End Tidal CO$_2$ vs. Cerebral Oximetry for Monitoring CPR Quality

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Magnitude of SCA in the US

- Stroke: 167,366
- Lung Cancer: 157,400
- Breast Cancer: 40,600
- AIDS: 42,156

SCA claims more lives each year than these other diseases combined.

450,000 SCA

References:
How We Currently Monitor Quality

**End Tidal CO\(_2\)** (ETCO\(_2\))
- Measures partial pressure of Carbon Dioxide expelled from the endotracheal tube
- Correlates well with the pulmonary blood flow, cardiac output, and coronary perfusion pressure generated during CPR
- Prognostic
  - After 20 minutes of ACLS, ROSC average of 32 mmHg
  - AHA recommendation to improve CPR quality if below 10 mmHg

Robert L. Levine, M.D., Marvin A. Wayne, M.D., and Charles C. Miller, Ph.D.

(American Heart Association)
Limitations of ETCO$_2$ Monitoring

- **Minute ventilation**
  - Notoriously elevated and impossible to get a constant tidal volume

- **Epinephrine**
  - ETCO$_2$ decreased as much as 51%
    
    *(Lindberg L et al. 2000 Jan; 43(2):129-40)*

- **Bicarbonate**
  - Acute increase of 6.6 mmHg

    *(Okamoto H et al. 1995 Jan 39(1): 79-84)*

*Need to be intubated*

*Port is easily clogged*
Cerebral Oximetry
(CereOx)

- Non-invasive
- Near Infrared Light
- Regional Oxygen saturation (rSO$_2$)
- Reflects cellular O$_2$ extraction
- Similar to Central Venus O$_2$ Saturation
- Does not require a pulse
- Strong correlation with cerebral blood flow and jugular vein bulb saturation (gold standard of cerebral O$_2$)
Cerebral Oximetry and Jugular Bulb Venous Saturation

- Cerebral oximetry accurately measures rSO$_2$ (Regional O$_2$ Sat)
- It has successfully and repeatedly been compared to SjvO$_2$
Cerebral Oximetry In Tilt Table
Current Utility of CereOx

- Clinical studies have shown that desaturations as little as 20% of baseline are associated with neurologic complications, reduced performance on the mini-mental status exam and stroke and prolonged length of stay.\textsuperscript{2,3,4}

- Range of normal values (50-80%), as with ScvO2
Objective

- The objective of this prospective observational study is to compare the simultaneous measurement of ETCO$_2$ and CereOx to investigate which monitoring method provides the best measure of CPR quality as defined by ROSC.
Methods

- Non-traumatic OOHCA of a presumed cardiac etiology
- Age > 18
- Resuscitation attempted by the ED physicians
Methods

• Demographics by Utstein Criteria

• Data was analyzed by univariate logistic regression followed by receiver operating characteristic (ROC) curve analysis on models fit based on derived variables

• Models were evaluated using the ROC area under the curve (AUC) (c-statistic) and Bayesian Information Criterion (BIC)
# Baseline Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>135</td>
</tr>
<tr>
<td>Mean age</td>
<td>65 ± 15</td>
</tr>
<tr>
<td>Witnessed</td>
<td>79 (66.9%)</td>
</tr>
<tr>
<td>Immediate CPR</td>
<td>69 (68.5%)</td>
</tr>
<tr>
<td>Average time of call to ED</td>
<td>25.6 ± 14.5</td>
</tr>
<tr>
<td>Initial Rhythm</td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td>49 (41.5%)</td>
</tr>
<tr>
<td>PEA</td>
<td>48 (40.7%)</td>
</tr>
<tr>
<td>VF/VT</td>
<td>21 (17.8%)</td>
</tr>
<tr>
<td>ROSC</td>
<td>34 (28.8%)</td>
</tr>
</tbody>
</table>
Series of binary logistic regression models were run in which various derivations of ETCO2 and CerOx were simultaneously entered into the model to predict ROSC.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CerOx p-value</th>
<th>ETCO\textsubscript{2} p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Value</td>
<td>&lt;0.017</td>
<td>&lt;0.919</td>
</tr>
<tr>
<td>Trend Last 5 min</td>
<td>&lt;0.000</td>
<td>&lt;0.610</td>
</tr>
<tr>
<td>Trend Whole code</td>
<td>&lt;0.001</td>
<td>&lt;0.344</td>
</tr>
<tr>
<td>Last Value</td>
<td>&lt;0.000</td>
<td>&lt;0.053</td>
</tr>
</tbody>
</table>
Both CerOx and ETCO$_2$ proved to be significant predictors of ROSC for the following variables:

- last value recorded during resuscitation
  - [CerOx $p<0.000$, ETCO$_2$ $p<0.009$],
- the change from first value recorded to last value recorded [CerOx $p<0.000$, ETCO$_2$ $p<0.000$]
For a Value of 15 on either the ETCO2 or Cerebral Oximetry

- ROC curve analysis was used to determine the best discriminating variable in predicting No ROSC

- AUC for the last value obtained:
  - CerOx AUC=0.856, ETCO2 AUC=0.761

- AUC for the max value obtained during the resuscitation
  - CerOx, AUC=0.802, ETCO2 AUC=0.630

All subjects who failed to obtain a max ETCO2 value of 15 had LOR, while 5 with CerOX of 15 had ROSC.
Case Study 1

CereOx Quality CPR and Early Indicator

CereOx and ETCO₂ Values

Time
Case Study 2
Potential Impact

• Define the true value of ETCO2 in predicting ROSC:
  • has not been well studied in a large multi-center clinical trial

• Define the utility of Cerebral oximetry to:
  • Determine futility
  • Determine quality of CPR
  • Determine those with high likelihood of ROSC
  • Could eliminate pulse checks
  • Drive therapies after ROSC
QUESTIONS?