The Fifth Link in the “Chain of Survival” Concept after Cardiac Arrest

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Disclosure

The speaker declares no financial conflicts of interest
The Fifth Link in the “Chain of Survival” Concept after Cardiac Arrest

1. Case

2. The fifth (final) link of chain of survival

3. Recent evidences
Case

One day in spring, 2008
58 male  Sudden cardiac arrest
1: Wife immediately called EMS (119)
2: Started chest compression
3: EMS performed defibrillation (still vf)
4: Adrenaline IV

**Took more than 150 min before return of spontaneous circulation**

What else could we do for him?
Chain of Survival Concept

Resuscitation Science

Continuous Improvements in “Chain of Survival” Increased Survival After Out-of-Hospital Cardiac Arrests
A Large-Scale Population-Based Study

Taku Iwami, MD, PhD; Graham Nichol, MD, MPH; Atsushi Hiraide, MD, PhD; Yasuyuki Hayashi, MD, PhD; Tatsuya Nishiuchi, MD; Kentaro Kajino, MD, PhD; Hiroshi Morita, MD, PhD; Hidekazu Yukioka, MD, PhD; Hisashi Ikeuchi, MD, PhD; Hisashi Sugimoto, MD, PhD; Hiroshi Nonogi, MD, PhD; Takashi Kawamura, MD, PhD

Circulation. 2009;119:728-734
History of the “chain of survival“ concept

  Early access, early CPR and early defibrillation: Cry of the 1988 Conference on Citizen CPR.

  Chain of Survival concept takes hold.
Improving Survival From Sudden Cardiac Arrest: The "Chain of Survival" Concept

A Statement for Health Professionals From the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association

CHAIN of SURVIVAL

Figure 1. Sequence of events in emergency cardiac care is displayed schematically by "chain of survival" metaphor.
Epidemiology of Post–Cardiac Arrest Syndrome

• The median survival time of patients who died after ROSC was 1.5 days.

• In-hospital mortality rates were 72% for patients with ROSC and 65% for patients admitted to the hospital.

• In Japan, 1 study reported that patients with ROSC after witnessed out-of-hospital cardiac arrest of presumed cardiac origin had an in-hospital mortality rate of 90%.
post-resuscitation care
Post-cardiac arrest care

- Management of patients following cardiac arrest is challenging

  Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication.
  *Circulation 2010*

- Early arterial hypotension is common, and is associated with increased mortality

  Postresuscitation myocardial dysfunction: correlated factors and prognostic implications
  *Intensive Care Medicine 2007*

- Pulmonary dysfunction after cardiac arrest is also common

  2010 American Heart Association guidelines. *Circulation 2010*
Treatments for post-cardiac arrest syndrome

- Brain
- Heart
- Lung
- Liver & Gut
- Kidney

- Coma
- Shock
- Respiratory failure
- Liver failure
- Renal failure

- Temperature management
- Coronary intervention
- Intensive Care
Case

One day in spring, 2008
58 male suddenly lost his consciousness

1: Wife immediately called 911
2: Started chest compression
3: EMS performed DC (still vf)
4: Adrenaline IV

Took more than 150 min before return of spontaneous circulation

What else could you do for him?
Clinical Question:

“Can we treat all post-cardiac arrest syndrome patients in this region at this ICU?”

“Could these treatments be performed outside the ICU?”

vasopressors
- Dopamine
- Dobutamine
- Noradrenaline
- Vasopressin
- Milrinone

ECMO

Intra-Aortic Balloon Pumping

Intensive Care + Therapeutic Hypothermia
Large inter-hospital variations in outcomes

Clinical paper

Inter-hospital variability in post-cardiac arrest mortality

Brendan G. Carr, Jeremy M. Kahn, Raina M. Merchant, Andrew A. Kramer, Robert W. Neumar

Heart rhythm disorders

Hospital characteristics are associated with patient outcomes following out-of-hospital cardiac arrest

Dion Stub, Karen Smith, Janet E Bray, Stephen Bernard, Stephen J Duffy, David M Kaye

DOI 10.1007/s00134-008-1353-x

A national analysis of the relationship between hospital factors and post-cardiac arrest mortality
Regional care system

A National Evaluation of the Effect of Trauma-Center Care on Mortality

Ellen J. MacKenzie, Ph.D., Frederick P. Rivara, M.D., M.P.H.,
Gregory J. Jurkovich, M.D., Avery B. Nathens, M.D., Ph.D.,
Katherine P. Frey, M.P.H., Brian L. Egleston, M.P.P., David S. Salkever, Ph.D.,
and Daniel O. Scharfstein, Sc.D.

Health Services and Outcomes Research

A Regional System to Provide Timely Access to Percutaneous Coronary Intervention for ST-Elevation Myocardial Infarction

Timothy D. Henry, MD; Scott W. Sharkey, MD; M. Nicholas Burke, MD; Ivan J. Chavez, MD;
Kevin J. Graham, MD; Christopher R. Henry, BS; Daniel L. Lips, MD; James D. Madison, MD;
Katie M. Menssen, BA; Michael R. Mooney, MD; Marc C. Newell, MD;
Wes R. Pedersen, MD; Anil K. Poulose, MD; Jay H. Traverse, MD; Barbara T. Unger, RN;
Yale L. Wang, MD; David M. Larson, MD
The concentration of post–cardiac arrest patients in regional centers may improve outcome (this is not yet proven) and should help to facilitate research.
The New Chain of Survival Concept

Target: Post-resuscitation period

Advanced intensive care & Therapeutic hypothermia
Aizu Chain of Survival Concept Campaign

New Regional System of Care for Out-of-Hospital Cardiac Arrest

Registered with the University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR ID:UMIN000001607) on January 1st, 2009

Fifth link: Multidisciplinary post-resuscitation care
The Fifth Link: Akabeko

Legendary cow:
Helps sick people and brings peace to the region
Fukushima Prefecture, Japan

Aizu region

12 emergency hospitals
1 tertiary care hospital
11 non-tertiary care hospitals

suburban/rural area with 300,000 residents
Post-resuscitation management

- A bolus infusion of 2000 mls chilled bicarbonate Ringer’s solution (Bicarbone; Ajinomoto, Tokyo, Japan) was given immediately after the ROSC.

- The Arctic Sun (Medivance, Inc., Louisville, CO, USA was used as the cooling device.

- Patient kept between 32 and 34°C for 24–48 h.

- Percutaneous coronary intervention
Advanced hemodynamic monitoring system
The PiCCO® system

Central Venous Catheter

PiCCO® catheter

thermodilution curve

Injection

$-T_b$
The precision of PiCCO measurements in hypothermic post-cardiac arrest patients.

Results
Outcomes

1 month favorable neurological outcome

All OHCA patients in the region:
CPC 1&2: 0.5% → 3.0%, P< 0.0001
Odds ratio = 5.8 (95% CI: 2.0 ~ 17.0)

Among witnessed ventricular fibrillation patients:
CPC 1&2: 7.9% → 26.2%, p = 0.03
Odds ratio = 4.1 (95% CI: 1.1 ~ 16.2)

Among survivors:
CPC 1&2: 19% → 51%, p = 0.01
Favorable neurologic outcome, %

Transition period

Before the Campaign

After the Campaign

Segmented regression analysis
Base line increase
3.4 %,  P = 0.04
<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (&lt;75)</td>
<td>10.2 (1.9–55.1)</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>0.42 (0.11–1.8)</td>
</tr>
<tr>
<td>EMS dispatch-to-scene</td>
<td>1.1 (0.90–1.3)</td>
</tr>
<tr>
<td>Collapse-to-ROSC</td>
<td>1.0 (0.97–1.0)</td>
</tr>
<tr>
<td>Pre-hospital ROSC achieved</td>
<td>11.2 (2.1–62.1)</td>
</tr>
<tr>
<td>First link: Witness-to-911</td>
<td>0.85 (0.70–1.1)</td>
</tr>
<tr>
<td>Second link: Bystander CPR performed</td>
<td>3.1 (0.70–14.2)</td>
</tr>
<tr>
<td>Third link: Pre-hospital AED performed</td>
<td>14.7 (3.2–67.0)</td>
</tr>
<tr>
<td>Fourth link: EMS dispatch-to-ACLS</td>
<td>1.0 (0.99–1.1)</td>
</tr>
<tr>
<td>Fifth link: Study period (after campaign)</td>
<td>7.8 (1.6–39.0)</td>
</tr>
</tbody>
</table>
Implementation of the Fifth Link of the Chain of Survival Concept for Out-of-Hospital Cardiac Arrest

Takashi Tagami, MD, PhD; Kazuhiko Hirata, MD; Toshiyuki Takeshige, MD, PhD; Junichiroh Matsui, MD, PhD; Makoto Takinami, MD, PhD; Masataka Satake, MD; Shuichi Satake, MD; Tokuo Yui, MD; Kunihiro Itabashi, MD; Toshio Sakata, MD; Ryoichi Tosa, MD; Shigeki Kushimoto, MD, PhD; Hiroyuki Yokota, MD, PhD; Hisao Hirama, MD
Recent evidences of the “final link”
Part 9: Post Cardiac Arrest Care: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Mary Ann Peberdy, Clifton W. Callaway, Robert W. Neumar, Romergrnyko G. Geocadin, Janice L. Zimmerman, Michael Donnino, Andrea Gabrielli, Scott M. Silvers, Arno L. Zaritsky, Raina Merchant, Terry L. Vanden Hoek and Steven L. Kronick

_Circulation_ 2010;122:S768-S786

DOI: 10.1161/CIRCULATIONAHA.110.971002
Aizu Chain of Survival Concept Campaign
Registered with the University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR ID: UMIN000001607) on January 1, 2009

2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care
Published October 2010

Circulation. 2010;122:S768-786

Circulation. 2012;126:589-597
Defibrillation sequence:

- 200J
- 300J
- 360J

Simplifying and Specializing Hands-only CPR
Regional Systems of Care for Out-of-Hospital Cardiac Arrest
A Policy Statement From the American Heart Association

Graham Nichol, MD, MPH, FAHA, Chair; Tom P. Aufderheide, MD, FAHA; Brian Eigel, PhD; Robert W. Neumar, MD, PhD; Keith G. Lurie, MD; Vincent J. Bufalino, MD, FAHA; Clifton W. Callaway, MD, PhD; Venugopal Menon, MD, FAHA; Robert R. Bass, MD; Benjamin S. Abella, MD, MPhil; Michael Sayre, MD; Cynthia M. Dougherty, PhD, FAHA; Edward M. Racht, MD; Monica E. Kleinman, MD; Robert E. O’Connor, MD; John P. Reilly, MD; Eric W. Ossmann, MD; Eric Peterson, MD, MPH, FAHA; on behalf of the American Heart Association Emergency Cardiovascular Care Committee; Council on Arteriosclerosis, Thrombosis, and Vascular Biology; Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation; Council on Cardiovascular Nursing; Council on Clinical Cardiology; Advocacy Committee; and Council on Quality of Care and Outcomes Research

Community Approaches to Improve Resuscitation After Out-of-Hospital Sudden Cardiac Arrest

Thomas D. Rea, MD, MPH; Richard L. Page, MD

Circulation 2010;121;1134-1140
Implementation of the Fifth Link of the Chain of Survival Concept for Out-of-Hospital Cardiac Arrest

Takashi Tagami, MD, PhD; Kazuhiko Hirata, MD; Toshiyuki Takeshige, MD, PhD; Junichiroh Matsui, MD, PhD; Makoto Takehiki, MD, PhD; Masataka Satake, MD; Shuichi Satake, MD; Tokuo Yui, MD; Kunihiko Itabashi, MD; Toshio Sakata, MD; Ryoichi Tosa, MD; Shigeki Kushimoto, MD, PhD; Hiroyuki Yokota, MD, PhD; Hisao Hirama, MD
Statewide Regionalization of Postarrest Care for Out-of-Hospital Cardiac Arrest: Association With Survival and Neurologic Outcome

Daniel W. Spaite, MD*; Bentley J. Bobrow, MD; Uwe Stolz, PhD, MPH; Robert A. Berg, MD; Arthur B. Sanders, MD; Karl B. Kern, MD; Vatsal Chikani, MPH; Will Humble, MPH; Terry Mullins, MBA; J. Stephan Stacpynski, MD; Gordon A. Ewy, MD; for the Arizona Cardiac Receiving Center Consortium†

*Corresponding Author. E-mail: dan@aemrc.arizona.edu.

Statewide system of cardiac receiving centers and EMS bypass was independently associated with increased overall survival and favorable neurologic outcome.
Conclusions: Active post-resuscitation care resulted in significantly improved outcomes in adult OHCA patients with a presumed cardiac etiology in a nationwide, retrospective, observational study. These findings might support the systemic inclusion of the fifth link in the chain of survival to improve the outcomes of OHCA.
Impact of case volume on outcome and performance of targeted temperature management in out-of-hospital cardiac arrest survivors

Seung Joon Lee, MD, Kyung Woon Jeung, MD, PhD, Byung Kook Lee, MD, PhD, Yong Il Min, MD, PhD, Kyu Nam Park, MD, PhD, Gil Joon Suh, MD, PhD, Kyung Su Kim, MD, Gu Hyun Kang, MD, for the Korean Hypothermia Network (KorHN) Investigators

Adverse events during targeted temperature management in propensity score-matched cohort

<table>
<thead>
<tr>
<th>Adverse Event</th>
<th>Low volume (n = 289)</th>
<th>High volume (n = 289)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overcooling</td>
<td>70 (24.2)</td>
<td>53 (18.3)</td>
<td>.084</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>37 (12.8)</td>
<td>53 (18.3)</td>
<td>.066</td>
</tr>
<tr>
<td>Hypokalemia</td>
<td>70 (24.2)</td>
<td>82 (28.4)</td>
<td>.257</td>
</tr>
<tr>
<td>Hyperglycemia</td>
<td>173 (59.9)</td>
<td>103 (35.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Bleeding</td>
<td>19 (6.6)</td>
<td>8 (2.8)</td>
<td>.030</td>
</tr>
<tr>
<td>Hypotension</td>
<td>126 (43.6)</td>
<td>85 (29.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Seizure</td>
<td>97 (33.6)</td>
<td>78 (27.0)</td>
<td>.085</td>
</tr>
<tr>
<td>Hyperthermia</td>
<td>39 (13.5)</td>
<td>24 (8.3)</td>
<td>.045</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>20 (6.9)</td>
<td>15 (5.2)</td>
<td>.383</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>27 (9.3)</td>
<td>22 (7.6)</td>
<td>.455</td>
</tr>
</tbody>
</table>

Data are presented as n (%).

Higher TTM case volume was significantly associated with early initiation of TTM and lower incidence of adverse events.
Resuscitation 83 (2012) 1338–1342

Clinical paper

Regionalisation of out-of-hospital cardiac arrest care for patients without prehospital return of spontaneous circulation

Won Chul Cha\textsuperscript{a,e}, Seung Chul Lee\textsuperscript{b,g,e}, Sang Do Shin\textsuperscript{c,g}, Kyoung Jun Song\textsuperscript{d,g}, Ae Jin Sung\textsuperscript{e}, Seung Sik Hwang\textsuperscript{f,g}

Higher rate of survival in high-volume center
• Analysis of 87 Austrian intensive care units data over a period of 13 years
• A high frequency of postcardiac-arrest care at an intensive care unit can improve the outcome of cardiac-arrest patients

Clinical paper

Emergency Department inter-hospital transfer for post-cardiac arrest care: Initial experience with implementation of a regional cardiac resuscitation center in the United States

Brian W. Roberts\textsuperscript{a}, J. Hope Kilgannon\textsuperscript{a}, Jessica A. Mitchell\textsuperscript{a}, Neil Mittal\textsuperscript{a}, Janah Aji\textsuperscript{b}, Michael E. Kirchhoff\textsuperscript{a}, Sergio Zanotti\textsuperscript{c}, Joseph E. Parrillo\textsuperscript{b,c}, Michael E. Chansky\textsuperscript{a}, Stephen Trzeciak\textsuperscript{a,c,*}

\textsuperscript{a} Department of Emergency Medicine, Cooper University Hospital, Camden, NJ, USA
\textsuperscript{b} Department of Medicine, Divisions of Cardiology, Cooper University Hospital, Camden, NJ, USA
\textsuperscript{c} Critical Care Medicine, Cooper University Hospital, Camden, NJ, USA

Resuscitation 84 (2013) 596–601

• Prospective observational study, USA
• Patients transferred from community ED to a cardiac arrest centers
• One-third of CRC transfers survived with good neurological function.
Tertiary care centers was associated with a higher survival even after adjustment for prognostic factors.

Circ Cardiovasc Qual Outcomes. 2015;8:268-276
Admission to tertiary centres is associated with lower mortality rates after OHCA compared with non-tertiary hospitals.
Take Heart America: A comprehensive, community-wide, systems-based approach to the treatment of cardiac arrest

Crit Care Med 2011; 39:26–33

Charles J. Lick, MD; Tom P. Aufderheide, MD; Robert A. Niskanen, MSEE; Janet E. Steinkamp, MA; Scott P. Davis, MD, FCCM; Susan D. Nygaard, RN; Kim K. Bemenderfer, NREMT-I; Louis Gonzales, EMT-P; Jeffrey A. Kalla, NREMT-P; Sarah K. Wald, BA; Debbie L. Gillquist, EMT-P; Michael R. Sayre, MD; Susie Y. Oski Holm, MPH; Dana A. Oakes, BS; Terry A. Provo, EMT-P; Ed M. Racht, MD; John D. Olsen, MD; Demetris Yannopoulos, MD; Keith G. Lurie, MD

Systems-Based Approach

- Widespread CPR & AED Training
- AEDs in communities
- Public Education

Lay Public

First Responder

Survival

Hospital

Emerging Medical Services (EMS)

- Rapid Response
- Start CPR immediately
- High Performance CPR
- Impedance Threshold Device
- Rapid AED placement

Resuscitation Centers of Excellence
- Therapeutic Hypothermia
- 24/7 Revascularization
- ICDs & Electrophysiology
- Track Outcomes
Take Heart America: A comprehensive, community-wide, systems-based approach to the treatment of cardiac arrest*

Crit Care Med 2011; 39:26–33

Table 4. Inhospital treatment of cardiac arrest patients who survived to hospital admission

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control (n = 106)</th>
<th>Intervention (n = 247)</th>
<th>Odds Ratio With 95% Confidence Intervals</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhospital hypothermia</td>
<td>0 of 37 (0%)</td>
<td>44 of 95 (46%)</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>Cardiac catheterization</td>
<td>8 of 37 (22%)</td>
<td>45 of 95 (47%)</td>
<td>3.26 (1.35–7.87)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Implantable cardiac defibrillator placed</td>
<td>5 of 37 (14%)</td>
<td>24 of 95 (25%)</td>
<td>2.16 (0.72–6.18)</td>
<td>.17</td>
</tr>
</tbody>
</table>

Table 5. Outcome of cardiac arrest patients during control and intervention periods

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Control (n = 106)</th>
<th>Intervention (n = 247)</th>
<th>Odds Ratio With 95% Confidence Intervals</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return of spontaneous circulation prehospital</td>
<td>40 (38%)</td>
<td>116 (47%)</td>
<td>1.46 (0.90–2.40)</td>
<td>.129</td>
</tr>
<tr>
<td>Admitted to intensive care unit</td>
<td>37 (35%)</td>
<td>95 (38%)</td>
<td>1.17 (0.71–1.93)</td>
<td>.551</td>
</tr>
<tr>
<td>Discharged alive from hospital</td>
<td>9 (8.5%)</td>
<td>48 (19%)</td>
<td>2.60 (1.19–6.26)</td>
<td>.011</td>
</tr>
<tr>
<td>Cerebral performance category score</td>
<td>1.63 ± 0.52</td>
<td>1.38 ± 0.70</td>
<td>Not applicable</td>
<td>.341</td>
</tr>
</tbody>
</table>
A system-wide approach from the community to the hospital for improving neurologic outcomes in out-of-hospital cardiac arrest patients

Won Sook Hwang\textsuperscript{a,b}, Jong Su Park\textsuperscript{c}, Su Jin Kim\textsuperscript{c}, Yun Sik Hong\textsuperscript{c}, Sung Woo Moon\textsuperscript{c} and Sung Woo Lee\textsuperscript{c}

Box 1: Five major CPR delivery enhancements

| (1) Early EMS activation (time interval from identification or witness of arrest to EMS call \(\leq 1\) min) |
| (2) Bystander CPR with or without dispatcher assistance |
| (3) Appropriate use of AED at the prehospital level: documentation of arrest rhythm and attempts of defibrillation, if indicated |
| (4) Delivery of high-quality ACLS at the ED (CPR with capnography or ECPR for cases of refractory arrest and rearrest at the ED) |
| (5) Standard PCAC at the ICU (successful TH in patients with coma, normothermia for alert patients, or immediate CAG for presumed cardiac etiology) |


Therapeutic hypothermia: \(3.7\%\) vs. \(34.4\%\)

Coronary angiography: \(61.5\%\) vs. \(87.1\%\)

Good neurologic outcome: \(3.3\%\) vs. \(8.5\%\)
Changes in therapeutic hypothermia and coronary intervention provision and in-hospital mortality of patients with out-of-hospital cardiac arrest: A nationwide-database study

Tagami et al. *Critical Care Medicine* 2015 in-press

- Japanese in-hospital nation-wide database
- 385 hospitals, 5 years, 3413 Cardiogenic OHCA due to vf.
- multiple propensity score analysis
Case

58 male
Suddenly lost his consciousness

1: Wife immediately called 911
2: Started chest compression
3: EMS performed DC (still vf)
4: Adrenaline IV

Took more than 150 min before return of spontaneous circulation
The “fifth link” is started after the first 4 in the chain.

Response to Letter Regarding Article, “Implementation of the Fifth Link of the Chain of Survival Concept for Out-of-Hospital Cardiac Arrest”  
Conclusions

Several recent evidences suggest that implementation of the fifth (final) link in the “Chain of Survival” is associated with significant and important improvements in survival and favorable neurologic outcome.