“Early PCI After Successful CPR: A Key to Post Resuscitation Care”

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University of Arizona
Tucson, Arizona
Director, Cardiac Catheterization Laboratories
& the Interventional Cardiology Fellowship
Only 25-35% of those initially resuscitated survive to leave the hospital!
Norway Experience-Sunde

- Found their own historical survival to discharge was only 26% of all those initially resuscitated
- NOT GOOD ENOUGH!
- Formalized Approach to Post Resuscitation Care:
  - Therapeutic Hypothermia
  - PCI when indicated
  - Hemodynamic Support
  - Ventilation Control
  - Glucose Control
### Control period (1996-98)
68 patients admitted to ED

- 10 excluded died before ICU admission
- 58 patients admitted to ICU
  - 18 (31%) patients survived
    - 9 CPC 1
    - 6 CPC 2
    - 2 CPC 3
    - 1 CPC 4
  - 15 (26%) patients with one-year survival

### Intervention period (2003-2005)
69 patients admitted to ED

- 8 excluded died before ICU admission
- 61 patients admitted to ICU
  - 34 (56%) patients survived
    - 31 CPC 1
    - 3 CPC 2
  - 34 (56%) patients with one-year survival
In the Interventional period (2003-05):

- 47/61 (77%) had coronary angiography
  - 45/47 (96%) had documented coronary disease
  - 37 of 45 (82%) had total occlusions including
    - 16/37 (43%) LAD
    - 11/37 (30%) CX
    - 10/37 (27%) RCA

- 30/61 (49%) had reperfusion
  - 27/30 had PCI
  - 3/30 had CABG

Resuscitation 2007;73:29-39
Sunde et al.

- Coronary angiography

  - Major indication was ST-elevation on admission ECG or strong suspicion for an MI as underlying etiology of the cardiac arrest

Resuscitation 2007;73:29-39
Sunde et al.

<table>
<thead>
<tr>
<th>Effects on Survival</th>
<th>OR</th>
<th>‘p’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reperfusion therapy</td>
<td>27.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>na</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Inotropic Rx</td>
<td>2.4</td>
<td>0.022</td>
</tr>
<tr>
<td>IABP</td>
<td>na</td>
<td>0.066</td>
</tr>
<tr>
<td>Volume replacement</td>
<td>na</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Insulin</td>
<td>10.7</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Resuscitation 2007;73:29-39
Sunde et al.

Experimental period 2003-2005: 56%
Control period 1996-1998: 26%

p = .001
Sunde et al.

Neurological status of survivors:

31/34 (91%) were CPC = 1

3/34 (9%) were CPC = 2

Resuscitation 2007;73:29-39
Sunde et al.

- Significant improvement in survival, with an aggressive and standardized approach to post resuscitation care

- Reperfusion therapy (PCI or CABG) had the most profound effect on outcome (Adjusted OR = 4.47)
  - Patients were transported directly from ED to the PCI Suite when clinically stable!

Resuscitation 2007;73:29-39
Swedish Experience--Werling

- May 2003 to Jan 2005
  - n = 385 patients with cardiac arrest; 85 resuscitated
- Single city experience (Goteberg, Sweden)
- “more aggressive attitude” towards PR care, but no strict guidelines for treatment post resuscitation
- Compared those treated with more aggressive measures vs those not; and against an historical control (1980-2000, n = 1,310)

Resuscitation 2007;73:40-45
Werling et al.

- N = 385 CA pts
  - 85/385 (23%) were admitted to hospital alive
    • 65% had a cardiac etiology for their CA
    • 50% had VF
    • 32% received therapeutic mild hypothermia
    • 28% underwent coronary angiography
    • 21% had PCI or CABG
  - 27/85 (32%) survived to 30 days

Resuscitation 2007;73:40-45
Werling et al.

- Coronary angiography
  - Major indication was ST-elevation on admission ECG or strong suspicion for an MI as underlying etiology of the cardiac arrest
  - PCI performed in 13/28 (46%)  
  - CABG in 5/28 (18%)  
  - Neither in 10/28 (36%)

Resuscitation 2007;73:40-45
Werling et al.

Effects on Survival:

Hypothermia = 37%
No hypothermia = 29%
(p = No difference)

Early coronary angiography = 67%
No early coronary angiography = 18%
(p < 0.0001)

Resuscitation 2007;73:40-45
 Werling et al.

Neurological status of survivors:

763/85 (74%) were CPC = 1

9/85 (11%) were CPC = 2

13/85 (15%) were CPC = 3

Resuscitation 2007;73:40-45
Werling et al.

Surv to DC

Experimental period
Control period

p = NS

2003-2005
1980-2000

0
5
10
15
20
25
30
35
40
45
50
Werling et al.

- No overall improvement in survival, but…
  - Only limited number received additional Rx
  - Hypothermia not employed well (<1/3 received)
  - Early cath/PCI did correlate with better outcome

- Authors call for even more aggressive approach to pts successfully resuscitated, particularly more early angiography and PCI

Resuscitation 2007;73:40-45
Keys to Improving Survival to Hospital Discharge

- Good BLS/ACLS for rapid ROSC
- Think “Cardiac”/Look for “Cardiac”
  - 1. Early 12 lead ECG
  - 2. Consider early cardiac catheterization/PCI
- Therapeutic mild hypothermia
- Actively follow and pursue:
  - Hemodynamic support, i.e. inotropes for PRMD
    - Check LVEF with echocardiography
  - Early extubation/ventilation control
  - Blood glucose control
Spaulding et al.

- 1994-1996

- 1762 patients with OOH CA
  - 910 had resuscitation efforts attempted
    - 312 were resuscitated in the field
    - 126/312 died in route to hospital
    - 102/312 were excluded for non-cardiac causes of their CA
    - 84/312 were taken to cath lab after successful resuscitation

- 60/84 (71%) had clinically significant CAD
- 40/84 (48%) had total occlusions
  - 37/84 (44%) had PCI attempted
    - 28/37 (76%) were successful

- In-hospital survivor rate was 38%

NEJM 1997;336:1629
“Clinical and electrocardiographic findings, such as chest pain and or ST elevation on the ECG were poor predictors of acute coronary occlusion.”
Coronary Intervention
Post Resuscitation for STEMI

- A number of clinical series now reported in the recent era, representative of these:
  - Bendz 2004
  - Quintero-Moran 2006
  - Gorup 2007
  - Garot 2007
  - Knafelj 2007
Long-term Prognosis after OOH Cardiac Arrest and 1° PCI

- Bendz et al. (2004)
  - N = 40
  - 36/40 were comatose at time of cath
  - Occluded vessel: LAD (50%); RCA (30%); LM (15%)
  - PCI success 38/40 (95%)
  - Survival:
    - Hosp DC = 72%
    - 2 year = 72%

No data provided on neurological function of survivors
PCI for CA 2° to STEMI. Influence of Immediate Paramedical/Medical Assistance on Clinical Outcome

- Quintero-Moran et al. (2006)
  - N = 63
    - [63/630 (10%) of all STEMI required resuscitation]
  - Three groups:
    - Group 1: OOH CA with delayed time from CA to CPR
    - Group 2: OOH CA with no delay in time from CA to CPR
    - Group 3: In-Hosp CA
  - PCI within 12 hours of CA
  - All pts:
    - Angiographic success was 56/63 (89%)
    - Survival:
      Hosp DC = 48/63 (76%)

J Invasive Cardiol 2006;18:269-272
Coronary Angiography
Post Resuscitation for STEMI

- Quintero-Moran et al. (2006)

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>13</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>Downtime</td>
<td>7±4</td>
<td>1±0</td>
<td>1±0</td>
</tr>
<tr>
<td>(CA to CPR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hosp DC</td>
<td>54%</td>
<td>79%</td>
<td>82%</td>
</tr>
<tr>
<td>30 day</td>
<td>46%</td>
<td>71%</td>
<td>75%</td>
</tr>
</tbody>
</table>

J Invasive Cardiol 2006;18:269-272
Coronary Angiography
Post Resuscitation for STEMI

Quintero-Moran et al. (2006)

- Only OOH CA patients
  - $N = 27$
  - Angiographic Success = $25/27$ (93%)
  - Survival to Hosp DC = $18/27$ (67%)

J Invasive Cardiol 2006;18:269-272
Acute STEMI after Successful CPR

- Gorjup et al. (2007)

- N = 135
  - [135/2393 (6%) of all STEMI pts from 1/00 to 1/05]

- Infarct Related Artery
  - LAD (52%); RCA (31%); CX (14%); others (3%)

- PCI success 87%

- Survival:
  - Hosp DC = 67%
  - CPC 1 or 2 = 53%

Resuscitation 2007;72:379-385
Coronary Angiography
Post Resuscitation for STEMI

- Gorjup et al. (2007)
  - N = 135
    - 86/135 (64%) were comatose at time of cath
    - 49/135 (36%) were conscious

- Comatose group had:
  - Less EMT witnessed or In-hosp CA
  - Longer time from collapse to ACLS
  - More non-VF initial rhythms
  - Less Defib only resuscitations
  - More recurrence of CA

Resuscitation 2007;72:379-385
Figure 1  The incidence of comatose and conscious survivors of cardiac arrest with acute ST-elevation myocardial infarction (STEMI) among consecutive patients admitted to our department between 1 January 2000 and 31 December 2004. The proportion of patients undergoing primary percutaneous coronary intervention (PCI), success rates in terms of epicardial TIMI 2/3 flow and hospital survival are also shown.
Coronary Angiography
Post Resuscitation for STEMI

- Gorjup et al. (2007)
- Distinct difference in CNS outcome depending on conscious or comatose after arrival at hospital
- Greatest influence on subsequent CNS function is the speed/ease of resuscitation

Resuscitation 2007;72:379-385
Coronary Angiography
Post Resuscitation for STEMI

- Gorjup et al. (2007)

- Basic neurological reflexes (corneal) and responses (pupil light and painful withdrawal) are important predictors of better CNS prognosis

Resuscitation 2007;72:379-385
Six Month Outcome of Emergency PCI After Cardiac Arrest Complicating STEMI.

Garot et al. (2007)

186 STEMI pts - all had PCI of infarct artery
ASA 250-500 mg
Ticlid or clopidogrel (300-600 mg)
2B3A GP Inhibitors per MD preference (only 17%)

161 (87%) had successful PCI (<50% residual stenosis)
138/186 (74%) had initially TIMI 0-1 flow
48/186 (26%) had better initial flow (TIMI 2-3), but at least a 75% stenosis

All were sedated and paralyzed at the time of cath
hence neuro function was not assessed pre-cath/PCI

Circulation 2007;115(11): 1354-62
Coronary Angiography
Post Resuscitation for STEMI

Garot et al. (2007)

Response and treatment times
- Onset of CA to arrival of the first responder = 6.2±7.5 min
- Onset of CA to defibrillation = 12.6±12.0 min
- Onset of CA to ROSC = 20.8±17.5 min

96/186 (52%) were in ‘shock’ (SBP <90 for 30 min with Hr > 100)

171/186 (92%) were mechanically ventilated at time of CCL

Mean time from onset of STEMI to angiography = 199±192 min

34/186 (18%) received mild hypothermia (since 2003)

Circulation 2007;115(11): 1354-62
Coronary Angiography
Post Resuscitation for STEMI

Garot et al. (2007)

103/186 (55%) survived to hospital discharge
  - DC at 18.2±14.1 days post admit

- Among all survivors:
  89/103 (86%) were CPC 1 (good cerebral function)
  10/103 (10%) were CPC 2 (some disability)
  4/103 (4%) were CPC 3 or 4 (severe disability)

Circulation 2007;115(11): 1354-62
Coronary Angiography
Post Resuscitation for STEMI

Garot et al. (2007)

- 83/186 (45%) expired in hospital
  - 39/83 (47%) from severe hemodynamic instability
  - 30/83 (36%) from anoxic cerebral damage
    - No difference between with/without hypothermia
      - 6/34 (18%) with hypothermia
      - 24/154 (16%) without hypothermia

- 10/83 (12%) recurrent and refractory cardiac arrest

- 4/83 (5%) are unaccounted for in this report

Circulation 2007;115(11): 1354-62
Coronary Angiography
Post Resuscitation for STEMI

Garot et al. (2007)

- 100/186 (54%) were alive at 6 months
  - all three post discharge deaths were from CHF

Circulation 2007;115(11): 1354-62
Coronary Angiography
Post Resuscitation for STEMI

Garot et al. (2007)

<table>
<thead>
<tr>
<th></th>
<th>Survivors</th>
<th>Non-Surv</th>
<th>“p”</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA in Public place</td>
<td>73%</td>
<td>40%</td>
<td>.0001</td>
</tr>
<tr>
<td>CA to 1st responder</td>
<td>2.1±2.4</td>
<td>10.5±8.6</td>
<td>.0001</td>
</tr>
<tr>
<td>CA to Defib</td>
<td>5.4±5.0</td>
<td>20.5±12.4</td>
<td>.0001</td>
</tr>
<tr>
<td>CA to ROSC</td>
<td>9.6±9.2</td>
<td>32.9±16.3</td>
<td>.0001</td>
</tr>
<tr>
<td>Shock on admit</td>
<td>32%</td>
<td>74%</td>
<td>.0001</td>
</tr>
<tr>
<td>LVEF</td>
<td>40±12%</td>
<td>31±9</td>
<td>.0001</td>
</tr>
<tr>
<td>No reflow</td>
<td>5%</td>
<td>6%</td>
<td>NS</td>
</tr>
<tr>
<td>Peak TpI</td>
<td>126±319</td>
<td>127±200</td>
<td>NS</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>15%</td>
<td>21%</td>
<td>NS</td>
</tr>
</tbody>
</table>

Circulation 2007;115(11): 1354-62
Coronary Angiography
Post Resuscitation for STEMI

Garot et al. (2007)

- No data on bystander CPR (assumed minimal if at all)
- Mean time from alert (911) to arrive of 1st responder was 10 min
- All were taken from field directly to CCL “after hemodynamic recovery and stabilization”
- Cardiac catheterization and angiography was performed in all patients at the time of hospital admission. Neurological function prior to catheterization was not reliable nor evaluated due to either medications or post resuscitation coma.

Circulation 2007;115(11): 1354-62
1° PCI and Mild Hypothermia in Comatose Survivors of VF with STEMI

- Knafelj et al. (2007)
  - N = 72;
    - all were comatose after resuscitation post STEMI
  - 40/72 (56%) received mild Hypothermia
  - 32/72 (44%) did not receive Hypothermia

- Survival- All
  - Hosp DC 61%
    - CPC 1 or 2 38%
  - 6 month 54%
    - CPC 1 or 2 38%

Resuscitation 2007;74:227-234
### Survival Post Cardiac Arrest After Early Coronary Angiography/PCI

<table>
<thead>
<tr>
<th>Author/Date</th>
<th>Surv to DC</th>
<th>Good Neuro among Survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kahn 1995</td>
<td>6/11</td>
<td>4/6</td>
</tr>
<tr>
<td>Spaulding 1997</td>
<td>32/84</td>
<td>30/32</td>
</tr>
<tr>
<td>Borger van der Berg 2003</td>
<td>39/42</td>
<td>NA</td>
</tr>
<tr>
<td>Keelan 2003</td>
<td>11/15</td>
<td>9/11</td>
</tr>
<tr>
<td>Bendz 2004</td>
<td>29/40</td>
<td>NA</td>
</tr>
<tr>
<td>Quintero-Moran 2006</td>
<td>18/27</td>
<td>NA</td>
</tr>
<tr>
<td>Gorjup 2007</td>
<td>90/135</td>
<td>72/90</td>
</tr>
<tr>
<td>Garot 2007</td>
<td>102/186</td>
<td>88/102</td>
</tr>
<tr>
<td>Richling 2007</td>
<td>24/46</td>
<td>22/24</td>
</tr>
<tr>
<td>Pleskot 2008</td>
<td>14/20</td>
<td>11/14</td>
</tr>
<tr>
<td><strong>Totals:</strong> n= 606 pts</td>
<td><strong>365/606</strong> (60%)</td>
<td><strong>236/279</strong> (85%)*</td>
</tr>
</tbody>
</table>

* Includes both conscious and comatose pts upon arrival at the cath lab
What If Emergent PCI was combined with Therapeutic Hypothermia Post Cardiac Arrest?
Combined TH and PCI Post Resuscitation

- Can it be done?
  - Logistics of such in the “90 min Door to Reperfusion” era?

- Should it be done?
  - Is it efficacious?
**Combined TH and PCI Post Resuscitation**

- Can it be done?
  - YES!
  - Start cooling immediately upon arrival at the ED or Hospital. Often temperature is reaching goal (33±1 °C) prior to beginning the angiogram. Some cooling devices are radiolucent (Artic Sun®) and cooling can continue during the Cath/PCI.
**PCI Combined with Therapeutic Hypothermia for STEMI After Resuscitation**

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Survival to Hosp DC</th>
<th>Survivors with Intact CNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hovdenes 2007</td>
<td>50</td>
<td>41/50 (82%)</td>
<td>34/41 (83%)</td>
</tr>
<tr>
<td>Knafelj 2007</td>
<td>40</td>
<td>30/40 (75%)</td>
<td>22/30 (73%)</td>
</tr>
<tr>
<td>Wolfrum 2008</td>
<td>16</td>
<td>12/16 (75%)</td>
<td>11/12 (92%)</td>
</tr>
</tbody>
</table>

**Total:** n = 106 83/106 (78%) 67/83 (81%)*

* = all were comatose prior to cath/PCI
Is Combining TH with PCI More Efficacious?

- PCI alone vs PCI plus TH
  - Survival:
    - 60% vs 78%; p=0.0004
  - Good Neuro function of survivors:
    - 85% vs 81%; p=0.23 (NS)

Survival Improved…

Neuro Status of Survivors not different…
Clinical Application

- **Therapeutic Hypothermia:**
  - Immediate initiation of cooling for any cardiac arrest victim resuscitated, but still comatose

- **Coronary Angiography/PCI:**
  - Resuscitated patients with STEMI on ECG
    - Yes!
  - Resuscitated patients without STEMI on ECG
    - Yes/No? Less certain but Probably
    - Remember can’t always tell by 12 lead ECG post resuscitation who has an occluded coronary vessel!
Immediate Coronary Angiography Post Resuscitation

- Resuscitated patients with STEMI on ECG
  ➢ Yes!

- Resuscitated patients without STEMI on ECG
  ➢ Yes/No Unknown but Probably

• Can be done (safe), but should it be done?
We are doing just that at the UofA Sarver Heart Center in Tucson, Arizona.

Here’s an example of why!
40 yr old male

- Athletic swimmer collapsed in shower post work out
- Continuous Chest Compression BLS begun immediately by bystander
- AED brought w/i 5 min and 2 shocks given
- Pulse present on EMS arrival, but comatose
Initial EKG in Emergency Department
Post Resuscitation from OOH VFCA
Immediate Angiography/PCI or NOT?

- Stat ED echocardiographic exam: decreased anterior wall motion
- Decision was then made to take to the CCL
- Mild therapeutic hypothermia started while in the ED
Echo after PCI: LVEF = 20%

Warmed up after 24 hours

COMPLETELY NORMAL CNS Function

Discharged 5 days later

Business trip the following week
Repeat Echo 6 weeks later:

LVEF = 45-50% with minimal septal hypokinesis
Brian Duffield, patient of Dr. Kern’s at the University of Arizona Sarver Heart Center treated with all three aspects of Cardiocerebral Resuscitation.
Brian Duffield,
Finishing the 3 mile Rough Water Swim in the Pacific Ocean on Sept 9, 2007.

16 months after being resuscitated from out-of-hospital cardiac arrest and then receiving therapeutic hypothermia and early cath/PCI.
Brian and Carolyn Duffield at the AHA Heart Ball, Tucson, Arizona February 2, 2008.

Brian was the Guest of Honor and spoke about his experience with Sudden Cardiac Death.
Aggressive Post Resuscitation Care is the Next Great Opportunity to Improve Long-term Survival Post Cardiac Arrest

Norwegians doubled their survival with aggressive Post Care…

Could You?
Immediate Percutaneous Coronary Intervention Can Improve Outcomes During and Post Resuscitation Particularly When Combined With Mild Therapeutic Hypothermia