EMS and STEMI
The Evolution of a Major Paradigm Shift

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Disclosures

• Participated in cardiac research studies and received speakers/consulting honorariums:
  – Tenecteplase (Genentech)
  – Eptifibatide (Millenium)
  – Enoxaparin (Aventis)
  – Bivalirudin (Medicines Co.)
• Member
  – ACC D2B Alliance Steering Committee
  – AHA Mission Lifeline Emergency Cardiac Care Committee
• Neutral Observer vs. Passionate Preacher
  promoting a major Paradigm Shift

Lecture Outline

• 1970-2005
• 2006 Institute of Medicine Report
• 2006 ACC D2B Alliance
• 2006 STEMI Receiving Center Networks
• 2007 Southern California STEMI Consortium
• 2007 AHA Mission: Lifeline
• 2008 PH-ECG Transmission
• 2008 Citizen’s Perspective
• 2008 Starting your own SRC network
• Q & A
So…why is this guy lecturing at NAEMSP?

Because….

1970’s *Emergency!*
Gage and DeSoto

Synergy between TV & Reality
- Dr J. Michael Criley started with a focus on “heart attacks” (1969)
- Paramedic Training Institute in LA
- Exponential growth of EMS across the nation
in Los Angeles

Early 2000’s

• Site investigator for multiple cardiology clinical trials
  – Boston TIMI Group
  – Duke DCRI Group
  – New York CRF Group
• Regularly attend cardiology meetings
  – American College of Cardiology (March)
  – American Heart Association (November)
   • $150 premium professional membership

“PCI is Worth the Wait”
(Jacobs, AK 2003 NEJM 349:798)

Long distance transport for primary angioplasty vs immediate thrombolysis in acute myocardial infarction
Final results of the randomized national multicentre trial—PRAGUE-2
A. Hradilek, P. Radil, J. Vrabc, B. Bhoj,
I. Andraus, J. Dobroz, J. Prochazka, on behalf of the PRAGUE Study Group
Wallis Annenberg Grant
2002-2004

• $3 Million funding to provide 12-lead PH-ECG for the two largest EMS providers in LA county
• 4 Visionary Individuals:
  – Dr Marc Eckstein (LACityFD)
  – Dr Frank Pratt (LACountyFD)
  – Sylvia Beanes (AHA vice president)
  – David Ross (AHA board member)

July 2003 Memo
Dr Eckstein, LAFD

• “Your base hospital may decide to divert the patient with a suspected AMI to a hospital with the capabilities to best treat that patient.”

Implementing a 12-lead Program
(Tom Bouthillet EMT-P, 2002, Zoll website)

• “Hospitals are not listening to EMS… when they perform a 12-lead ECG”
• “It can hard to convince your paramedics that it’s worth their while….”
• “Too many times….they’ve had their ECG thrown on the little silver table next to the patients ED bed…never to be seen again.”
My Psycho-Social Issues

• Jealous of Trauma Systems
  – Prioritized care, Trauma team, pre-registered pts.
• Rage with “EMS Wall Time”
• Rebellious about STEMI Roulette

“Golden Rule” of Ethics

• Treat others as you would like to be treated
  – Fundamental Moral Principle
  – Ethic of Reciprocity
• Helps guide treatment in “Golden Hour” of STEMI care

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Hospital-Based Emergency Care (IOM 2006)

- Over-crowding in the Emergency Dept.
- ED Boarding of admitted patients
- Ambulance Diversions
- Shortage of on-call specialists
EMS at the Crossroads
(IOM 2006)

• EMS is “Fragmented”
• Tremendous variability in Quality
• Lacking national standards
• **EMS needs to be more…**
  – Regionalized
  – Coordinated
  – Accountable

The 4 Silos of STEMI Care
*Patient-EMS-ED-Cardio*

NRMI \(\Rightarrow\) D2B versus Mortality

Odds of in-hospital mortality, Cannon
*CP 2006 JAMA 295:2941*

In-hospital mortality, McNamara RL
*2006 JACC 47:2190, Regardless of St process or risk (N=29,222)*
Primary Percutaneous Coronary Intervention (PCI) is the most complex, multi-disciplinary, and time-sensitive therapeutic intervention in the world of medicine.

- Our process is measured in Minutes
- Our outcomes are measured in terms of Mortality
- Teamwork and smooth Transitions are essential
D2B Alliance Goal

- “To achieve a door-to-balloon (D2B) time of ≤ 90 minutes for at least 75% of non-transfer primary PCI patients with ST-elevation myocardial infarction (STEMI) in all participating hospitals performing primary PCI”

- National baseline about 50% rate D2B ≤ 90
D2B Alliance
Tier-I strategies
1. ED physician activates the cath lab
2. One call activates the cath lab
3. Cath lab team ready in 20-30 minutes
4. Prompt data feedback
5. Senior management commitment
6. Team-based approach
   Optional = Pre-hospital ECG to activate the cath lab

2004 Olympics 100m Sprint
1. USA-Justin Gatlin
2. NGR-Obikwelu Francis
3. USA-Maurice Greene
4. USA-Shawn Crawford

USA Lost!!
2004 Olympics 4x100m Relay
Oops!!
Lessons from Sprint Relay Race Analogy

- Individual superstars can NOT win a relay race without teamwork
- Hand-offs and smooth transitions are critical
- Any member of the relay team can “champion” teamwork… the new role of EMS!
- D2B is a multi-disciplinary team effort!!
  - NOT a turf battle
  - Time is our common enemy
  - “Beat the clock!!”

D2B Alliance Tier-I strategies

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Optional = Pre-hospital ECG to activate the cath lab
Boston EMS
(Moyer, 2004 Crit Path Cardio 3:53)

Implications of the Mechanical (PCI) vs Thrombolytic Controversy for ST Segment Elevation Myocardial Infarction on the Organization of Emergency Medical Services

The Boston EMS Experience

Peter Moyer, MD, MPH, James Fieldman, MD, Jan Lazio, MD, FACP, and friends (2004 Crit Path Cardio 3:53)

Joseph A. Adamson, MD, John E. Golovan, MD, MD, FACP, and friends (2004 Crit Path Cardio 3:53)

Boston EMS

STEMI Receiving Center
(SRC) Networks
(Rokos IC, 2006 AHJ 152:661)

Two types of STEMI Regionalization

Pre-hospital Cardiac Triage (PCT)

• EMS identifies STEMI & transports directly to PCI capable hospital
• Similar to nation’s current trauma system: sick pts = special care

Inter-Hospital Transfer (IHT)

• Spoke hospital identifies STEMI & transfers immediately to PCI hospital
• <50% rate D1B2 ≤ 90 min
• Henry et al, Minneapolis, Circulation August, 2007
• Ting et al, Mayo Program, Circulation August, 2007
• Jollis et al, North Carolina, (RACE) JAMA Nov. 2007

Recent developments have provided a unique opportunity for the organization of regional STEMI receiving center (SRC) networks. These developments have transformed the current model of care for STEMI by developing regional STEMI networks that serve highly selected patients with STEMI. The development of these networks has been driven by the need for better patient care. The improvements in care have been achieved through the development of regional STEMI networks, which involve the use of highly trained and experienced physicians and cardiologists. These networks have demonstrated improved outcomes for patients with STEMI, including reduced mortality rates and shorter hospital stays. The effectiveness of these networks has been demonstrated through various studies, including those conducted in Minneapolis, Mayo Clinic, and North Carolina. The effectiveness of these networks has been further supported by several reports that have highlighted the benefits of implementing regional STEMI networks.
SRC Network Thesis

• The full potential of Pre-hospital Electrocardiograms (PH-ECG) can NOT be realized….
• Unless a regional STEMI system is created which coordinates….
  – Pre-hospital = Emergency Medical Services (EMS)
  – Hospitals = STEMI Receiving Centers
    • Designated primary PCI-capable hospitals

Impact of PH-ECG on D2B prior to SRC network in 2005
(Eckstein, Pratt, Cooper, Nguyen, Abs #176, ACEP.07)

N = 235 at 4 hospitals in LA County
• Retrospective
• If EMS median 95 min, then ≤ 50% rate of D2B ≤ 90 minutes

(1) Key elements of Pre-hospital Cardiac Triage (PCT)

• Pre-Hospital Electrocardiogram (PH-ECG) to identify STEMI
  – Automated Computer Algorithm (on-site)
  – Manual Interpretation by Paramedics (on-site)
  – PH-ECG Transmission so that a physician is responsible for ECG interpretation (off-site)
(2) Key elements of Pre-hospital Cardiac Triage (PCT)

- **Diversion** protocol for regional EMS system
- Cardiac cath lab **accessible** 24/7/365 regardless of ED-diversion status
- **Parallel processing** ⇒ patient transport and cath lab activation occurring simultaneously
- Plan A = PCI, Plan B = Fibrinolytics
- Regional Continuous Quality Improvement (CQI)

Published **single-center** experience
PH-ECG triage and CCL pre-activation

- **Medford, Oregon**
  - N = 81, Jun 03 – Dec 04
  - Gross BW, 2007 AJC 99:1360
- **Ottawa, Ontario, Canada**
  - N = 108, Jul 04 – Jun 05
  - LeMay MR, 2006 AJC 98:1329
- **Beaumont Hosp., Michigan**
  - N = 31, Jan 03 - Oct 05
  - Swor R, 2006 Prehospital Emergency Care 10:374

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Regional STEMI Networks in Southern California Reduce Door-to-Balloon Times: Pooled Data from 4 Counties

Ivan Rokos, MD FACEP

On behalf of the
Southern California STEMI Consortium
October 22, 2007 at TCT.07

Southern California STEMI Consortium Co-authors
- William Koenig MD
- Samuel Stratton MD
- Angelo Salvucci MD
- Bruce Haynes MD
- Franklin Pratt MD
- Marc Eckstein MD
- Ken Miller MD
- Beverly Nighswonger RN
- Greg Boswell RN
- Janet O’Leary RN
- Lynn Tadlock RN
- Benjamin Sun MD
- William French MD
- And MANY others…..

Map of 58 California Counties

Regional STEM Networks
- Ventura Co.
- Los Angeles Co.
- Orange Co.
- San Diego Co.
Ventura County ⇒ 3 SRCs

- SRC network launched **Jan. 2007**
- PH-ECG funding
  - Private Ambulances ⇒ AMR, Gold Coast, and Lifeline
  - Fire Departments ⇒ Ventura City, Ventura County, and Fillmore

Los Angeles County ⇒ 25 SRCs

- SRC network launched **Dec. 2006**
- PH-ECG funding
  - Annenberg Foundation Grant via AHA of $3 Million in 2003
  - LA county Board of Supervisors added $4 Million in 2006

Orange County ⇒ 11 SRCs

- SRC network launched **Feb. 2005**
- PH-ECG funding
  - Initial donation by St Jude Medical Center (Fullerton, CA)
  - Individual Fire Depts. funded acquisition with internal budgets
San Diego County ⇒ 13 SRCs

- SRC network launched Jan. 2007
- PH-ECG funding
  - Initiated by STEMI patient who donated $500,000 to city of SD
  - Three hospitals funded their area Fire Depts.
  - Other EMS providers used internal budgets

Southern California Overview

- 16.8 Million Citizens in 4 Counties
- >4500 Paramedics
- 127 Paramedic-Receiving Hospitals
- 52 of 127 are designated STEMI Receiving Centers (SRCs)

Methods

- All 4 county EMS agencies each have a Continuous Quality Improvement (CQI) data
- Pooled analysis of ALL consecutive patients
  - Pre-hospital-ECG (PH-ECG)+ for STEMI
  - Transported to a designated SRC per protocol
  - Determined the rate of D2B ≤ 90 minutes
  - Data through April 30, 2007
D2B Results

• 909 patients with a PH-ECG+ for STEMI
• 699 of 909 (77%) underwent primary PCI
  – 85% rate of D2B ≤ 90 minutes
    – (82%, 87%) = 95% confidence intervals
    – Range for all 4 counties = 75% to 90%

Results

• 210 of 909 (23%) did NOT receive PPCI.
• This heterogeneous group could NOT be further characterized in this analysis

Raising the Bar on Reperfusion Speed for STEMI

• Door-to-balloon (D2B) time < 90 min
  (Class I-A)
• First Medical contact-to-balloon ≤ 90 min
  (Class I-B)
• ACC/AHA 2004 STEMI Guidelines JACC 44:671
E2B Challenge
EMS-to-Balloon time

- EMS = Emergency Medical Services
- **Time Zero** = Date and Time auto-stamped on first pre-hospital ECG with computer interpretation showing ***acute MI***
- **E2B** builds upon the D2B Alliance
  - Goal of ≥ 75% rate of E2B ≤ 90 Minutes

E2B Results

- 909 patients with PH-ECG+ for STEMI
- 699 of 909 underwent primary PCI
- 331 of 699 (47%) had PH-ECG time recorded
  - **71% rate of E2B ≤ 90 minutes**
    - (65%, 76%) = 95% confidence intervals
    - Range by county = 62% to 75% for 3 counties

30-30-30 Goal
E2B ≤ 90 Conceptual Framework

< 30 minutes for Emergency Med Services (EMS)
< 30 minutes for the Emergency Department (ED)
< 30 minutes for the Cardiac Cath Lab (CCL)
Limitations

• No comprehensive baseline data on rate of D2B ≤ 90 minute in Southern California
• **No resources for auditing source data**
  • Database variation across 4-counties
    – Tracking pre-hospital ECG time
    – Tracking PH-ECG+ patients without PCI
• **No clinical outcomes data reported**

Conclusions

Regional STEMI Networks

• **85% rate of D2B ≤ 90 minutes (N =699)** across 4 counties in Southern California
  – A metro region with 16.8 million citizens
  – 52 designated STEMI Receiving Centers
  – Pre-hospital Cardiac Triage focus
• SRC networks exceed the **D2B Alliance** benchmark of 75% rate of D2B ≤ 90 minutes
• **71% rate of E2B ≤ 90 minutes (N=331)**

AHA Mission: Lifeline
Launched May 30, 2007
11 Articles from Task Force
AHA Mission: Lifeline

• Quickly activating the appropriate chain of events critical to opening a blocked artery to the heart that is causing a heart attack
  – Patients recognize symptoms early
  – Call 9-1-1
  – Regional systems of care
  – GWTG secondary prevention therapies

AHA Mission: Lifeline

• Focus on increasing the number of patients with timely access to primary PCI
• Inclusive to engage ALL hospitals
  – STEMI Receiving Hospital
  – STEMI Referral Hospital

AHA Mission: Lifeline

Four Simultaneous Directions

• EMS Systems Assessment
• Evaluate Existing Models
• Establish Local Initiatives
• Explore National Certification
  – STEMI Receiving Hospitals
  – STEMI Referral Hospitals
  – Entire Regional STEMI Networks??
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False(+) CCL Activations for Inter-Hospital Transfer
(Larson 2007 JAMA 298:2754)

“False-Positive” Cardiac Catheterization Laboratory Activation Among Patients With Suspected ST-Segment Elevation Myocardial Infarction

Context: Observational, cohort study from the cardiac catheterization laboratory activation among patients with suspected acute coronary syndrome. The primary outcome was 90-day mortality or re-ECG activation following a positive CCL activation for STEMI in patients with a negative ECG.

Objective: To determine the prevalence of false positive cardiac catheterization laboratory activation in patients with suspected acute coronary syndrome.

Methods: A total of 1,440 patients were included in the study. All patients underwent a positive CCL activation for STEMI and were subsequently re-activated for suspected acute coronary syndrome.

Results: Among the 1,440 patients, 9.2% were false positive CCL activations.

Conclusion: False-positive CCL activations for inter-hospital transfer may be common and have significant implications for patient care.

Thinking about Larson’s paper…

?? Concordant Interpretations False+
• Stress cardiomyopathy
• Myocarditis
• Prior MI
• Etc.
• Culprit(-), biomarker(+)

?? Discordant Interpretations False+
• Early Repolarization
• Non-diagnostic ECG
• Pericarditis
• LVH
• Etc.
• Culprit(-), Biomarker(-) in 9.2%
Current PH-ECG Manufacturers

• Medtronic/Physio-Control
• Philips
• Welch Allyn
• Zoll

In 2008, can PH-ECG transmission minimize discordant interpretation false(+) CCL Activations?

Pre-hospital ECG (PH-ECG) Transmission

(STEMIsystems.org, Issue 4, Dec 07)

Optimizing prehospital wireless ECG transmission: new data, new ideas

Adam Landman, MD, MS, MS', Ivan Rokos, MD, MS', William J. French, MD, MS',
Brian Greens, MD, MS'

1Department of Emergency Medicine, Olive View UCLA Medical Center, Los Angeles, CA, USA
2Department of Medicine, Division of Cardiology, Harbor-UCLA Medical Center, Torrance, CA, USA
3The Heart Clinics of Southern California, AE, Whittier, CA, USA

STAT-MI Newark NJ

(Dhruva, 2007 JACC 50:509)

• Medtronic system
• 80 PH-ECG transmitted to cardiology
• 20 patients resulted in Cath Lab Activation
• D2B times (mean) improved
  – 145 minutes D2B in 2005 (N=29)
  – 80 minutes D2B Jun-Dec 2006 (N=20)
• TIME magazine Medicine A-Z 2007
In-TIME Concord, NC
(Adams, GL. 2007 AJC 98:1160)

• Welch Allyn system
• Median times (minutes):
  – D2B = 50 for N=24 with PH-ECG transmit
  – D2B = 78 for N =19 with transmit failure
  – D2B = 96 for N = 101 self-transport STEMI

Escondido CA
**Presented at NAEMSP.06
(Davis, DP, 2007 PHEC 11:399)

• Phase I = 54 EMS activation of cath lab
• Phase 2 = 56 EDP activation of cath lab
• Results of Phase 1 vs. Phase 2
  – Cardiology confirm STEMI: 78% to 96%
  – Disposition for emergent PCI: 70% to 91%
  – Angiographic lesions: 69% to 89%
  – P < 0.01 for all comparisons

CAPTURE Method
(STEMIsystems.org, Issue 4, Dec. 07)

• CAPTURE
  – CAmera
  – Phone
  – Transmission
    and
  – Universal
  – Routing
    of Pre-hospital
  – Electrocardiograms
CAPTURE Method
(STEMIsystems.org, Issue 4, Dec. 07)

CAPTURE Method of Wireless PH-ECG Transmission

| Step 1. Take picture of printed ECG using camera phone |
| Step 2. Send picture via standard cell phone multimedia messaging |
| Step 3. View digital ECG image |

Table 1: Strategies for prehospital electrocardiogram (PH-ECG) interpretation and cardiac catheterization laboratory (CCL) activation. ED: emergency department.

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>PH-ECG Interpretation Prehospital STEMI cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Prehospital physician activates the CCL based on a verbal report from paramedics.</td>
</tr>
<tr>
<td>2.</td>
<td>ED physician activates the CCL based on a written report from paramedics.</td>
</tr>
<tr>
<td>3.</td>
<td>ED physician activates the CCL based on a direct review of the PH-ECG.</td>
</tr>
<tr>
<td>4.</td>
<td>ED physician activates the CCL based on a direct review of the PH-ECG, and then activates the CCL, only if the ED physician agrees with the prehospital interpretation.</td>
</tr>
</tbody>
</table>

CAPTURE Method
(STEMIsystems.org, Issue 4, Dec. 07)

Mt. Bailey, Oregon
In 2008, reflecting on the BIG Issues

- **IOM** = Regionalized, Coordinated, and Accountable
- **ACC** = Quality
- **ACEP** = Access
- **AHA** = Disparities
- **TCT** = Time as a “Therapy”
  - Miracle Drug
  - Magic Device

“9-1-1 provides Timely Access to Quality Care”

...For Time-Critical Medical Conditions to any Citizen who calls 9-1-1 in areas with a regional STEMI network
MITI trial of pre-hospital Lytics
(Weaver, WD 1993 JAMA 270:1211)

- Sx onset-to-Drug
  - ≤ 70min, 1.2% death
  - >70min, 8.7% death
- “It appears that if pts can be identified and treated very early after Sx onset, the infarction process can be essentially aborted”

“The Slope of the Curve”
(Gersh, B 2005 JAMA 293:979)

SRC Networks have the potential to “Time-Terminate” STEMI

Time is the most potent “Therapy” for STEMI
Not just a “Therapeutic Variable”
Starting a STEMI Receiving Center (SRC) Network in your region customized to local issues

2007 ACC/AHA STEMI Guidelines


J. Am. Coll. Cardiol. published online Dec 10, 2007:

2007 ACC/AHA STEMI Guidelines (Item 4, Reperfusion)

• “This committee continues to endorse the concept that faster times to reperfusion and better systems of care are associated with important reductions in morbidity and mortality in pts with STEMI.”
• “An under-utilized but effective strategy for improving systems for care… is to expand the use of PH-ECG’s by EMS.”
In 2008, EMS is the new “consumer” for STEMI Quality

- “EMS will bring your hospital STEMI patients identified by pre-hospital ECG (PH-ECG)”
- “Hospitals will provide EMS agency with data that confirms hospital is providing the highest quality care”
  - D2B ⇒ Door-to-Balloon time
  - E2B ⇒ EMS-to-Balloon time (PH-ECG+ for STEMI)
  - F2B ⇒ First call (911)-to-Balloon time
  - S2B ⇒ Symptom onset-to-Balloon time

STEMI Systems Defined

- Webster’s dictionary ⇒
  - “a regularly interacting or interdependent group of items forming a unified whole”
- In an Organized System ⇒
  - Good clinicians can Excel
  - Average clinicians still do the Right Thing.

Rapid Reperfusion “Tripod” of Success

[Diagram of Rapid Reperfusion “Tripod” of Success]
Paradigm Shift in California …and STEMI care

“Make my Day” “Have a Nice Day”

Can you see the STEMI solution now?

The STEMI Train…Always on Time

Conclusion

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