DETERMINING TERMINATING DETERMINANTS: WHAT’S A REASONABLE DURATION OF CARDIAC ARREST EFFORTS?

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DISCLOSURES

None
Last January, a Minnesota man’s heart stopped beating for an amazing 96 minutes. Emergency room doctors thought he was dead. But first responders who gave CPR on the scene decided not to give up, in part because of technology that allowed them to see their efforts were working.

It’s called capnography, and it measures how much carbon dioxide is being expelled with each breath. This information helps doctors and emergency medical
A Case of Survival after Cardiac Arrest and 3½ Hours of Resuscitation

Although survival rates after cardiac arrest remain low, new techniques are improving patients’ outcomes. We present the case of a 40-year-old man who survived a cardiac arrest that lasted approximately 3½ hours. Resuscitation was performed with strict adherence to American Heart Association/American College of Cardiology Advanced Cardiac Life Support guidelines until bedside extracorporeal membrane oxygenation could be placed. A hypothermia protocol was initiated immediately afterwards. The patient had a full neurologic recovery and was bridged from dual ventricular assist devices to a total artificial heart. On hospital day 160, he underwent orthotopic heart and cadaveric kidney transplantation. On day 179, he was discharged from the hospital in ambulatory condition.

To our knowledge, this is the only reported case in which a patient survived with good neurologic outcomes after a resuscitation that lasted as long as 3½ hours. Documented cases of resuscitation with good recovery after prolonged arrest give hope for improved overall outcomes in the future. (Tex Heart Inst J 2014;41(2):222-6)
FIELD DECISION-POINTS

Do I Initiate Resuscitation?

How long should I perform field efforts?

Which patients without a pulse should I transport?

None

Patients not meeting Universal TOR Criteria

All
MAJOR METRO EMS SYSTEMS IN THE UNITED STATES

Minimum Duration of Resuscitative Efforts (min)

Presenting Rhythm

- PEA
- VF
- Asystole
- All

Mean
Median

Source: Correspondence with Eagles Consortium of U.S. Medical Directors, 2017
Special Contributions

Resuscitation in the out-of-hospital setting: Medical futility criteria for on-scene pronouncement of death ☆ ☆☆

Presented at the Turtle Creek Conference II, Dallas, Texas, March 2000.

Paul E. Pepe MD, MPH, Robert A. Swor DO, Joseph P. Ornato MD, Edward M. Racht MD, Donald M. Blanton MD, John K. Griswell MD, Thomas Blackwell MD, James Dunford MD

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Resuscitation in the out-of-hospital setting: Minimal utility criteria for on-scene pronouncement of death

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JOIN US FOR THE MOST EXCITING CONFERENCE IN EMS!!!!

“EMS STATE OF THE SCIENCE: A BALE OF TURTLES 2000”
STATE OF THE LITERATURE

1. Observational
2. Reporting of time to ROSC at which <1% of patients survive
3. Prone to prognostication bias
EARLY IDENTIFICATION OF NON-SURVIVORS IN 6 MIN?

Universal Termination of Resuscitation Criteria
1. Not EMS Witnessed
2. No Shocks Delivered
3. No ROSC

SHOULD DURATION OF EFFORTS BE BASED ON PRESENTING RHYTHM?

Vancouver, BC
N=1,617


**SHOCKABLE, WITNESSED, BYSTANDER CPR EXTEND THERAPEUTIC WINDOW**

ROC-PRIMED
N=11,368
### SUMMARY OF RECENT STUDIES: OHCA

<table>
<thead>
<tr>
<th>Author</th>
<th>Outcome</th>
<th>Presenting Rhythm</th>
<th>Time to 99% with ROSC (or likelihood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drennan IR, et al.*</td>
<td>Survival with Good Neuro</td>
<td>All</td>
<td>37</td>
</tr>
<tr>
<td>Grunau B, et al. †</td>
<td>Survival to Discharge</td>
<td>All</td>
<td>28</td>
</tr>
<tr>
<td>Grunau B, et al. †</td>
<td>Survival with Good Neuro</td>
<td>All</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shockable</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Shockable</td>
<td>15</td>
</tr>
<tr>
<td>Reynolds JC, et al.*</td>
<td>Survival with Good Neuro</td>
<td>All</td>
<td>37</td>
</tr>
<tr>
<td>Nagao K, et al.</td>
<td>Survival with Good Neuro</td>
<td>All (bystander witnessed)</td>
<td>40</td>
</tr>
</tbody>
</table>

*partially overlapping populations
†partially overlapping populations
WHAT IS THE BENEFIT OF EXTENDING FIELD EFFORTS?
British Columbia
N=5,674
2007-2011

What if all these patients had been resuscitated for at least 40 min?

**Figure 3.** Histogram of durations until termination of resuscitation in 3041 patients who did not achieve return of spontaneous circulation.

British Columbia
N=5,674
2007-2011

Survivors

Estimated Gain in Survivors from Extending Resuscitation to 40 min


NNT of 500 for one additional survivor
WHAT IS THE COST OF EXTENDING FIELD EFFORTS?

Source: The Knife and Gun Club by Eugene Richards
Resuscitation Duration and Outcomes After OHCA

Circulation. 2016;134:2084–2094. DOI: 10.1161/CIRCULATIONAHA.116.023309

December 20/27, 2016

ORIGINAL RESEARCH ARTICLE

duration of resuscitation efforts and related this tendency to survival. Subjects at hospitals with longer resuscitation attempts were more likely to achieve ROSC and to survive to hospital discharge. It is important to note that there was no difference in proportion of good functional outcome at hospital discharge between groups. This was compelling evidence that prolonging resuscitation efforts can increase survival without a substantial increase in severe neurological injury among survivors. Our data identify patient phenotypes in OHCA most likely to benefit from this approach.

Conversely, clinicians may use resuscitation duration in the absence of ROSC to justify TOR after some elapsed interval. At face value, the probability curves in Figure 3 appear to support this in subjects with unfavorable case features. One commonly accepted definition of medical futility is <1% probability of success. The upper bound of the 95% CI fell below 1% after 12 minutes of CPR in the subgroup with nonshockable initial cardiac rhythm and after 17 minutes of CPR in the subgroup with unwitnessed cardiac arrest. However, hypothetical termination at these points would have missed 53 (23%) and 26 (16%) subsequent subjects with favorable outcome, respectively. Drennan et al tested the combination of CPR duration and absence of ROSC as a hypothetical TOR rule. In their cohort, hypothetical TOR based solely on absence of ROSC after 20 minutes of resuscitation would have missed 10% of all survivors and 10% of survivors with favorable functional outcome. Taken together, these data argue against using resuscitation duration in isolation or with ad hoc case features to justify TOR. Instead, we turn attention to validated TOR decision rules.

Last, our findings support consideration of novel resuscitation strategies in appropriate candidates who do not immediately respond to conventional resuscitation. The current strategies have been optimized for 60 years, but the essence of resuscitation has not fundamentally changed. A new paradigm may be needed to achieve more than modest improvements in patient outcome. One such intervention is extracorporeal CPR (E-CPR), the incorporation of extracorporeal life support into cardiac arrest resuscitation. This resource-intensive therapy is associated with improved functionally favorable survival in selected candidates with favorable case features. However, the cost and resource intensity of E-CPR mandate that it be applied in a rational manner with optimal chance to benefit patients. Our data demonstrate declining proportions of subjects who have favorable recovery with each minute that traditional CPR fails to achieve ROSC. Furthermore, traditional resuscitation usually fails, making it reasonable to mobilize a novel therapy such as E-CPR early after recognition of cardiac arrest with a favorable phenotype that can withstand prolonged efforts concurrently with traditional CPR. Considering the time demands of transporting to hospital and initiating E-CPR, early mobilization is also logistically

DURATION OF RESUSCITATION INVERSELY IS ASSOCIATED WITH NEURO OUTCOME

DURATION OF RESUSCITATION INVERSELY IS ASSOCIATED WITH NEURO OUTCOME

Denmark
N=1,316

POTENTIAL CONS OF INCREASING DURATION OF FIELD EFFORTS

Increase in number of non-neurologically intact survivors

Increase time out of service and man hours
(~96 man-hours/life saved)
PROPOSED MINIMUM DURATIONS

- **Meet Universal TOR?**
  - Yes: Terminate Resuscitation
  - No: 
    - **Meet eCLS criteria?**
      - Yes: Transport
      - No: 
        - **Non-shockable Initial Rhythm?**
          - Yes: Terminate Resuscitation
          - No: 
            - **Shockable Initial Rhythm?**
              - Yes: Terminate Resuscitation
              - No: Terminate Resuscitation

Positive Factors: PEA with high ETCO2, persistent VF, arrest EMS witnessed, bystander CPR, young/healthy
The Role of EtCO2 in TOR

- 150 consecutive PEA arrest patients
- At 20 minutes, if EtCO2 <10 mmHg, no survival
  - 100% positive predictive value
  - 100% negative predictive value
  - 100% specificity
  - 100% sensitivity
Effect of Sodium Bicarbonate on EtCO2

Figure 2. EtCO2 in TOR cases with and without NaHCO3 (2013-2016) (50 highest EtCO2 readings)

- EtCO2 with NaHCO3
  Mean = 39.9 mm Hg
- EtCO2 without NaHCO3
  Mean = 27.7 mm Hg
p = 0.0018

- Retrospective observational study
  - 93 received NaHCO3 (EtCO2 x=26)
  - 89 did not receive NaHCO3 (EtCO2 x=19)
  - EtCO2 significant difference (p=0.026)
Where Do We Go Next?

- TOR criteria?
- Use of EtCO\(_2\) in TOR?
- Is there an EtCO\(_2\) threshold?
- Was NaHCO\(_3\) used?