How to Improve Cardiac Arrest Survival in your Center

Ankur A. Doshi, MD FACEP
Post Cardiac Arrest Service – UPMC Presbyterian
Department of Emergency Medicine
University of Pittsburgh School of Medicine
doshiaa@upmc.edu @ankdoshi

Presenter Disclosure Information

Ankur A. Doshi, MD FACEP
How to Improve Cardiac Arrest Survival in your Center

FINANCIAL DISCLOSURE:
Employer: University of Pittsburgh/UPMC
Grants/Research Support: Pittsburgh Emergency Medicine Foundation
Learning objectives

• Review survival rates/outcomes after cardiac arrest

• Discuss patient variables after cardiac arrest that affect outcomes

• Describe ICU treatments helpful in managing cardiac and neurologic injury after cardiac arrest

• Discuss post-ICU treatments that affect outcomes for post arrest patients

What we won’t cover

• Treatment during cardiac arrest

• Targeted temperature management

• Ventilator management

• Detailed neuroprognostication
First the good news

Buick CCQO 2018

Daya Resusc 2015
Regional variation in survival

Girotra NEJM 2012

Daya Resusc 2015
Tertiary centers affect early survival

- Survival different for first 5 days
- More intensive cardiac AND ICU interventions

N=987 persons discharged from 7 hospitals.
Link to National Death Index to determine survival time.
Center 1 has a dedicated post-arrest service line with >250 patients per year

Differences persist long term

N=987 persons discharged from 7 hospitals.
Link to National Death Index to determine survival time.
Center 1 has a dedicated post-arrest service line with >250 patients per year
Step 1 – identify patient variations

Etiologies of CA patients vary

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause determined reliably</td>
<td>238</td>
<td>85</td>
</tr>
<tr>
<td>Recognized correctly by emergency team during ALS</td>
<td>198</td>
<td>66</td>
</tr>
<tr>
<td>Cardiac</td>
<td>156</td>
<td>60</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>100</td>
<td>39</td>
</tr>
<tr>
<td>Heart failure</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Myocardial ischemia</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Cardiac tamponade</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Ventricular wall rupture</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>4 hrs and 4 hrs</td>
<td>108</td>
<td>42</td>
</tr>
<tr>
<td>Myocardia</td>
<td>51</td>
<td>20</td>
</tr>
</tbody>
</table>

Cardiac 156 60
Myocardial infarction 100 39

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tamponade cardiac</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Tension pneumothorax</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Torsos</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>40</td>
<td>16</td>
</tr>
<tr>
<td>Seizures</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Cardiac bleeding/infarction</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Aortic aneurysm with rupture</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Cardiac seizure</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Esophageal varico bleeding</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Other causes</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Unknown</td>
<td>44</td>
<td>15</td>
</tr>
</tbody>
</table>
Initial severity of patients vary

Rittenberger Resusc 2011
Initial illness severity and outcome

Pretest
Admitted after Cardiac Arrest
- Survival: 46% (207/459)
  - Good Outcome: 31% (141/459)

Check Cardiopulmonary Status and FOUR Score

Posttest
- Awake 30% (141/459)
  - 81% (114/141) survive
  - 60% (85/141) good outcome
- Coma without Shock 22% (99/459)
  - 58% (57/99) survive
  - 34% (34/99) good outcome
- Coma with Shock 14% (63/459)
  - 44% (28/63) survive
  - 25% (16/63) good outcome
- Missing Brainstem Reflexes 34% (156/459)
  - 9% (14/156) survive
  - 5% (8/156) good outcome

Why does this matter?
Step 2 – treat what can be treated

Cardiac catheterization for STEMI

AHA CPR/ECC Guideline (2015): Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR)
Cardiac catheterization for nonSTEMI

Dumas CircCVInterventions 2010

Reynolds Resusc 2014
AHA CPR/ECC Guideline (2015): Emergency coronary angiography is reasonable for select (eg, electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR)

Caveat: Non-randomized data

Coming soon to a center near you......
FYI: another new approach

Yannopoulos JACC 2017

The University of Minnesota refractory ventricular fibrillation (VF) protocol mobilizes patients with failed initial resuscitation with ongoing cardiopulmonary resuscitation (CPR) to enter the cardiac catheterization laboratory (Cath Lab) where extracorporeal life support (ECLS) is implemented as a bridge to coronary angiography, intervention, and recovery. The program has identified that 86% of the patients had severe coronary artery disease. Survival to hospital discharge was 45%. Historical control subjects treated with the previous standard of care had access to the hospital only after return of spontaneous circulation (ROSC) was achieved and, as such, survival was poor. AHA — American Heart Association; ECLS — extracorporeal membrane oxygenation; PCI — percutaneous coronary intervention; VT — ventricular tachycardia.
Step 3 – neuroresuscitation
Perfuse/oxygenate the brain

```
<table>
<thead>
<tr>
<th>Mean arterial pressure (mmHg)</th>
<th>Cerebral blood flow (ml/100g/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>
```

“Pressure passive”

Individual physiology varies

```
<table>
<thead>
<tr>
<th>Mean arterial pressure (mmHg)</th>
<th>Brain tissue oxygen (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>10</td>
</tr>
<tr>
<td>90</td>
<td>20</td>
</tr>
<tr>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>130</td>
<td>40</td>
</tr>
</tbody>
</table>
```

```
<table>
<thead>
<tr>
<th>Mean arterial pressure (mmHg)</th>
<th>Brain tissue oxygen (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>115</td>
<td>40</td>
</tr>
</tbody>
</table>

Intact autoregulation
Pressure passive
Hypoxia corrected

Autoregulation essentially intact throughout
No tissue hypoxia at any MAP

Elmer Semin Neurol 2017
Hemodynamic goal

MAP > 80 mmHg

Local brain tissue hypoxia is bad and common

• $O_2$ delivery/diffusion impaired
• Perivascular edema

Menon CritCareMed 2004
This effect also varies across patients

Is hyperoxia bad?

- Drives oxidative injury, ROS generation, etc
- Hyperoxia is common
- Some OBSERVATIONAL data associate extreme hyperoxia with worse outcomes

**Kilgannon JAMA 2010**
Oxygenation goals

• Measure \( \text{PaO}_2 \)
  • *In vivo* \( \text{PaO}_2 \) 5 mmHg lower per 1°C
• Normoxia
  • Significant hyperoxia is (probably) bad and frequent
  • Brain tissue hypoxia is (probably) bad and often quite severe

\[ \text{PaO}_2 \text{ 100-200 mmHg} \]

Carbon dioxide goals

• Observational data

<table>
<thead>
<tr>
<th>Death OR failure to be discharged home</th>
<th>Hypo- vs. normocapnia</th>
<th>Hyper- vs. normocapnia</th>
<th>Hyper- vs. hypocapnia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.23 (1.10–1.37)</td>
<td>0.97 (0.89–1.06)</td>
<td>0.79 (0.70–0.89)</td>
</tr>
<tr>
<td>Discharge home among survivors</td>
<td>0.81 (0.70–0.94)</td>
<td>1.16 (1.03–1.32)</td>
<td>1.43 (1.22–1.69)</td>
</tr>
</tbody>
</table>

\[ \text{PaCO}_2 \text{ 40 mmHg} \]

(temp corrected)

*Schneider Resus 2013*

*Roberts Circulation 2013*
Seizures after cardiac arrest – bad or fatal?

- Incidence of malignant patterns: 8-40%
- Mix of different types
- **AAN Guideline (2006):** Patients with myoclonus status epilepticus within the first day after a primary circulatory arrest have a poor prognosis (Level B)

*Reynolds SeminNeurol 2017*

---

<table>
<thead>
<tr>
<th>CPC</th>
<th>CPC 1–2</th>
<th>CPC 3–4</th>
<th>Disposition</th>
<th>Good</th>
<th>Poor</th>
<th>Total (N=120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPn</td>
<td>2</td>
<td>17</td>
<td>8</td>
<td>11</td>
<td>19 (15.8%)</td>
<td></td>
</tr>
<tr>
<td>- MSE</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4 (3.3%)</td>
<td></td>
</tr>
<tr>
<td>- SE</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>5 (4.2%)</td>
<td></td>
</tr>
<tr>
<td>- GPED</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>10 (8.4%)</td>
<td></td>
</tr>
<tr>
<td>- Seizure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pure-SB</td>
<td>8</td>
<td>14</td>
<td>14</td>
<td>8</td>
<td>22 (18.2%)</td>
<td></td>
</tr>
<tr>
<td>Epileptiform discharges</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>10 (8.4%)</td>
<td></td>
</tr>
<tr>
<td>Non-malignant</td>
<td>29</td>
<td>40</td>
<td>46</td>
<td>23</td>
<td>69 (57.5%)</td>
<td></td>
</tr>
<tr>
<td>Background reactivity</td>
<td>27</td>
<td>58</td>
<td>29</td>
<td>56</td>
<td>85 (70.8%)</td>
<td></td>
</tr>
</tbody>
</table>

MSE, myoclonic status epilepticus; SE, status epilepticus; GPED, generalized periodic discharges; SB, suppression-burst.

*Amorim Resusc 2015*
### Patients awaken late

#### Table

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Malignant PAMM</td>
</tr>
<tr>
<td>Background</td>
<td>Burst suppressed</td>
</tr>
<tr>
<td>Suppression ratio, median [IQR]</td>
<td>Burst suppressed, continuous, variable</td>
</tr>
<tr>
<td>Discharges</td>
<td>Identical high-amplitude polyspike-wave bursts</td>
</tr>
<tr>
<td>Treatment responsive?</td>
<td>No</td>
</tr>
<tr>
<td>Prevalence (No, N/A)</td>
<td>48/69, 70% (57–80%)</td>
</tr>
<tr>
<td>Survival (No, N/A)</td>
<td>2/48, 3% (0–14%)</td>
</tr>
<tr>
<td>Favorable outcome</td>
<td>0/2, 0% (0–8%)</td>
</tr>
<tr>
<td></td>
<td>6/9, 12% (5–22%)</td>
</tr>
<tr>
<td></td>
<td>4/8, 50% (16–84%)</td>
</tr>
<tr>
<td></td>
<td>4/4, 100% (40–100%)</td>
</tr>
<tr>
<td></td>
<td>2/69, 2% (0–10%)</td>
</tr>
<tr>
<td></td>
<td>0/2, 0% (0–8%)</td>
</tr>
<tr>
<td></td>
<td>7/69, 10% (4–20%)</td>
</tr>
<tr>
<td></td>
<td>1/7, 14% (0–58%)</td>
</tr>
<tr>
<td></td>
<td>0/0, N/A</td>
</tr>
<tr>
<td></td>
<td>0/1, 0% (0–98%)</td>
</tr>
</tbody>
</table>

#### Graph

**Number of Patients**

- Discharged Neurologically Intact
- Discharged Not Neurologically Intact
- Did Not Survive to Discharge

**Days Post-Arrest**

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15

**Prevalence**

- 48/69, 70% (57–80%)

**Survival**

- 2/48, 3% (0–14%)

**Favorable outcome**

- 0/2, 0% (0–8%)

---

*Grossstreuer Resusc 2013*
Most patients die b/c of withdrawal of care

- 2,137 non-survivors after OHCA
  - Largest cause of in-hospital death was WLST for “neurological” reasons (61.2%)

Callaway Resusc 2014

Most neurologic withdrawal is early

Elmer Resusc 2016
Delay neuro-prognostication for 72 hours

Step 4 – post ICU care
Survival ≠ outcome

Outcomes after discharge
Domains that matter to patients

Functional / physical
Cognitive
Spiritual / emotional
Psychiatric
Social

Assess serially – at least up to one year
ICF* as an Organizer

Health condition (disorder or disease)

- Body Functions and Structures
- Activities
- Participation

- Environmental Factors
- Personal Factors

* International Classification of Functioning, Disability and Health (WHO, 2001)
Figure 2  Neuropsychological test scores in out-of-hospital cardiac arrest survivors with ventricular fibrillation compared to the normal population

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean Score</th>
<th>95% CI</th>
<th>Adj. p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WASI Index Score Performance IQ</td>
<td>104.5</td>
<td>(100.3, 108.7)</td>
<td>0.148</td>
</tr>
<tr>
<td>% Retention Long Term Memory</td>
<td>8.1</td>
<td>(7.2, 9.0)</td>
<td>0.001</td>
</tr>
<tr>
<td>MOANS Standardized Score</td>
<td>87.6</td>
<td>(82.6, 92.6)</td>
<td>0.000</td>
</tr>
<tr>
<td>Learning efficiency</td>
<td>86.2</td>
<td>(81.2, 91.2)</td>
<td>0.000</td>
</tr>
<tr>
<td>Delayed recall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trail Making Test Part B</td>
<td>9.8</td>
<td>(8.7, 10.9)</td>
<td>1.000</td>
</tr>
<tr>
<td>MOANS Standardized Score</td>
<td>9.5</td>
<td>(8.6, 10.4)</td>
<td>0.839</td>
</tr>
<tr>
<td>Stroop Color Word</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOANS Standardized Score</td>
<td>104.4</td>
<td>(101.8, 107.0)</td>
<td>0.006</td>
</tr>
<tr>
<td>Mayo Estimated Verbal IQ</td>
<td>9.8</td>
<td>(8.7, 10.9)</td>
<td>1.000</td>
</tr>
<tr>
<td>MOANS Age-Corrected Standardized Score IQ</td>
<td>28.6</td>
<td>(27.9, 29.3)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

CI = confidence interval; MOANS = Mayo's Older Americans Normative Studies; WASI = Wechsler Abbreviated Scale of Intelligence.
Assessment and treatment of cognitive domain

Koller Resusc 2017

*Passed with further testing: impairment presence is unknown
*No further testing recommended: impairment present, patient is unlikely to pass further exams
*No further testing recommended: patient is likely to pass further exams, impairment is unlikely
*Passed with further testing: impairment type and degree is unknown, will be characterized by further exams
Ketisdottir A Eur J of Cardiovascular Nursing 2014

“I have filtered out those whom I think are a waste to spend time with. Instead, I try to focus on those close to me. You sort of prioritize your relationships differently.”

Forslund AS Scand J Caring Sci 2017

“There was no room for me in heaven that day”
“I’ve got a second chance at life”

Palacios-Cena D Nurs Health Sci 2011

“No one really knows the true meaning of my experience. I literally died and came back [from death]. Who can begin to grasp such a thing? Only someone who has shared the same experience”

“One has to learn to live again, one has to learn to die . . . it sounds very dramatic but that is how I feel.”
Surviving Sudden Cardiac Arrest:
A Pilot Qualitative Survey Study of Survivors

Kelly N. S. Sawyer, MD, MS\textsuperscript{1}, Frances Brown, PsyD, LPC\textsuperscript{2}, Roxanne Christiansen, MA, TLLP\textsuperscript{2},
Colleen Daino, PsyD, LPC\textsuperscript{2}, Mary M. Newman, MS\textsuperscript{2}, and Michael C. Kurz, MD, MS-HES\textsuperscript{2}

<table>
<thead>
<tr>
<th>SCA survivor global themes</th>
<th>Family member/friend (FFM) global themes</th>
</tr>
</thead>
</table>
| Significance of others    | "My FFM did/is still experiencing memory loss."
| "We are in this together" | There was a lack of information at discharge |
| Too many feelings         | "I received no mental health resources."
| Seeking a New Normal      | What if it happens again?               |
|                           | "I wish I had known..."                |

DEPARTMENT OF
Emergency Medicine

UNIVERSITY OF PITTSBURGH SCHOOL OF MEDICINE
Services after ICU care

- **Functional / cognitive domains:**
  - Structured PT, OT eval
  - PMR, Rehab if needed
  - Cardiac rehab v exercise program
  - Follow > 6 m

- **Psychiatric domain:**
  - HADS, GAD-7
  - In-hospital
  - 6 m
  - 12 m
  - Refer for treatment if needed

- **Spiritual / social domains:**
  - Referral to survivor’s networks
  - SCAA
  - SCAF
  - Local survivors / peer to peer
Step 5 – track care and outcomes

Summary

Step 1 – identify patient variations
Step 2 – treat what can be treated
Step 3 – neuroresuscitation

In-hospital interventions

Assess individual patients
Tailor treatment
Cardiac catheterization early

TTM
MAP > 80
Normoxia (PaO2 100-200)
PaCO2 ~ 40
Eval and treat seizure
Delay neuroprognostion > 72
**Summary**

**Step 4 – post ICU care**

- PT
- OT
- PMR
- Psychiatry
- Social work
- Survivor communities

**Recovery takes > 12 months**

**Step 5 – track outcomes**

- Join a registry

---

**Recap**

- We can increase survival after cardiac arrest
  - Some centers are better than others

- Etiologies of arrest differ – and so do treatments somewhat

- Treat the heart and the brain – the bundle still matters

- Treatment doesn’t end at discharge