MAP target post-arrest

We don’t measure ICP routinely following resuscitation from arrest

Hard to titrate blood pressure to ICP if the ICP isn’t measured
Post-arrest neuroprognostication

Prognostication After Cardiac Arrest

2015 (New): The earliest time to prognosticate a poor neurologic outcome using clinical examination in patients not treated with TTM is 72 hours after cardiac arrest, but this time can be even longer after cardiac arrest if the residual effect of sedation or paralysis is suspected to confound the clinical examination.

Clinical exam is unreliable for at least 72 hours following resuscitation

Cannot withdraw based on bedside exam
Prognostication is a challenge. Timing of prognostication reinforces the notion that withdrawal decisions should be delayed >72 h post-rewarming; clinical neuro exam poorly predictive.
Tools to assist neuroprognostication

- EEG
- Bispectral index (BIS)
- Somatosensory evoked potential (SSEP)
- neuroimaging

Varying strength of data for each modality; no one approach sufficient for prognostication
SSEP is an underutilized modality

Somatosensory evoked potential (SSEP)

N20 response at 72 hours – Relatively strong predictor of outcome
BIS index as post-arrest monitor

Neurologic prognostication and bispectral index monitoring after resuscitation from cardiac arrest

Marion Leary\textsuperscript{a}, David A. Fried\textsuperscript{a}, David F. Gaieski\textsuperscript{a}, Raina M. Merchant\textsuperscript{a}, Barry D. Fuchs\textsuperscript{b}, Daniel M. Kolansky\textsuperscript{c}, Dana P. Edelson\textsuperscript{d}, Benjamin S. Abella\textsuperscript{a,b,\ast}

BIS measurement is most reliable neuroprognosticator
At 24 hours post-arrest

Still relatively poor predictor:
24 hr BIS cutoff of 45 to predict good outcome: sensitivity of 63%, specificity of 86% (positive likelihood ratio of 4.7)
BIS = 0 strongly predicted poor outcome
Options for neurologic assessment

AHA offers “menu” of options to help assess neurologic outcomes

Note the fine print: sedatives, paralytics, shock and other conditions can confound findings.
Cardiac catheterization should be considered after resuscitation and performed for select patients

PCI required for STEMI post-arrest
**Difficult to predict coronary disease**

Initial Clinical Predictors of Significant Coronary Lesions After Resuscitation from Cardiac Arrest


<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Univariate analysis</th>
<th>Adjusted analysis</th>
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<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>p-Value</td>
</tr>
<tr>
<td>Age &gt; 50 years</td>
<td>1.78 (0.7–4.4)</td>
<td>0.210</td>
</tr>
<tr>
<td>Past medical history</td>
<td></td>
<td>0.8 (0.3–2.3)</td>
</tr>
<tr>
<td>Coronary disease</td>
<td>7.2 (2.0–25.9)</td>
<td>0.002</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.4 (0.6–3.0)</td>
<td>0.45</td>
</tr>
<tr>
<td>Tobacco use</td>
<td>2.1 (0.9–4.6)</td>
<td>0.079</td>
</tr>
<tr>
<td>Initial rhythm (VF/VT)</td>
<td></td>
<td>6.2 (1.6–24.4)</td>
</tr>
<tr>
<td>Abnormal initial troponin</td>
<td>3.0 (1.2–7.3)</td>
<td>0.018</td>
</tr>
<tr>
<td>ST/T wave abnormalities on initial postarrest ECG</td>
<td>1.25 (0.5–2.8)</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Only prior coronary history and initial rhythm were associated with significant coronary lesions on post-arrest catheterization.

Age, troponin, ECG findings were NOT associated with coronary dz.
Temperature dynamics of TTM

Benefit of prompt post-arrest PCI

Early coronary angiography and induced hypothermia are associated with survival and functional recovery after out-of-hospital cardiac arrest.


2014

Post-arrest catheterization associated with improved outcomes – effect size greater than for TTM

Survival to hospital discharge (N=1368)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Odds ratio</th>
<th>Adjusted odds ratio</th>
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<tbody>
<tr>
<td>Early coronary angiography (N=765)</td>
<td>495(64.7%)</td>
<td>4.08(3.65, 4.56)</td>
<td>1.69 [1.06, 2.70]</td>
</tr>
<tr>
<td>Reperfusion subjects (PCI or fibrinolytics) (N=705)</td>
<td>377(62.4%)</td>
<td>5.30(4.74, 5.93)</td>
<td>1.94 [1.1, 2.82]</td>
</tr>
<tr>
<td>Induced hypothermia (N=1566)</td>
<td>637(40.7%)</td>
<td>1.60(1.43, 1.78)</td>
<td>1.36 [1.01, 1.83]</td>
</tr>
</tbody>
</table>

Important secondary result: survival is greater if post-arrest volume is larger
Cardiac catheterization is associated with superior outcomes for survivors of out of hospital cardiac arrest: Review and meta-analysis

Anthony C. Camuglia\textsuperscript{a,b,c,*}, Varinder K. Randhawa\textsuperscript{d}, Shahar Lavi\textsuperscript{d}, Darren L. Walters\textsuperscript{c,e}

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Acute angiography</th>
<th>No acute Angiography</th>
<th>Odds Ratio M-H, Random, 95% CI</th>
<th>Odds Ratio M-H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurore 2011</td>
<td>31 133</td>
<td>30 312</td>
<td>2.86 [1.65, 4.96]</td>
<td></td>
</tr>
<tr>
<td>Bro-Jeppesen 2012</td>
<td>129 198</td>
<td>87 162</td>
<td>1.61 [1.05, 2.47]</td>
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</tr>
<tr>
<td>Bulut 1999</td>
<td>4 10</td>
<td>10 27</td>
<td>1.13 [0.26, 5.01]</td>
<td></td>
</tr>
<tr>
<td>Cronier 2011</td>
<td>54 91</td>
<td>6 20</td>
<td>3.41 [1.20, 9.67]</td>
<td></td>
</tr>
<tr>
<td>Grasner 2011</td>
<td>80 154</td>
<td>57 430</td>
<td>7.07 [4.64, 10.78]</td>
<td></td>
</tr>
<tr>
<td>Hollenbeck 2013</td>
<td>80 122</td>
<td>71 147</td>
<td>2.04 [1.24, 3.34]</td>
<td></td>
</tr>
<tr>
<td>Mooney 2011</td>
<td>63 101</td>
<td>15 39</td>
<td>2.65 [1.24, 5.67]</td>
<td></td>
</tr>
<tr>
<td>Nanjaya 2012</td>
<td>18 35</td>
<td>12 35</td>
<td>2.03 [0.78, 5.33]</td>
<td></td>
</tr>
<tr>
<td>Nielsen 2009</td>
<td>303 479</td>
<td>187 507</td>
<td>2.95 [2.27, 3.82]</td>
<td></td>
</tr>
<tr>
<td>Reynolds 2009</td>
<td>40 63</td>
<td>22 33</td>
<td>0.87 [0.36, 2.11]</td>
<td></td>
</tr>
<tr>
<td>Strote 2012</td>
<td>44 61</td>
<td>88 179</td>
<td>2.68 [1.42, 5.03]</td>
<td></td>
</tr>
<tr>
<td>Torre 2011</td>
<td>76 145</td>
<td>9 29</td>
<td>2.45 [1.04, 5.74]</td>
<td></td>
</tr>
<tr>
<td>Waldo 2013</td>
<td>57 84</td>
<td>7 26</td>
<td>5.73 [2.15, 15.27]</td>
<td></td>
</tr>
<tr>
<td>Zanutini 2012</td>
<td>33 48</td>
<td>21 45</td>
<td>2.51 [1.08, 5.86]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>1752</td>
<td>2048</td>
<td>2.77 [2.00, 3.72]</td>
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</tbody>
</table>

Angiography associated with improved survival
Similar results for both survival and good neurologic outcome
Most studies from 2010 onward (post-arrest TTM era)
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