Large Randomized Trial
of Continuous vs. Interrupted Chest Compressions
In Out-of-Hospital Cardiac Arrest:
Resuscitation Outcomes Consortium (ROC) CCC Trial

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Conclusions

In patients with out-of-hospital cardiac arrest, CPR strategy of continuous chest compressions with positive pressure ventilation as compared with chest compressions interrupted for ventilation by EMS providers did not significantly improve survival or neurologic status.

• Results previously presented at AHA Resuscitation Science Symposium, November 2015
• Results published in the New England Journal of Medicine, November 2015
• Multicenter cluster-randomized trial

• Resuscitation Outcomes Consortium
  – 9 Regional Clinical Coordinating Centers
  – 114 EMS agencies
Study Funding Partners

- NIH National Heart, Lung and Blood Institute
- CIHR IRSC Institute of Circulatory and Respiratory Health of the Canadian Institute of Health Research
- Defence Research and Development Canada
- United States Army
- Heart and Stroke Foundation of Canada
- American Heart Association
Participating UTSW/BioTel EMS Agencies
Objectives

- To understand why this study was conducted
- To explain the major results of the study
- To suggest how EMS systems may utilize this study to determine how providers should perform CPR.
Higher Survival with Continuous than Interrupted CPR

- Bobrow JAMA 2008
- 3 cycles of 200 compressions @ 100/min, then rhythm analysis
  - Single shock
  - No post-shock pulse check or rhythm analysis
  - IV epi 1 mg
  - Passive oxygenation or BVM
  - Deferred endotracheal intubation
- Observational data – not randomized

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Before N=218</th>
<th>After N=668</th>
<th>Adjusted Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC</td>
<td>15.6%</td>
<td>23.1%</td>
<td>1.3 (0.8, 2.0)</td>
</tr>
<tr>
<td>Survival to Hospital Admission</td>
<td>16.1%</td>
<td>16.9%</td>
<td>0.8 (0.5, 1.2)</td>
</tr>
<tr>
<td>Survival to Hospital Discharge</td>
<td>1.8%</td>
<td>5.4%</td>
<td>3.0 (1.1, 8.1)</td>
</tr>
</tbody>
</table>
Background

• **CPR consists of:**
  – Chest compressions
  – Ventilations

• **Chest compression interruptions may reduce blood flow**

• **Strategies to mitigate interruptions**
  – Asynchronous ventilation without stopping chest compressions

*Berg, Circulation 2011*
Previous Observational Studies of Continuous Chest Compressions

• Bobrow, JAMA 2008
• Large improvements in survival to discharge

Limitations
– Before-after design - non-randomized
– No verification of actual CPR treatment
– No CPR process measurement
– Multiple simultaneous interventions
– Low baseline survival

Improvements may have been due to:
– Improved CPR performance
– Concurrent system improvements
– Hawthorne effects
Study Objective

• To PROSPECTIVELY compare the effectiveness of continuous vs. interrupted chest compressions in EMS provider CPR upon outcomes after out-of-hospital cardiac arrest.
Protocol

Adult, non-traumatic out-of-hospital cardiac arrest
Chest compressions by dispatched EMS

INTERVENTION
Continuous Chest Compressions (CCC)
Ventilations at 10:1 without interruptions

CONTROL
Interrupted Chest Compressions (ICC)
Ventilations at 30:2 with interruptions
Protocol – CCC vs. ICC

Begin CPR

CCC
BVM at 10:1
no pauses

200 comp
or 2 min

CCC
BVM at 10:1
no pauses

200 comp
or 2 min

CCC
BVM at 10:1
no pauses

Con’t CPR
until intubation

CCC
BVM at 10:1
no pauses

ICC
BVM at 30:2
with pauses

200 comp
or 2 min

ICC
BVM at 30:2
with pauses

200 comp
or 2 min

ICC
BVM at 30:2
with pauses

CONTINUE
ACLS

Early IV/IO, Epinephrine or Vasopressin within 5 minutes
Study Monitoring

• CPR process measured by cardiac monitors
  • PhysioControl, Zoll, Philips
• EMS agency performance monitored by study monitoring committee
Outcome Measurements

• **Primary**
  • Survival to Hospital Discharge

• **Secondary**
  • Favorable neurologic status at discharge
  • Adverse events
Estimated Sample Size

• **Estimated N=23,600 patients**
  - 11,800 per group

• **90% power**

• **Detect absolute difference in survival to discharge of 1.3%**
  - 8.1% vs 9.4%
Trial Enrollment

Total Screened (n = 35,904)

- Excluded, n=9,756
  - EMS witnessed, n=4,215
  - Non-trial EMS agency initiated CPR, n=2,512
  - Obvious respiratory or asphyxia, n=1,169
  - Existing DNR, n=861
  - Protected populations, n=624
  - Pre-existing trach, n=253
  - Exsanguination, n=91
  - Advanced airway prior to study, n=29
  - Mechanical compression device, n=1
  - Incomplete information about eligibility, n=1

Total Enrolled (n = 26,148)

- CCC (n = 14,108)
  - CCC in active enrollment phase (n = 12,653)
    - CCC with available vital status (n = 12,613)

- ICC (n = 12,040)
  - ICC in active enrollment phase (n = 11,058)
    - ICC with available vital status (n = 11,035)
<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>CCC N=12,653</th>
<th>ICC N=11,058</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD)</td>
<td>66.4 (17.2)</td>
<td>66.2 (17.0)</td>
</tr>
<tr>
<td>Male, %</td>
<td>63.5</td>
<td>64.4</td>
</tr>
<tr>
<td>Obvious Cause of Arrest, %</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Public Location, %</td>
<td>14.2</td>
<td>14.8</td>
</tr>
<tr>
<td>Witness Status, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bystander Witnessed</td>
<td>40.9</td>
<td>42.7</td>
</tr>
<tr>
<td>Not Witnessed</td>
<td>56.4</td>
<td>55.4</td>
</tr>
<tr>
<td>Bystander CPR, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>46.9</td>
<td>47.1</td>
</tr>
<tr>
<td>No</td>
<td>53.1</td>
<td>52.9</td>
</tr>
</tbody>
</table>
## Post-Treatment Patient Characteristics

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>CCC N=12,653</th>
<th>ICC N=11,058</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch to first EMS arrival in minutes, mean (SD)</td>
<td>5.9 (2.5)</td>
<td>5.9 (2.6)</td>
</tr>
<tr>
<td>Dispatch to first ALS arrival in minutes, mean (SD)</td>
<td>9.0 (5.1)</td>
<td>9.0 (5.1)</td>
</tr>
<tr>
<td>Treated by ALS, %</td>
<td>97.1</td>
<td>97.1</td>
</tr>
<tr>
<td>First rhythm shockable, %</td>
<td>22.4</td>
<td>22.6</td>
</tr>
<tr>
<td>Endotracheal intubation attempted, %</td>
<td>56.9</td>
<td>58.1</td>
</tr>
<tr>
<td>Endotracheal intubation successful, %</td>
<td>84.0</td>
<td>84.6</td>
</tr>
<tr>
<td>Epinephrine dose in mg, mean ± SD</td>
<td>3.8 ± 2.0</td>
<td>3.8 ± 2.1</td>
</tr>
<tr>
<td>Enrolled in ALPS trial, %</td>
<td>9.7</td>
<td>10.1</td>
</tr>
<tr>
<td>Hospital Hypothermia, %</td>
<td>54.4</td>
<td>52.8</td>
</tr>
</tbody>
</table>
# Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>CCC N=12,653</th>
<th>ICC N=11,058</th>
<th>Adjusted Difference (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC at ED arrival, %</td>
<td>24.2</td>
<td>25.3</td>
<td>−1.1 (−2.4 to 0.1)</td>
<td>0.07</td>
</tr>
<tr>
<td>Admitted, %</td>
<td>24.6</td>
<td>25.9</td>
<td>−1.3 (−2.4 to −0.2)</td>
<td>0.03</td>
</tr>
<tr>
<td>Survival to discharge, %</td>
<td>9.0</td>
<td>9.7</td>
<td>−0.7 (−1.5, 0.1)</td>
<td>0.07</td>
</tr>
<tr>
<td>Discharged to home, %</td>
<td>6.7</td>
<td>7.2</td>
<td>−0.5 (−1.2, 0.2)</td>
<td>0.15</td>
</tr>
<tr>
<td>MRS ≤ 3, %</td>
<td>7.0</td>
<td>7.7</td>
<td>−0.6 (−1.4, 0.1)</td>
<td>0.09</td>
</tr>
<tr>
<td>MRS, mean (SD)</td>
<td>5.6 (1.3)</td>
<td>5.6 (1.4)</td>
<td>0.04 (0.0, 0.08)</td>
<td>0.04</td>
</tr>
<tr>
<td>Hospital-free survival (mean days - SD)</td>
<td>1.3 (5.0)</td>
<td>1.5 (5.3)</td>
<td>−0.2 (−0.3, −0.1)</td>
<td>0.004</td>
</tr>
<tr>
<td>Survival to discharge (Safety Population), %</td>
<td>9.1</td>
<td>9.6</td>
<td>−0.5 (−1.3, 0.2)</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Treatment Differences by Site

- Favorable Neurological Status at Discharge in ICC Group
- Absolute Difference in Survival to Discharge
- Favor CCC
- Favor ICC
- P = 0.54
### Differences in Survival Adjusted for Pre-Treatment Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Adjusted Difference 95% CI</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted for site</td>
<td>-0.6 (-1.3, 0.1)</td>
<td>0.09</td>
</tr>
<tr>
<td>Adjusted for age</td>
<td>-0.7 (-1.5, 0.1)</td>
<td>0.07</td>
</tr>
<tr>
<td>Adjusted for sex</td>
<td>-0.7 (-1.5, 0.1)</td>
<td>0.07</td>
</tr>
<tr>
<td>Adjusted for public location</td>
<td>-0.7 (-1.4, 0.1)</td>
<td>0.09</td>
</tr>
<tr>
<td>Adjusted for bystander witnessed</td>
<td>-0.6 (-1.4, 0.3)</td>
<td>0.18</td>
</tr>
<tr>
<td>Adjusted for bystander CPR</td>
<td>-0.7 (-1.5, 0.0)</td>
<td>0.07</td>
</tr>
<tr>
<td>Adjusted for arrival time</td>
<td>-0.7 (-1.5, 0.0)</td>
<td>0.07</td>
</tr>
<tr>
<td>Adjusted for all above covariates</td>
<td>-0.03 (-1.1, 0.4)</td>
<td>0.38</td>
</tr>
</tbody>
</table>
Key Observation

- CCC did not improve survival or neurologic status over ICC
  - No difference by site or CPR quality
Strengths

• Largest cardiac arrest randomized trial
• Multiple participating EMS agencies
• CPR process data on >90% cases
• CPR consistent with contemporary practice guidelines
Limitations

• Did not measure oxygenation or minute ventilation
• Did not mandate post-resuscitation care
In an accompanying editorial....
Dr. Rudolph Koster (Academic Medical Center, Amsterdam, the Netherlands) noted that based on recent observational studies, the latest 2015 AHA guidelines includes a new class Iib recommendation that “it may be reasonable for EMS to initiate resuscitation with three initial periods of 200 continuous chest compressions with passive oxygen insufflations”. He adds that this recommendation was not made in the concurrent 2015 guidelines from the European Resuscitation Council.

Koster suggests that "if the results of the current ROC study had been available, the guidelines committee might have decided to retain the previous recommendation to give chest compressions interrupted for ventilations and perhaps even to upgrade that recommendation to a class Ila recommendation for EMS providers." He concludes with the question: "Should the AHA reconsider its recommendation?”
As always, more shall be revealed...

Subgroup and additional data analysis is ongoing.
Where Do We Go From Here?
Is CCC:
• Easier to teach?
• Easier to perform?
• Does skill retention last longer?
Medical Directors must determine whether to recommend 30:2 or Continuous Chest Compressions.

My recommendation....
Thank You for Your Attention !!!