Systems Approach to STEMI

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What is the best treatment for ST elevation myocardial infarction?
Case Study

64 yo male

Onset of severe central chest pain
“like indigestion, only a whole lot worse”
Nausea, diaphoresis

Onset at 0620 after sitting up to get out bed
Case Study

Calls the QAS who administer $O_2$, anginine and aspirin

Arrives at country hospital ER 0700

VF arrest on arrival

Prompt cardioversion to SR
Case Study
Case Study
21.81% chest pain admitted to monitored beds in Acute Care Facilities in Australia

Managing STEMI

- Occluded artery
- Thrombolytic therapy
- Balloon angioplasty
- Stent placement

Goals:
- Reestablish coronary patency
- Salvage myocardium
- Improve survival
Time Is Muscle
Wave-front of Necrosis marches on!
What is the best strategies for achieving myocardial perfusion
Frequency of Optimal Reperfusion

- 90-min patency: 85%
- 60-min patency: 75%
- TIMI grade 3 flow: 57%

No myocardial perfusion: 23%
Intermittent patency: 34% → 44%
Reocclusion: 13% → 29%

25%

Lincoff and Topol: Circ, 1993
20-30% of patients are ineligible for thrombolytics due to bleeding risk.
Initial Thrombolytic regimens have the following limitations:

- Failure to achieve patency in 15 – 20% of patients; and
- Failure to achieve normal (TIMI Grade III) flow in 40 – 50%
- 5 - 15% greater reocclusion
- A finite risk of intracranial haemorrhage
Systems Approach to STEMI

Meta-Analysis of 23 Randomized Trials of PCI vs Lysis (n=7739)

Keeley, Lancet 2003
Trends in STEMI Rx in GRACE

N=44,372 ACS Patients
113 Hospitals, 14 Countries

- Lytic: 49.5% (1999) vs 27.8% (2005) with P<0.001
- Primary PCI: 52.7% (2005)
- CABG: 3.2% (1999) vs 2.7% (2005)
- No Reperfusion: 34.1% (1999) vs 28.6% (2005)

Fox. JAMA 2007;297:1892-1900.
Some Realities

- Primary PCI is the preferred reperfusion strategy
- Acute care hospitals in US = 4927
  - Rural hospitals in US = 2178
  - % with PCI capability = 4%
- Cath labs in US = 2200
  - PCI capable = 1200
- 75% patients present to non PCI centers
- In Qld <15% patients with STEMI receive PCI
- In Australia significant variation in referral for invasive services (20% ➞ 66%)
- 70% of patients with contraindications to fibrinolytics do not receive primary PCI.

Some Realities

► Limited access to PCI
► Likelihood of undergoing angiography revascularization

• Intervention vs non interventional (non metropolitan) centre is 7:1

Some Realities

► CABG is rare in treatment of Acute STEMI
► A significant proportion (1/3) of patients receive no reperfusion therapy
Regionalized Approach to Managing STEMI

► Can access to PCI services be improved?
DANAMI-2: Management of Major Heart Attack

Presented at ACC 2002 Dr. Henning Rud Andersen
for the DANAMI-2 investigators

Randomised
Thrombolysis
Or
Transfer &
Angioplasty

DENMARK

5.4 mill. inhabitants
5 PCI centers
24 referral hospitals
62% of Danish population
Transport distance up to 95 US miles (mean 35 miles)
## Regionalized PCI

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>OR and 95% CI</th>
<th>Lytic</th>
<th>Transport</th>
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</thead>
<tbody>
<tr>
<td>DANAMI-2</td>
<td>1572</td>
<td>(0.5)</td>
<td>13.7%</td>
<td>8.0%</td>
</tr>
<tr>
<td>PRAGUE-2</td>
<td>825</td>
<td></td>
<td>15.2%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Air PAMI</td>
<td>138</td>
<td></td>
<td>13.6%</td>
<td>8.4%</td>
</tr>
</tbody>
</table>

Transport and PCI Better

Lytic Better
Regionalized Approach to Managing STEMI

- Bypass Model
- Treat and transfer Model
Regionalized Approach to Managing STEMI

STEMI SYSTEMS OF CARE

12 lead ECG

Hospital w/o PCI

Bypass Model

PCI center

From A Jacobs AHA 2007
Systems Approach to STEMI
Systems Approach to STEMI

STEMI Triage Plan and Treatment Strategy

Point of entry:
- 12 lead ECG
- ECG categorised as STEMI or no ST elevation
- Pre hospital notification
- Transfer to a PCI centre
- Receiving centre cannot be on bypass ever
- Non ST elevation chest pain goes to nearest

STEMI SYSTEMS OF CARE

Boston EMS Bypass
STEMI Triage Plan & Treatment Registry

Point of Entry:

- Twelve leads from ECG, or “not ST elevation”
- ECG called “STEMI”, or “not ST elevation”
- Early notification to hospital receiving patient assigned to PCI
- Patient arrives
- Receiving center flag
- “Non-ST elevation” vs. PCI capable or not

Registry/QA
Data center
DSMB

Minimal standards:
( >36 1^0 PCI, >90% cath, d-b <90min)

Systems Approach to STEMI

**STEMI SYSTEMS OF CARE**

**Boston EMS Bypass**

*STEMI Triage Plan & Treatment Registry*

*Median Door-to-Balloon Time*

- July 2003 to Nov 2003: 91.0 min
- Year Ending Dec 2004: 83.5 min
- Year Ending Dec 2005: 73 min
- Year Ending Dec 2006: 67.5 min
Systems Approach to STEMI

- Sydney
  - Salami Model
  - ETAMI Model
Regionalized Approach to Managing STEMI
Systems Approach to STEMI

STEMI SYSTEMS OF CARE

Hospital Transfer: Twin Cities Program

- Red: Zone II (90-120 mins)
- Blue: Zone I (< 90 mins)

- 60 - 210 miles
- < 60 miles
**STEMI Systems of Care**

Twin Cities Pilot: Integrated Transfer Program

- standardized treatment protocol
- training of all personnel
- tool kits with check lists, transfer forms, standing orders, adjunctive meds
- comprehensive feedback and quality assurance plan

## Systems Approach to STEMI

**Stemi Systems of Care**

Minneapolis Heart Institute

**Median Door-to-Balloon Time**

<table>
<thead>
<tr>
<th></th>
<th>Door 1-Balloon (min)</th>
<th>Sx-Balloon (min)</th>
<th>30 Day Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI Center N=297</td>
<td>65</td>
<td>4.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Zone 1 N=627</td>
<td>171</td>
<td>95</td>
<td>5.7</td>
</tr>
<tr>
<td>Zone 2 N=421</td>
<td>203</td>
<td>120</td>
<td>5.7</td>
</tr>
<tr>
<td>Zone 3 N=421</td>
<td>214</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Up to 360 km away

Systems Approach to STEMI

- Community based National initiative
- Involve Key Stakeholders
- Improve quality of care + outcomes in STEMI
- Improve health care system
- Readiness and response to STEMI.
Some Realities

► Primary PCI is the preferred reperfusion strategy
► Acute care hospitals in US = 4927
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     (% with PCI capability = 4%)
► Cath labs in US = 2200
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75% patients present to non PCI centers
Regionalized Approach to Managing STEMI

Is a PCI only strategy achievable? Perhaps
Regionalized Approach to Managing STEMI

Field triage to primary angioplasty combined with emergency department bypass reduces treatment delays and is associated with improved outcome.

Cartensen S et al
Royal North Shore Hospital


Field triage is a critical ingredient to improve systems of care for STEMI
Systems Approach to STEMI

- Field triage reduces D2B times by an average of 20 mins

  Acquirre, Circulation 2007 et al

- D2B times for field activation rival D2B times achieved when patients present to the ED

  Ong ETAMI
  Cartensen et al 2007 Eur Heart J
Regionalized Approach to Managing STEMI

Perhaps Not
Current Limitations to Implementing Regional STEMI Centers

- > 50% of patients do not use QAS: “walk ups”
- Majority QAS ambulances do not do 12 lead ECG
- Geographic distribution of hospitals
- Prolonged transfer in rural setting
- Financial disincentives for transfer
- Current transfer times are often unacceptable
- Hospital EDs frequently on diversion
Regionalized Approach to Managing STEMI

- Potentially achievable
- Would require investment in $$
- Would require commitment of Clinicians
- Would require unprecedented organization
- Would require Public and Private Collaboration
- Would require Pre hospital diagnosis
How about thrombolysis?

Can we increase access to thrombolysis when PCI is delayed or unavailable?

Improve hospital based systems

- Earlier diagnosis and management in the ED

Time from triage to ECG < 10 mins 55%
Time to thrombolysis < 2h 83%

Time to ECG and troponin is better in smaller centers?
Factors Leading to Delays to Thrombolysis

- delay in patient registration;
- delay in initial evaluation;
- delay in drug preparation;
- request for consultation

THEREFORE consider pre-hospital thrombolysis
Pre Hospital Thrombolysis is both safe and effective

The Supporting Evidence

- Intensive Care Paramedics can accurately identify STEMI on a 12-lead ECG
  (91.5% accuracy compared with opinion of two cardiologists)

- Intensive Care Paramedics can accurately select suitable recipients for thrombolysis
  (89% accuracy compared with opinion of two cardiologists)

- Intensive Care Paramedics can provide timely thrombolysis
  (A potential reduction in “time to needle” of 52 minutes)


Intensive Care Paramedics administering thrombolysis potentially can avert some STEMI deaths.

Prehospital administration of thrombolysis is “good value for money”.

How do we arrive at an integrated strategy for managing STEMI

- Improve access to PCI
  - Right center: high volume experienced operators
  - Right time frame: 70% <90 mins

- Increase access to thrombolysis when PCI is delayed or unavailable
  - Most effective when given early

- Time is muscle
  - Reperfusion must be occur ASAP!
State-wide Systems approach to Reperfusion ??
Queensland Ambulance Service

Integrated Cardiac Reperfusion Strategy
Field Triage

► Direct & timely transport to nearest E.D. with pre-notification.

► Direct & timely transport to nearest P.C.I. facility with pre-notification.

► Paramedic initiated fibrinolysis where appropriate.

► Stakeholder engagement
  - QAS
  - PCI hospitals/ non PCI hospitals
  - Cardiology/ED
  - Public and private sectors
Pre-hospital 12 Lead ECG triage to Pre-Hospital Fibrinolysis and then to Primary Coronary Intervention

Pre-hospital 12 lead ECG confirmed STEMI

From S Rashford with permission
Pre implementation Validation

Contentious areas

- Borderline ST segment changes
- Misdiagnosis of LBBB

Sensitivity: 82%
Specificity: 97%
PPV: 93%
NPV: 92%
<table>
<thead>
<tr>
<th><strong>PARAMEDIC INDICATIONS FOR THROMBOLYSIS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ST elevation $\geq 1$mm in at least two contiguous limb leads and/or $\geq 2$mm in two contiguous precordial leads?</td>
</tr>
<tr>
<td>(Not thrombolysing patients with Bundle Branch Blocks)</td>
</tr>
<tr>
<td>Time from first patient contact to a hospital capable of fibrinolysis is $&gt; 20$ minutes?</td>
</tr>
<tr>
<td>Patient is $&lt; 75$ years of age</td>
</tr>
<tr>
<td>Systolic BP $&lt; 180$</td>
</tr>
<tr>
<td>Diastolic BP $&lt; 110$</td>
</tr>
<tr>
<td>GCS = 15</td>
</tr>
</tbody>
</table>

**All patients eligible for reperfusion must provide informed consent.**
<table>
<thead>
<tr>
<th>Contra-Indications for Thrombolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known allergy to T-PA, heparin of clopidogrel?</td>
</tr>
<tr>
<td>Known structural nervous system disease, in particular intracranial neoplasm?</td>
</tr>
<tr>
<td>Known structural cerebrovascular lesion (eg Arteriovenous malformation)?</td>
</tr>
<tr>
<td>Prior intracranial haemorrhage?</td>
</tr>
<tr>
<td>History of significant closed head/facial trauma within last 3 months?</td>
</tr>
<tr>
<td>Ischaemic stroke or TIA within the last 12 months?</td>
</tr>
<tr>
<td>Suspected aortic dissection?</td>
</tr>
<tr>
<td>History of major trauma or surgery (incl laser eye surgery) within last 6 weeks?</td>
</tr>
<tr>
<td>Internal bleeding within last 6 weeks?</td>
</tr>
<tr>
<td>Bleeding or clotting disorder (haemophilia etc), excluding menses?</td>
</tr>
<tr>
<td>Current anticoagulant therapy (eg warfarin)?</td>
</tr>
<tr>
<td>CPR &gt; 10 mins?</td>
</tr>
<tr>
<td>Known to be pregnant or delivered within the last two weeks?</td>
</tr>
<tr>
<td>Resident of an aged care facility requiring care for daily living and GCS &lt;15?</td>
</tr>
</tbody>
</table>
Key Concepts

- Conservative approach
- STEMI (No to new BBB)
- No telemetry of ECGs
- Strict audit requirements
- If in doubt – do NOT thrombolyse
- If delays to PCI thrombolyse
- Staged role out: stakeholder input
- Can’t go on bypass
- Incremental strategy
Right Hospital,
Right cardiologist and it is **timely**!
What is Door to Balloon?

► Hospitals treating acute STEMI patients with primary PCI should aim to reliably get the patient from triage to reperfusion (balloon angioplasty) in 90 minutes or less.

► This is ‘The Door to Balloon Time’ (D2B)

► AHA benchmark is 75% cases

In-hospital mortality rises with increased D2B times.

3%, 4.2%, 5.7%, 7.4% for D2B times <90, 90-120, 121-150, >150 minutes respectively.

In subgroup analyses, increasing mortality with increasing door-to-balloon time was seen regardless of symptom onset-to-door time (1 h, 1 to 2 h, 2 h) and regardless of the presence or absence of high-risk factors.4

Options for Transport of Patients With STEMI and Initial Reperfusion Treatment

Onset of symptoms of STEMI

9-1-1 EMS Dispatch

EMS on-scene
- Encourage 12-lead ECGs.
- Consider prehospital fibrinolytic if capable and EMS-to-needle within 30 min.

GOALS
- Patient: 5 min.
- EMS: 8 min.
- Dispatch: 1 min.

EMS Transport
- Prehospital fibrinolysis EMS-to-needle within 30 min.
- EMS transport EMS-to-balloon within 90 min.
- Patient self-transport Hospital door-to-balloon within 90 min.

A new benchmark

Antman EM, et al. J Am Coll Cardiol 2008. Published ahead of print on December 10, 2007. Available at http://content.onlinejacc.org/cgi/content/full/j.jacc.2007.10.001. Figure 1.
Prince Charles Hospital

► PCI for ST elevation as dedicated policy during office hours since 2001
► PCI when Interventionist Rostered since 2002
► 24x7 PCI 2005
► District Wide PCI service 2008
Prince Charles Hospital

- Single call
- CCL staff available within 30 mins
- Process of care feedback

- AHA standards
PCI STEMI Management

1997-2007

- Acute STEMI: 798
- Rescue: 167

Age: 60 ± 12 yr
Male: 76.4%
Door to Balloon times

D2B in Hours
- <90 mins: 89%
- <120 mins: 92%

D2B out Hours
- <90 mins: 73%
- <120 mins: 90%
## PCI STEMI Management

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No or Slow reflow</td>
<td>13.7</td>
</tr>
<tr>
<td>VF arrest</td>
<td>9.1</td>
</tr>
<tr>
<td>Urgent Surgery</td>
<td>0.3</td>
</tr>
<tr>
<td>Death in Lab</td>
<td>0.6</td>
</tr>
<tr>
<td>Mortality 30 d</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Outcomes?
Overcome the Barriers
State-wide approach to Reperfusion

- Pre hospital thrombolysis
- PCI Centers: Public
  - TPCH
  - GCH
  - RBWH
Regionalized Approach to Managing STEMI
Implemented 2/2008,

Options for managing appropriate patients with STEMI by QAS Intensive Care Paramedics include:

- Timely admission to a PCI facility (Heparin & Clopidogrel)
- Administer thrombolysis (Tenecteplase with Heparin)
- Transport to a very close ED capable of thrombolysis

QAS ‘Local Work Instructions’ guide Paramedic decision making in particular areas in consultation with cardiologists.
► Paramedic-led decision making
► MD reviews each case suspected STEMI
► MD on call 24:7 for ICP consult if required
Activity Feb ’08 – Feb ‘09

Total 12-leads 414

Cases identified as suspected STEMI 284

Total cases TNK 83

STEMI suspected TNK NOT administered 201

Direct PCI requested by paramedic 48
<table>
<thead>
<tr>
<th>Event</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptom onset to 000 call</td>
<td>33 min</td>
<td>0-60.5hr</td>
</tr>
<tr>
<td>Symptom onset to 12-lead</td>
<td>71 min</td>
<td>7min-61hr</td>
</tr>
<tr>
<td>000 to 12-lead</td>
<td>27 min</td>
<td>0-107 min</td>
</tr>
<tr>
<td>Time on scene to 12-lead</td>
<td>15 min</td>
<td>0-83min</td>
</tr>
<tr>
<td>Symptom onset to TNK</td>
<td>86 min</td>
<td>20-360min</td>
</tr>
<tr>
<td>000 to TNK</td>
<td>44 min</td>
<td>12-120min</td>
</tr>
<tr>
<td>Time on scene to TNK</td>
<td>31 min</td>
<td>6-68min</td>
</tr>
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</table>
## PCI Patients

<table>
<thead>
<tr>
<th>Event</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptom onset to QAS on-scene</td>
<td>44 min</td>
<td>12-360 min</td>
</tr>
<tr>
<td>Symptom onset to 12-lead</td>
<td>67 min</td>
<td>21-365 min</td>
</tr>
<tr>
<td>Symptom onset to handover PCI</td>
<td>100 min</td>
<td>57-420 min</td>
</tr>
<tr>
<td>000 to QAS on scene</td>
<td>11 min</td>
<td>4-55 min</td>
</tr>
<tr>
<td>000 to 12-lead</td>
<td>32 min</td>
<td>10-60 min</td>
</tr>
<tr>
<td>000 to handover PCI</td>
<td>67 min</td>
<td>31-120 min</td>
</tr>
</tbody>
</table>
Door to Balloon times

Field triage median D2B 23 mins

D2B in Hours  
- <90 mins 89%
- <120 mins 92%

D2B out Hours  
- <90 mins 73%
- <120 mins 90%
Outcomes to date

- 4 inappropriate administrations of TNK
- No significant adverse effects
- All attending paramedics for these events are de-briefed and provided with supportive re-training/revision & opportunities to spend a couple of days in a cath lab with cardiologist
Conclusions

► Intensive care paramedics (ICPs) are demonstrating accuracy in the diagnosis of STEMI.

► ICPs are demonstrating a high degree of compliance with ambulance reperfusion protocols and provide an appropriately cautious approach when considering thrombolytic therapy.

► An integrated strategy is providing timely thrombolytic therapy and/or rapid access to PCI for some STEMI patients.
64 yo male

Onset of severe central chest pain

“like indigestion, only a whole lot worse”

Nausea, diaphoresis

Onset at 0620 after sitting up to get out bed
Case Study

Would a systems strategy have improved the management of this patient?
Conclusion:

► Integrated Statewide strategy
► Improve access to PCI
  ● Right center
  ● Right time frame
► Increase access to thrombolysis when PCI is delayed or unavailable
  ● Most effective when given early
► Time is muscle
Acknowledgements

► Dr Stephen Rashford, Medical Director QAS
► V Tippett, Australian Centre for Prehospital Research, QAS
► J Bryant, Prince Charles Hospital
► Consultant Cardiologists and teams at PCI facilities
► QAS Intensive Care Paramedics