Improving Survival after In-hospital Cardiac Arrest: Life after Death
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Disclosures
• Co-chair, Adult Research Task Force
  Get With The Guidelines-Resuscitation
  American Heart Association

Learning Objectives
• Describe epidemiology of in-hospital cardiac arrest
• Describe processes of care associated with improved survival
• Outline potential strategies for improving survival and neurologic outcomes
History of CPR

1500-1700

Modern History

- Peter Safar
  - Head tilt, chin lift
  - Mouth-to-mouth respiration
  - ‘ABC’ of resuscitation

- William Kouvenhoven
  - closed cardiac massage

- Bernard Lown
  - Modern defibrillators
Recommended Guidelines for Reviewing, Reporting, and Conducting Research on In-Hospital Resuscitation:

The In-Hospital ‘Utstein Style’


Circulation
Volume 95(8):2213-2239
April 15, 1997

Conceptual Model

Cardiac Arrest → “Surviving a Code” or ROSC → Neurologically Intact Survival

Acute Resuscitation Phase
- Patient Factors (age, sex, co-morbidities)
- Cardiac arrest characteristics (rhythm, witnessed)
- Resuscitation response (response time, quality of CPR, timely defibrillation)

Post Resuscitation Phase
- Availability of treatment (hypothermia, cardiac cath)
- Supportive critical care (intensive care nurses, structured treatment protocols)
- Resources & Personnel (specialists, physicians)
- Variability in advanced care directives

National Registry of Cardiopulmonary Resuscitation (NRCPR)

- Established in 2000
- Based on the Utstein template for cardiac arrest
- Multi-center registry of IHCA
- Multi-pronged strategy for identifying IHCA
- Rich clinical data abstracted by trained personnel
- Focus – quality improvement
- Now “Get With The Guidelines-Resuscitation”
Epidemiology of in-hospital CA

- 200,000 patients in U.S. every year
- 20% are black
- 25% of IHCA is due to VF/VT
- Burden of co-morbidities is higher
- Survival 17%

Peberdy et al Resuscitation 2003
Merchant et al Crit Care Med 2011

Delayed Defibrillation for VF/VT

The overall median time to defibrillation was 1 minute (interquartile range, 3 to 3 minutes). Delayed defibrillation occurred in 20.45 patients (31%). Characteristics associated with delayed defibrillation included black race, noncardiac admitting diagnosis, and occurrence of cardiac arrest at a hospital with fewer than 250 beds, in an unmonitored hospital unit, and during after-hours periods (5 p.m. to 8 a.m. on weekdays). Delayed defibrillation was associated with a significantly lower probability of surviving to hospital discharge (22.2%, vs. 39.3% when defibrillation was not delayed; adjusted odds ratio, 0.48; 99% confidence interval, 0.42 to 0.54; P<0.001). In addition, a graded association was seen between increasing time to defibrillation and lower rates of survival to hospital discharge for each minute of delay (P for trend = 0.001).
Survival to discharge RR

Unadjusted 0.73 (0.67-0.79)

Adjusted for age and sex 0.70 (0.64-0.76)

plus clinical characteristics 0.81 (0.75-0.86)

plus hospital characteristics 0.82 (0.76-0.89)

plus time to defibrillation 0.90 (0.83-0.96)

N=84,625 patients between 2000-2009 at 374 hospitals

Examined whether survival outcomes have improved over time using a GEE model
**Risk-Adjusted Survival to Discharge**

- **Overall:**
  - Adjusted RR per 10 years: 1.42 (1.23-1.64)
  - P for trend < 0.001

- **By Rhythm:**
  - Asystole & PEA: Adjusted RR per 10 years = 1.71 (1.39-2.10)
  - VF & VT: Adjusted RR per 10 years = 1.25 (1.08-1.44)

**Neurological Disability**

- Adjusted RR per 10 years = 0.82 (0.74, 0.99)
- P for trend 0.02

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*Girotra et al, NEJM 2012*
Racial differences in survival trends

Overall

Stratified by rhythm type

Long-term survival

Has improvement in survival been uniform, or have some hospitals improved more than others
Hospital variation in IHCA survival

Chan et al. JACC 2013

Adjusted Hospital Trends

OVERALL 1st Quartile (Bottom) 2nd Quartile 3rd Quartile 4th Quartile (Top)

Mean change 1.07 1.01 1.05 1.05 1.13

Range 0.97-1.18 0.97-1.03 1.03-1.07 1.04-1.07 1.11-1.18

Hospital Rates of Survival to Discharge

2000-2003 2007-2010
Association of Hospital Characteristics with Survival Improvement

<table>
<thead>
<tr>
<th>Hospital Characteristic</th>
<th>P for interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Census Region</td>
<td>0.81</td>
</tr>
<tr>
<td>Location (Urban or rural)</td>
<td>0.57</td>
</tr>
<tr>
<td>Ownership status</td>
<td>0.55</td>
</tr>
<tr>
<td>Bed size</td>
<td>0.73</td>
</tr>
<tr>
<td>Teaching</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Post-resuscitation phase of IHCA

- Accounts for nearly 40% of in-hospital cardiac arrest deaths
- Limited evidence regarding effectiveness of different strategies for improving post-resuscitation survival in IHCA
- Extrapolated from studies of OHCA
  - Therapeutic hypothermia
  - Early coronary angiography
Hospital variation in post-resuscitation survival

Girotra et al Unpublished data

 Hospital variation in IHCA survival

Lessons from STEMI Care

- Identified top-performers for STEMI care
  - Hospitals that had consistently shorter D2B times
- Mixed-methods study
  - Site visits at top performing hospitals
  - Key strategies at top performing hospitals
  - Surveyed hospitals to narrow down

Bradley et al JACC 2006
Bradley et al Circ 2006
Survey of hospital practices
- Therapeutic hypothermia
- Early coronary angiography
- Intensive care
- Nurse-patient ratio
- Structured treatment protocols
- Quality improvement activities
Summary

• In-hospital cardiac arrest is common, and associated with poor survival

• Processes of care such as time to defibrillation can be important metrics to monitor resuscitation quality

• Survival after IHCA has improved in recent years, although the underlying factors remain unclear

Summary

• Marked variation in survival across hospitals persists

• Identifying best-practices related to resuscitation care at hospitals could be an innovative strategy to improve IHCA survival

Acknowledgements

• National Institutes of Health
  – K08 Career Development Award

• American Heart Association

• Mentors
  – Paul Chan
  – Peter Cram
  – Gary Rosenthal

• Mentees
  – Ankur Vyas
  – Lee Joseph
  – Rohan Khera
Hospital variation in post-resuscitation survival - unadjusted

Girotra et al Unpublished data
Trends in Survival

Acute Resuscitation Survival vs. Post-resuscitation survival

P for trend < 0.001

Girotra et al NEJM 2012

Hospital Variation in Survival Trends

- N=93,342 IHCA patients at 231 hospitals
- Two-level hierarchical multivariable regression model (random intercept & random slope model)
- Magnitude of survival improvement at each hospital was quantified using odds ratio
  - Odds ratio = 1 (No improvement)
  - Odds ratio > 1 (improvement in survival)
  - Odds ratio < 1 (worsening of survival)

Girotra et al JAHA 2014

Hospital Characteristics

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>N=231</th>
</tr>
</thead>
<tbody>
<tr>
<td>Census Region</td>
<td></td>
</tr>
<tr>
<td>North Mid-Atlantic</td>
<td>33 (14.3)</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>59 (25.5)</td>
</tr>
<tr>
<td>North Central</td>
<td>52 (22.5)</td>
</tr>
<tr>
<td>South Central</td>
<td>41 (17.7)</td>
</tr>
<tr>
<td>Mountain/Pacific</td>
<td>46 (19.9)</td>
</tr>
<tr>
<td>Urban Location</td>
<td>207 (89.9)</td>
</tr>
<tr>
<td>Non-profit ownership</td>
<td>162 (70.1)</td>
</tr>
<tr>
<td>Bed size &lt; 250</td>
<td>82 (35.5)</td>
</tr>
<tr>
<td>Major Teaching</td>
<td>55 (23.8)</td>
</tr>
</tbody>
</table>
Unadjusted Hospital Trends

<table>
<thead>
<tr>
<th>OVERALL</th>
<th>1st Quartile (Bottom)</th>
<th>2nd Quartile</th>
<th>3rd Quartile</th>
<th>4th Quartile (Top)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean change</td>
<td>1.04</td>
<td>1.00</td>
<td>1.03</td>
<td>1.08</td>
</tr>
<tr>
<td>Range</td>
<td>0.97-1.12</td>
<td>0.97-1.01</td>
<td>1.01-1.04</td>
<td>1.07-1.10</td>
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Hospital variation in post-resuscitation survival - unadjusted
Epidemiology

- Cardiac arrest is the 3rd leading cause of death in the industrialized world

- In Canada,
  - 30,000–45,000 patients suffer an out-of-hospital cardiac arrest
  - XXX patients suffer an in-hospital cardiac arrest

- In the United States,
  - OHCA: 350,000 per-year
  - IHCA 210,000 per-year
Conceptual Model

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Acute Resuscitation Phase
- Patient Factors (age, sex, comorbidities)
- Cardiac arrest characteristics (rhythm, witnessed)
- Resuscitation response (response time, quality of CPR, timely defibrillation)

Post Resuscitation Phase
- Availability of treatment (hypothermia, cardiac cath)
- Supportive critical care (intensive care nurses, structured treatment protocols)
- Resources & Personnel (specialists, physicians)

Post-resuscitation phase
- Approximately 30-50% of cardiac arrest deaths occur during post-resuscitation phase
- Most of these deaths are due to deleterious consequences of no-flow state
- Emerging evidence that care during the post-resuscitation phase may impact patient outcomes

https://www.youtube.com/watch?v=ILxjxFB4zNk
IMPLICATIONS

• Assuming a stable incidence 200,000 cardiac arrests / year

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2009</th>
<th>Net Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival to discharge</td>
<td>27,400</td>
<td>44,600</td>
<td>17,200</td>
</tr>
<tr>
<td>No significant neurological disability</td>
<td>18,385</td>
<td>32,067</td>
<td>13,682</td>
</tr>
</tbody>
</table>