# End Tidal $CO_2$ vs. Cerebral Oximetry for Monitoring CPR Quality

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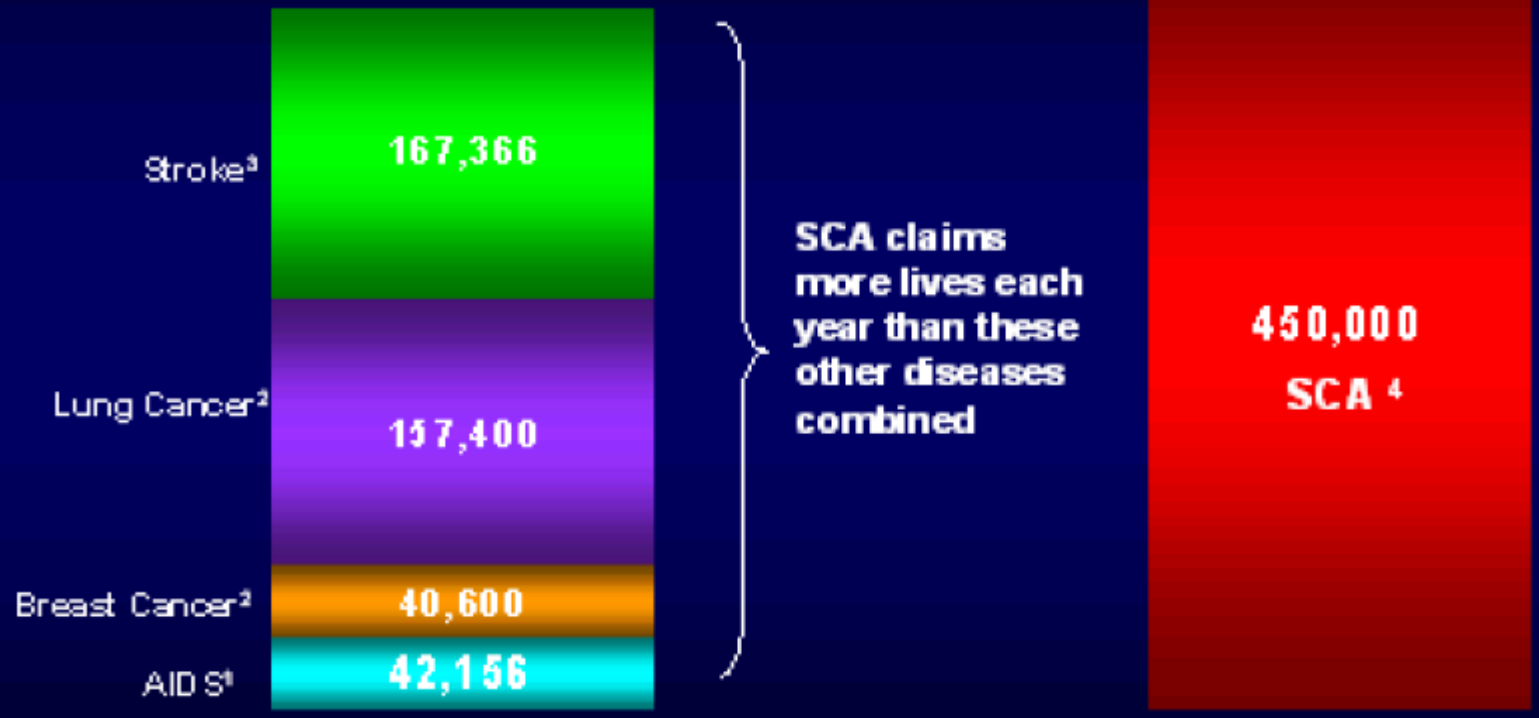
# Magnitude of SCA in the US

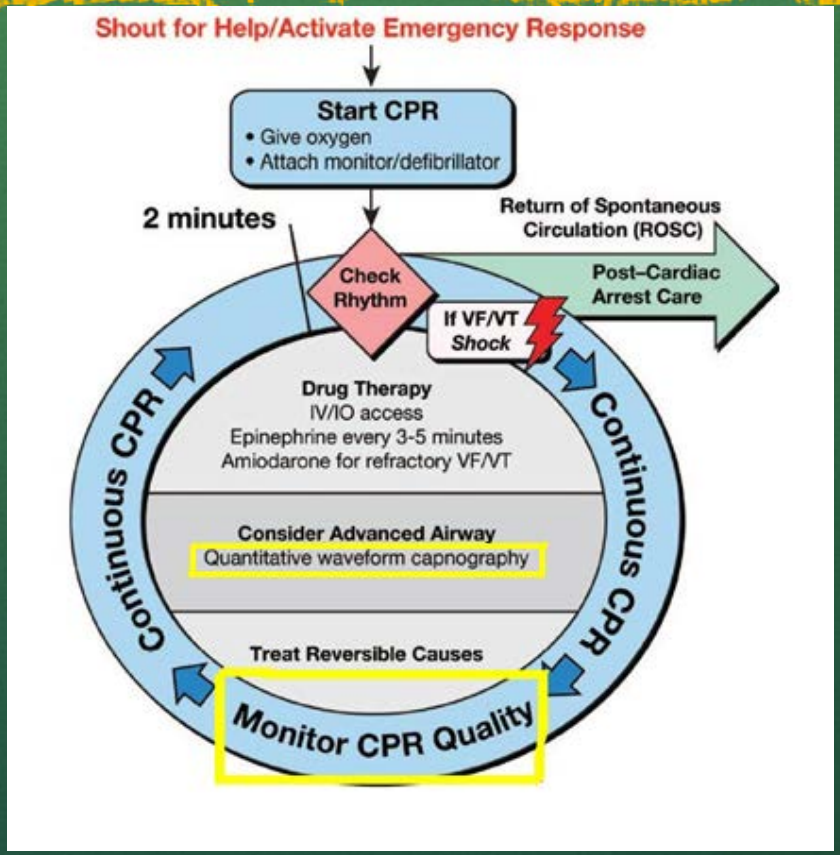



[1] U.S. Census Bureau, *Statistical Abstract of the United States: 2001*.
[2] American Cancer Society, Inc., *Surveillance Research Cancer Facts and Figures 2001*.
[3] *2002 Heart and Stroke Statistical Update*, American Heart Association.
[4] *Circulation* 2001;104:2158-2163.

# 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 10mmHg




Robert L. Levine, M.D., Marvin A. Wayne, M.D., and Charles C. Miller, Ph.D.
N Engl J Med 1997; 337:301-306

*(American Heart Association)*

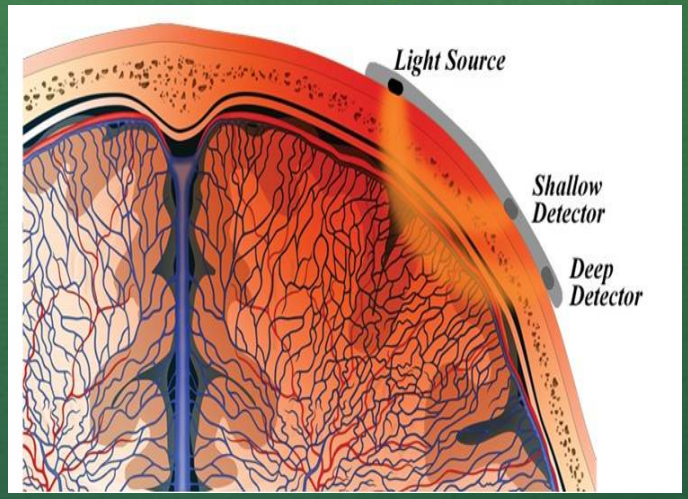
# Limitations of $ETCO_2$ Monitoring

- **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***

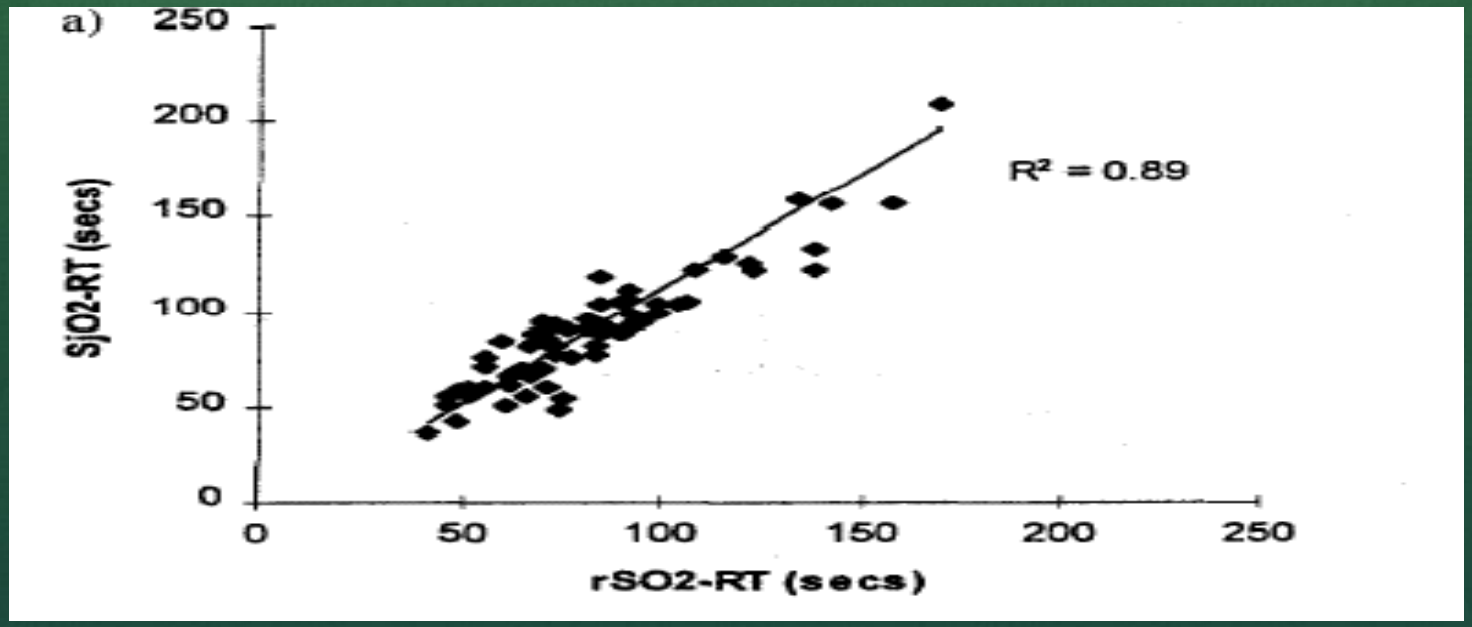
# Cerebral Oximetry (CereOx)



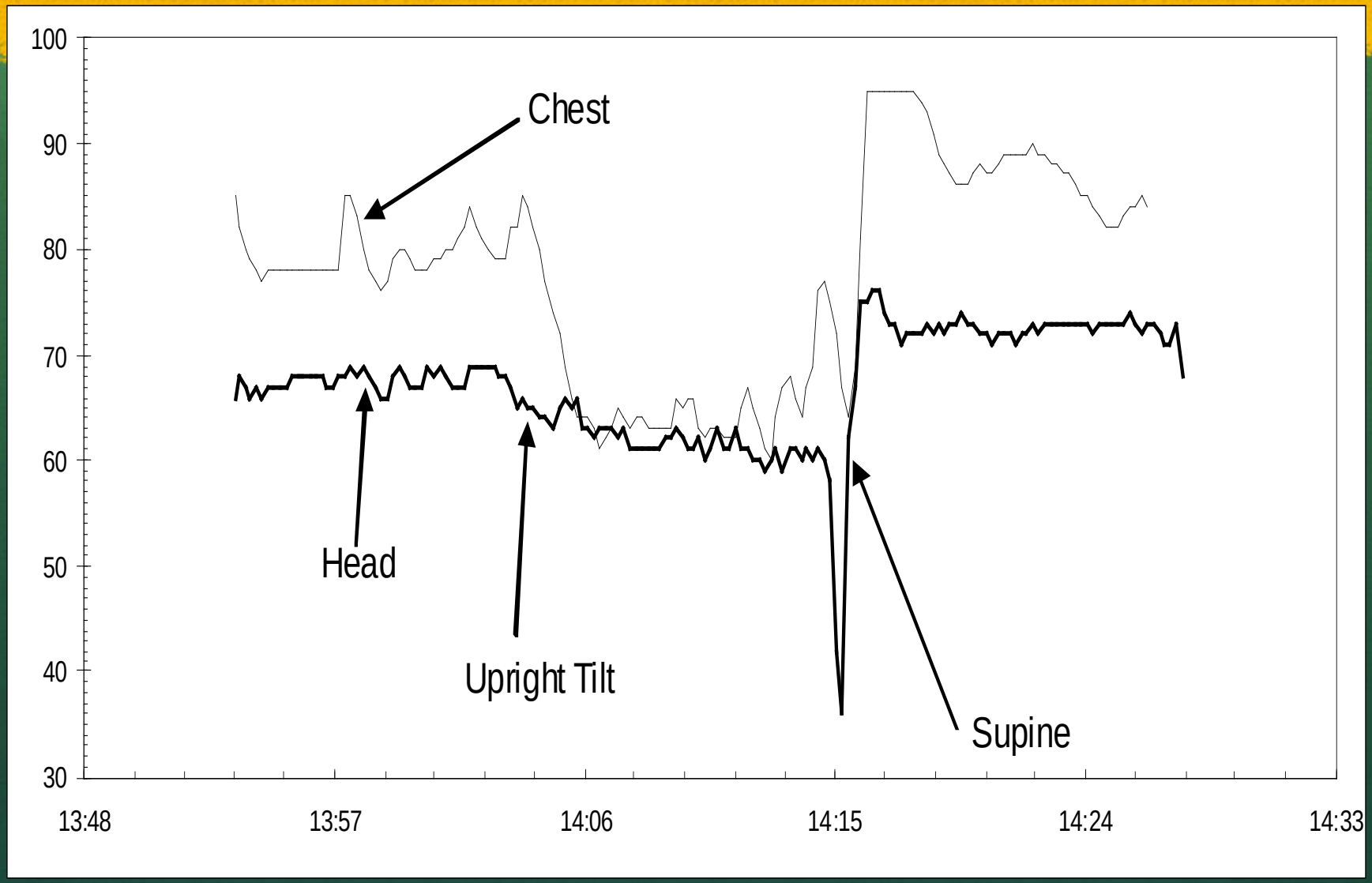

- Non-invasive
- Near Infrared Light
- Regional Oxygen saturation ($rSO_2$)
- Reflects cellular $O_2$ extraction
- Similar to Central Venus $O_2$ Saturation
- Does not require a pulse
- Strong correlation with cerebral blood flow and jugular vein bulb saturation (gold standard of cerebral $O_2$)

# 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 $SjvO_2$

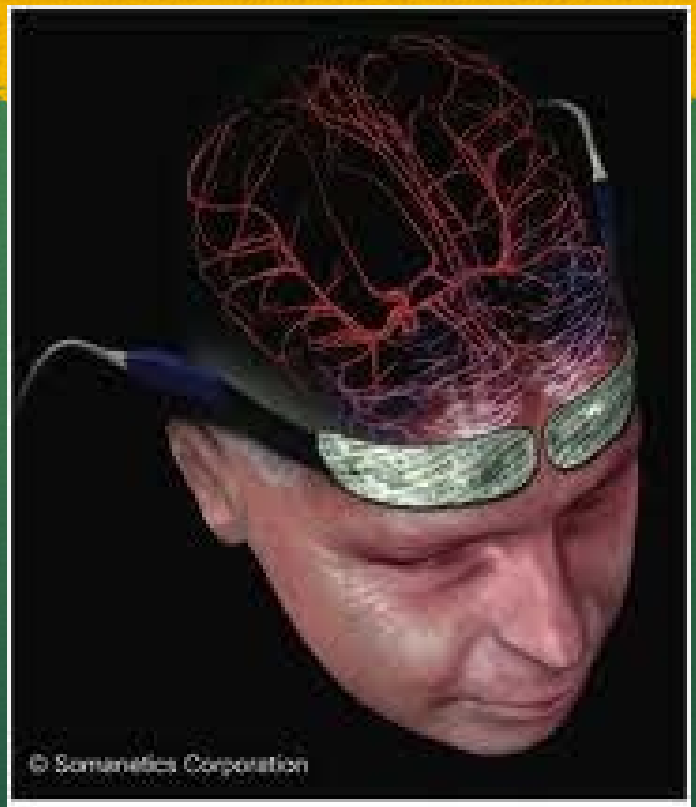


# Cerebral Oximetry In Tilt Table



# 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.** [2,3,4]
- range of normal values (50-80%), as with ScvO2




Cerebral oximetry measures hemoglobin and red-colored oxygenated hemoglobin molecules with red blood cells to determine whether there is adequate oxygenation.

# 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)

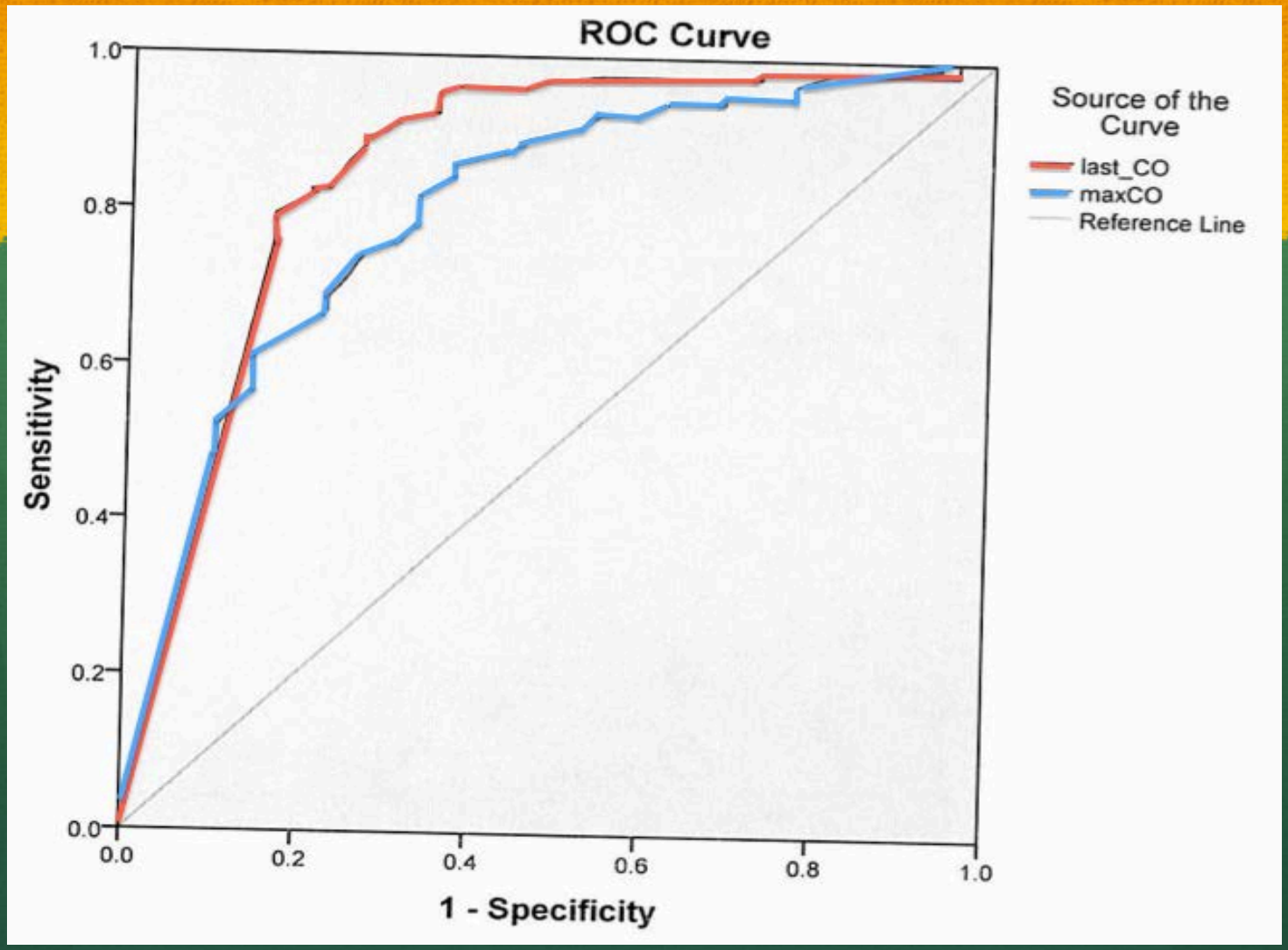
# Baseline Demographics

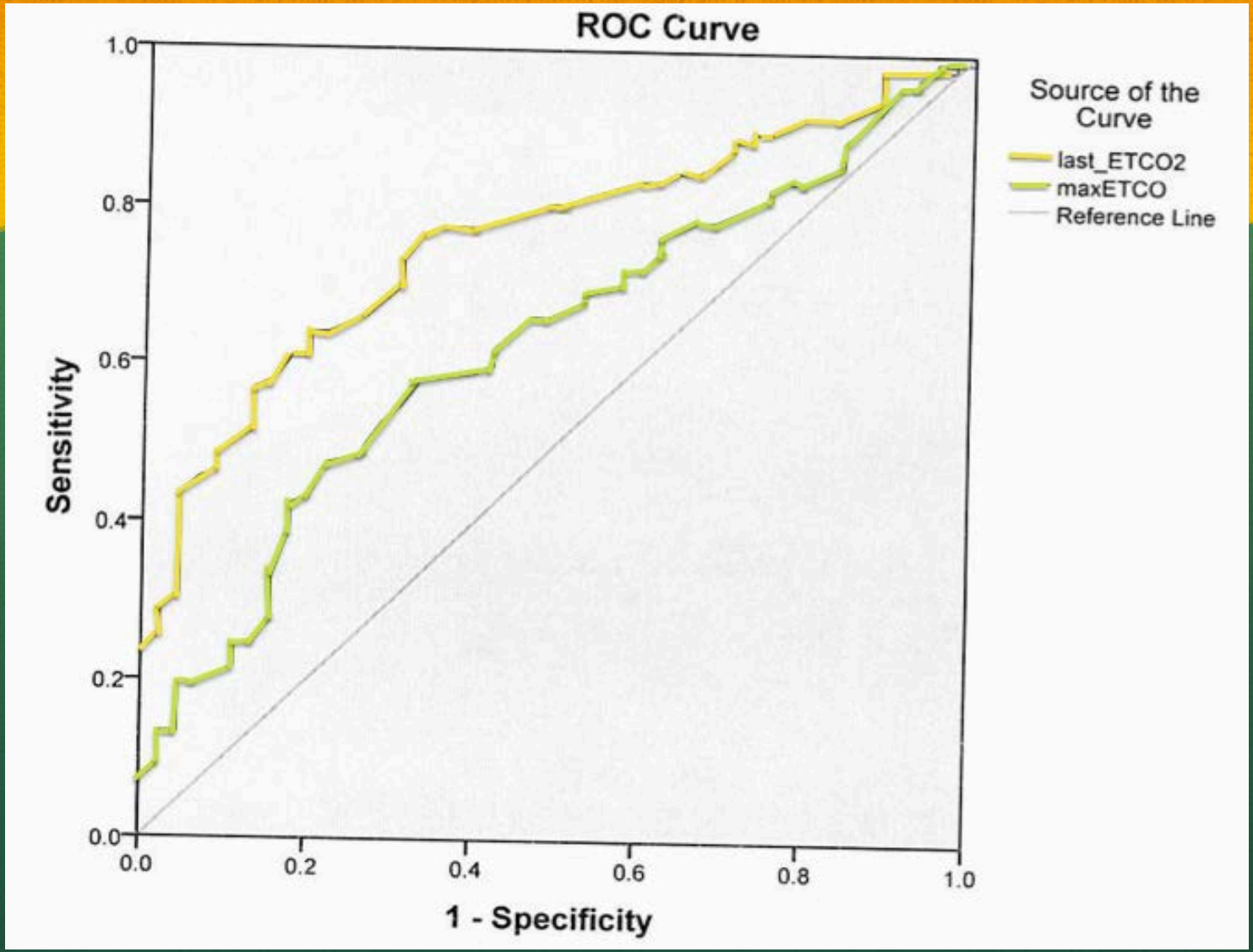
| Variable | Value |
|---|---|
| Number of subjects | 135 |
| Mean age | 65 ± 15 |
| Witnessed | 79 (66.9%) |
| Immediate CPR | 69 (68.5%) |
| Average time of call to ED | 25.6 ± 14.5 |
| Initial Rhythm | Asystole = 49 (41.5%)<br>PEA = 48 (40.7%)<br>VF/VT = 21 (17.8%) |
| ROSC | 34 (28.8%) |

# RESULTS:

| Variable | CerOx p-value | $ETCO_2$ p-value |
|---|---|---|
| Initial Value | <0.017 | <0.919 |
| Trend Last 5 min | <0.000 | <0.610 |
| Trend Whole code | <0.001 | <0.344 |
| Last Value | <0.000 | <0.053 |

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.


ROC Curve
Sensitivity
1 - Specificity
0.0
0.2
0.4
0.6
0.8
1.0
Source of the Curve
last_CO
maxCO
Reference Line


ROC Curve
Sensitivity
1 - Specificity
0.0
0.2
0.4
0.6
0.8
1.0
Source of the Curve
last_ETCO2
maxETCO
Reference Line

# Analysis

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 $p<0.000$, $ETCO_2$ $p<0.000$

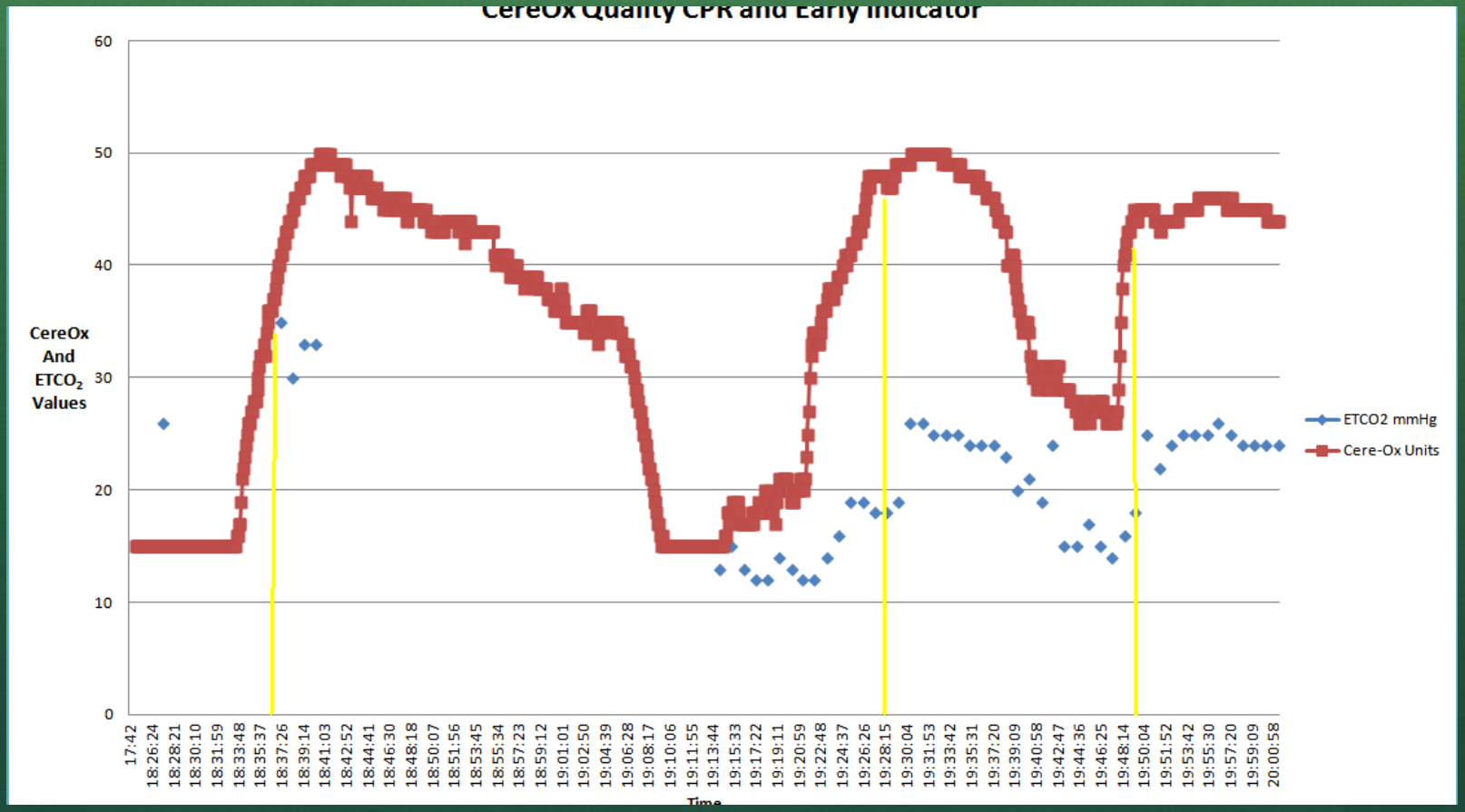
# Predictors of futility

For a Value of 15 on either the ETCO2 or Cerebral Oximetry

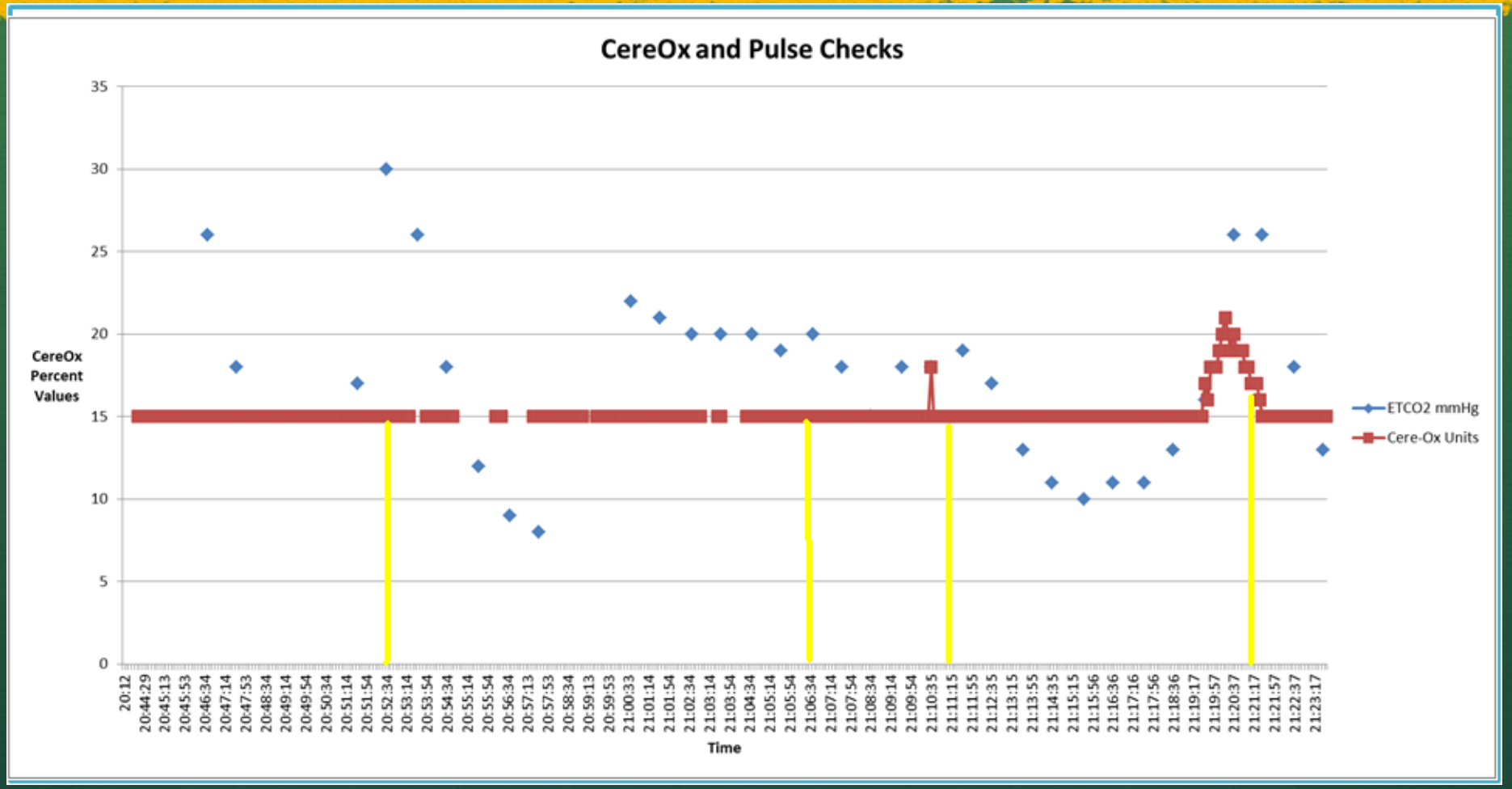
- ROC curve analysis was used to determine the best discriminating variable in predicting No ROSC
- AUC for the last value obtained:
  - CerOx AUC=.856, $ETCO_2$ AUC= .761
- AUC for the max value obtained during the resuscitation
  - CerOx, AUC=.802, $ETCO_2$ AUC=.630

All subjects who failed to obtain a max $ETCO_2$ 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
60
50
40
30
20
10
0
17:42
18:26:24
18:28:21
18:30:10
18:31:59
18:33:48
18:35:37
18:37:26
18:39:14
18:41:03
18:42:52
18:44:41
18:46:30
18:48:18
18:50:07
18:51:56
18:53:45
18:55:34
18:57:23
18:59:12
19:01:01
19:02:50
19:04:39
19:06:28
19:08:17
19:10:06
19:11:55
19:13:44
19:15:33
19:17:22
19:19:11
19:20:59
19:22:48
19:24:37
19:26:26
19:28:15
19:30:04
19:31:53
19:33:42
19:35:31
19:37:20
19:39:09
19:40:58
19:42:47
19:44:36
19:46:25
19:48:14
19:50:04
19:51:52
19:53:42
19:55:30
19:57:20
19:59:09
20:00:58
Time
ETCO2 mmHg
Cere-Ox Units

# Case Study 2


CereOx and Pulse Checks
CereOx Percent Values
35
30
25
20
15
10
5
0
20:12
20:44:29
20:45:13
20:45:53
20:46:34
20:47:14
20:47:53
20:48:34
20:49:14
20:49:54
20:50:34
20:51:14
20:51:54
20:52:34
20:53:14
20:53:54
20:54:34
20:55:14
20:55:54
20:56:34
20:57:13
20:57:53
20:58:34
20:59:13
20:59:53
21:00:33
21:01:14
21:01:54
21:02:34
21:03:14
21:03:54
21:04:34
21:05:14
21:05:54
21:06:34
21:07:14
21:07:54
21:08:34
21:09:14
21:09:54
21:10:35
21:11:15
21:11:55
21:12:35
21:13:15
21:13:55
21:14:35
21:15:15
21:15:56
21:16:36
21:17:16
21:17:56
21:18:36
21:19:17
21:19:57
21:20:37
21:21:17
21:21:57
21:22:37
21:23:17
Time
ETCO2 mmHg
Cere-Ox Units

# 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?