IT’S A WONDERFUL TIME TO BE UNDEAD

Resuscitation Science in 2018

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DISCLOSURES
Nothing to disclose

Question

• At midnight on Friday the 13th you are called to see a patient who is attempting to become a ghost. The patient is a 76 y/o female admitted with acute renal failure who is unresponsive, pale, and agonal.
• Which of the following predicts increased survival-to-hospital discharge for this patient?
  • End-tidal CO. of 10mmHg at outset of resuscitation
  • Strict adherence to ACLS protocols
  • Hyperoxia during post-resuscitation care
  • Administration of sodium bicarbonate for acidosis
  • Use of a mechanical compression device rather than manual compressions
In-Hospital Cardiac Arrest (IHCA)

- Some Background...
  - Etiology of IHCA in ward patients
  - Survival as a function of time-of-day
  - Minimally improved survival from IHCA over the past decade
  - Neurological status of survivors of IHCA

What Causes IHCA on Ward Patients?

- Cardiac Causes (50%)
  - Ischemia 70%
  - CHF 11%
  - Complication following cardiac procedure 6%
  - Other (tamponade, dissection, etc) 13%

- Noncardiac Causes (50%)
  - Infection 46%
  - Hemorrhage 12%
  - PE 9%
  - Other (electrolytes, idiopathic, airway obstruction, etc) 34%

Survival Based on Time of Day IHCA
Leadership in High Performing Hospitals

- Quantitative and qualitative study comparison survival-to-hospital discharge rates of top, middle, and bottom quartiles of hospitals nationally
- Most important features of high-performing hospitals:
  - Dedicated resuscitation teams
  - Diverse teams represented on Code Teams (i.e., respiratory, administration, radiology, etc)
  - Clear roles and responsibilities
  - Better communication during codes
  - In-depth mock codes on a regular basis

Overall Survival to Hospital Discharge

- General trend in improvement over past 10 years, but still only around 13.4% annually
- Cardiac patients have a much higher survival to non-cardiac patients (39.3% vs 10.7%)
- Survival lowest on unmonitored or unwitnessed arrests
- Most attrition is survival occurs prior to discharge
Cerebral Performance Category Score

92% of patients who do survive 1 year have decent neurological function (CPC score 1-2—either near normal, or adequate for ADLs and light work)

Cerebral Performance Category (CPC) score scale:

- CPC 1: Corroborated performance: conscious, alert, no weakness, might have mild weakness in physical abilities
- CPC 2: Corroborated performance: conscious, alert, some weakness, might have mild weakness in physical abilities
- CPC 3: Independent: conscious, alert, can perform daily activities safely and independently
- CPC 4: Full support: conscious, alert, unable to perform daily activities safely and independently
- CPC 5: Vegetative: unconscious, cannot wake or be awakened

Capnography is a measure of 4 components:

- Carbon Dioxide Production
- Lung Perfusion
- Alveolar Ventilation
- Cardiac Output
EtCO₂ is an excellent direct surrogate for

- Cardiac index (r=0.79, p<0.001)
- Coronary perfusion (r=0.78, p<0.01)
- Cerebral perfusion (r=0.64, p=0.01)
- Chest compression quality

- EtCO₂ as a marker of ROSC
  - Sudden spike of >10mmHg could suggest perfusable rhythm

- EtCO₂ as a predictor of death
  - Prehospital data >20 minute ALS protocol
  - Patients ≤10mmHg did not survive
  - 100% sensitivity and specificity—confirmed in two trials
End-Tidal CO₂ Monitoring

In general, no consensus predictive guideline for mortality

- Survivors’ EtCO₂ levels tend to increase with time
- Non-survivors’ EtCO₂ levels tend to decrease with time

In our patient, her EtCO₂ levels are not encouraging but are not positively correlated with survival.
**Adherence to ACLS Guidelines**

- Strict adherence to protocols has a very strong predictive value for survival
- Incidental finding: 0% of patients with unwitnessed cardiac arrest survived to discharge
- In our patient this would positively correlate to likelihood of survival
- Study limitation: does not provide neurologically intact survival predictions

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**Hyperoxia During and After Resuscitation**

- Achieving a 100% hemoglobin oxygen saturation = hyperoxia
- A saturation of 94% hemoglobin oxygen saturation = normoxia

<table>
<thead>
<tr>
<th>Study name</th>
<th>Statistics for each study</th>
<th>Odds ratio and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patel et al (2010)</td>
<td>0.702 (0.287 to 1.76)</td>
<td>p = 0.50</td>
</tr>
<tr>
<td>Spink et al (2010)</td>
<td>0.719 (0.285 to 1.80)</td>
<td>p = 0.51</td>
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<tr>
<td>Wang et al (2017)</td>
<td>1.377 (1.189 to 1.593)</td>
<td>p = 0.0000</td>
</tr>
<tr>
<td>Johnson et al (2017)</td>
<td>0.670 (0.419 to 1.087)</td>
<td>p = 0.125</td>
</tr>
<tr>
<td>Van Kruiningen et al (2017)</td>
<td>0.397 (0.296 to 0.535)</td>
<td>p = 0.0000</td>
</tr>
<tr>
<td>Hembrecht et al (2016)</td>
<td>0.696 (0.499 to 1.009)</td>
<td>p = 0.0500</td>
</tr>
<tr>
<td>Oh et al (2016)</td>
<td>1.99 (0.892 to 4.47)</td>
<td>p = 0.119</td>
</tr>
<tr>
<td>Lee et al (2016)</td>
<td>1.392 (0.864 to 2.234)</td>
<td>p = 0.119</td>
</tr>
<tr>
<td>Balouk et al (2016)</td>
<td>1.871 (1.052 to 3.313)</td>
<td>p = 0.028</td>
</tr>
<tr>
<td>Kilgren et al (2016)</td>
<td>1.343 (1.078 to 1.663)</td>
<td>p = 0.0000</td>
</tr>
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Heterogeneity: $I^2 = 12.3$
Hyperoxia During and After Resuscitation

• Conclusions:
  • Hyperoxia is protective until ROSC
  • Thereafter, hyperoxia may increase harm including mortality in some studies
  • Take home: rapid titration down to 94% is appropriate
  • Pathophysiology may have to do with oxygen radicals causing harm to damaged neurons (elevated neuron specific enolase (NSA) noted)
  • Our patient should receive normoxia post-resuscitation

Pathophysiology may have to do with oxygen radicals causing harm to damaged neurons (elevated neuron specific enolase (NSA) noted). Our patient should receive normoxia post-resuscitation.

Use of Bicarbonate in IHCA

<table>
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<th>Medication group</th>
<th>Fraction (%) alive and brain dead during resuscitation after</th>
<th>99% CI</th>
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<tbody>
<tr>
<td>Epinephrine</td>
<td>80% (50-100)</td>
<td>75-75%</td>
</tr>
<tr>
<td>Epinephrine &amp; Calcium</td>
<td>80% (50-100)</td>
<td>75-75%</td>
</tr>
<tr>
<td>Epinephrine, HCO3, Calcium, &amp; Epinephrine drip</td>
<td>60% (50-70)</td>
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CI = confidence interval


Use of Mechanical Compression Devices

A benefit at 90 days or hospital discharge

Treatment 1 vs. Treatment 2

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Manual vs. ILCPR</th>
<th>ILCPR vs. half ILCPR</th>
<th>Manual vs. half ILCPR</th>
</tr>
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<tr>
<td>Benefit</td>
<td>0.08 (0.03 - 0.13)</td>
<td>0.30 (0.20 - 0.40)</td>
<td>1.40 (1.08 - 1.88)</td>
</tr>
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Use of Mechanical Compression Devices

• Bottom line: manual compressions are still state of the art
• Lowest likelihood of complications such as hematoma or pneumothorax
• Good compressions:
  • Start now
  • Push hard
  • Pump fast
  • Good recoil
  • Don’t stop