STEMI Transfer: Wheels or Blades
Insight from the Copenhagen PCI Center

Peter Clemmensen MD, DMSc, FESC, FSCAI
Maria S Ripa, MD, DMSc
Mikkel Schoos, MD
Jacob Steinmetz, MD, PhD
Rasmus Hesselfeldt, MD, PhD
Lars Rasmussen, MD, DMSc
Lene Holmvang, MD, DMSc

Department of Cardiology
The Heart Center
Rigshospitalet
Copenhagen University
Denmark
Peter Clemmensen

I have the following potential conflicts of interest to report:

Research contracts
Consulting

Abbott, Acarix, AstraZeneca, Aventis, Bayer, Boeringer Ingelheim, Bristol Myers Squibb, Daiichi Sankyo, Eli-Lilly, Merck, Myogen, Medtronic, Mitsubishi Pharma, Nycomed, Organon, Pfizer, Pharmacia, Sanofi-Aventis, Sanofi-Synthelabo, Searle, The Medicines Company.
Prehospital and in-hospital management, and reperfusion strategies within 24 h of FMC

STEML diagnosis

Primary-PCI capable center

- Preferably < 60 min
  - Primary-PCI
  - Rescue PCI

Primary-PCI

- Immediately

Rescue PCI

- Preferably 3-24 h
  - Coronary angiography

EMS or non primary-PCI capable center

- PCI possible < 120 min?
  - Yes
    - Immediate transfer to PCI center
      - Preferably ≤ 90 min
        - ≤ 60 min in early presenters
      - Immediate transfer to PCI center
  - No
    - Preferably ≤ 30 min
    - Immediate fibrinolysis

Successful fibrinolysis

- Yes
  - Primary-PCI
  - Rescue PCI

Cath = catheterization laboratory; EMS = emergency medical system; FMC = first medical contact; PCI = percutaneous coronary intervention; STEML = ST-segment elevation myocardial infarction.
The Danish Solutions

STEMI networks
Prehospital Triage
Background:

15 Telemedicine centers

450 ambulance vehicles transmit ECGs
Ambulances

- Defibrillators 100%
- 12 lead ECG 100%
- ECG Transmission 100%
Paper vs. Fax vs. LCD
Pre-hospital diagnosis & triage by tele-ECG

12 lead EKG
LIFEPAK 12/15
Medtronic

Attending Cardiologist

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Door-to-PCI</td>
<td>34 (19-46)</td>
<td>97 (80-124)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Δ=63 minutes

Ripa, Clemmensen et al. Am J Cardiol 2008
The Danish Solutions

Real World Data

University of Copenhagen
PCI Center
Denmark 5.5 M Inhabitants

2010
Politicians
Closed
1/5
pPCI
Center

Uptake area
2.5 Mio
24/7
pPCI
# Treatment delays when doubling the cathment area for pPCI in STEMI

<table>
<thead>
<tr>
<th></th>
<th>1/6-2010 - 31/5-2011 (n = 472)</th>
<th>1/6-2011 - 31/5-2012 (n = 936)</th>
<th>↑ 98%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptom to ECG</td>
<td>75 (40-158)</td>
<td>76 (42-155)</td>
<td>→</td>
</tr>
<tr>
<td>Transport delay (ECG to arrival)</td>
<td>75 (47-105)</td>
<td>59 (38-89)</td>
<td>↓ 21%</td>
</tr>
<tr>
<td>Door-to-balloon</td>
<td>23 (18-33)</td>
<td>23 (19-30)</td>
<td>→</td>
</tr>
<tr>
<td>Symptom to balloon</td>
<td>196 (137-304)</td>
<td>175 (125-270)</td>
<td>↓ 11%</td>
</tr>
<tr>
<td>ECG to balloon</td>
<td>101 (77-134)</td>
<td>85 (64-115)</td>
<td>↓ 16%</td>
</tr>
</tbody>
</table>

*Median minutes (interquartile range)*

Telemedicine triage of STEMI 1/6-2011 - 31/5-2012: 68%
Transmit ECG from the field
Centralized Heart Station
Teletransmitted ECG’s visible on all Hospital Computers
Results: Reperfusion delays

<table>
<thead>
<tr>
<th></th>
<th>Zone 1 (0-25 km)</th>
<th>Zone 2 (65-100 km)</th>
<th>Zone 3 (100-185 km)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient delay</td>
<td>(n=238)</td>
<td>(n=115)</td>
<td>(n=119)</td>
<td>0.009</td>
</tr>
<tr>
<td>Call to scene</td>
<td>6 (4-7)</td>
<td>17 (10-22)</td>
<td>14 (10-19)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time at scene</td>
<td>20 (15-25)</td>
<td>16 (8-22)</td>
<td>18 (12-23)</td>
<td>0.002</td>
</tr>
<tr>
<td>Scene to PCI center</td>
<td>9 (7-12)</td>
<td>60 (50-70)</td>
<td>91 (75-125)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Door to balloon</td>
<td>45 (33-70)</td>
<td>30 (20-39)</td>
<td>30 (23-45)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pre-hospital delay</td>
<td>35 (29-43)</td>
<td>98 (82-129)</td>
<td>135 (110-173)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FMC to balloon</td>
<td>79 (65-100)</td>
<td>119 (102-168)</td>
<td>160 (128-210)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>System delay</td>
<td>86 (72-113)</td>
<td>133 (116-178)</td>
<td>173 (145-215)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Treatment delay</td>
<td>135 (100-200)</td>
<td>235 (158-350)</td>
<td>235 (187-330)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
## Results: Complications during transfer and mortality

<table>
<thead>
<tr>
<th></th>
<th>Zone 1 (0-25 km)</th>
<th>Zone 2 (65-100 km)</th>
<th>Zone 3 (100-185 km)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF/VT/asystoly</td>
<td>18 (7.6)</td>
<td>12 (10.4)</td>
<td>14 (11.8)</td>
<td>0.178</td>
</tr>
<tr>
<td>SBT &lt;100</td>
<td>49 (20.6)</td>
<td>11 (9.6)</td>
<td>18 (15.1)</td>
<td>0.092</td>
</tr>
<tr>
<td>HR &gt;100</td>
<td>33 (13.9)</td>
<td>21 (18.9)</td>
<td>14 (11.4)</td>
<td>0.736</td>
</tr>
<tr>
<td>AV block &gt;2nd degree</td>
<td>4 (1.7)</td>
<td>4 (3.5)</td>
<td>2 (1.7)</td>
<td>0.842</td>
</tr>
<tr>
<td>Killip class 2-4</td>
<td>26 (11.8)</td>
<td>13 (12.5)</td>
<td>8 (7.8)</td>
<td>0.731</td>
</tr>
<tr>
<td>Mortality 24 hours</td>
<td>10 (4.2)</td>
<td>1 (0.9)</td>
<td>1 (0.8)</td>
<td>0.036</td>
</tr>
<tr>
<td>Mortality 7 days</td>
<td>16 (6.8)</td>
<td>4 (3.5)</td>
<td>5 (4.2)</td>
<td>0.239</td>
</tr>
<tr>
<td>Mortality 30 days</td>
<td>19 (8.1)</td>
<td>7 (6.1)</td>
<td>8 (6.8)</td>
<td>0.501</td>
</tr>
<tr>
<td>Mortality Final follow-up</td>
<td>56 (23.8)</td>
<td>23 (20)</td>
<td>20 (16.9)</td>
<td>0.126</td>
</tr>
</tbody>
</table>

Schoos M, Clemmensen P et al; EHJ ACVC 2012
Results: Reperfusion delays

Direct referral FMC to balloon

<table>
<thead>
<tr>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>109 min (92-121)</td>
<td>139 min (121-160)</td>
</tr>
</tbody>
</table>

Pre-hospital triage feasible in 73% of STEMI patients (self-presenters excluded)


Schoos M, Clemmensen P et al; EHJ
2011 Single Center Experience

1282 Consecutive acute CAG (IHD, Chest pain, Cardiogenic shock, OHCA)

702 Tele-ECG Triage
580 Transferred from spoke ER/CCU

P PCI 81%
P PCI 41%

Clemmensen P; Schoos M et al. J Electrocardiol 2013
STEMI time delays when using Ambulances or Helicopters
STEMI - Methods

- Prospective, controlled, observational
- Ambulance 16 months vs Helicopter 12 months
- STEMI transferred for pPCI
- >30 min. Transport by Ambulance
- Both prehospital and interhospital
Time analysis - STEMI
# STEMI Time delays

<table>
<thead>
<tr>
<th>All transferred pts</th>
<th>Ambulance n=336</th>
<th>Helicopter n=114</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG – Cath Lab</td>
<td>104 (63-225)</td>
<td>84 (60-160)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Distance in km</td>
<td>94 (64-162)</td>
<td>97 (65-172)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>n=262</th>
<th>n=91</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms - ECG</td>
<td>90 (21-497)</td>
<td>90 (16-405)</td>
<td>0.80</td>
</tr>
<tr>
<td>ECG / FMC - Balloon &lt;120 min</td>
<td>132 (84-262)</td>
<td>114 (78-221)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>48%</td>
<td>65 %</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Door-2-Balloon</td>
<td>32 (18-70)</td>
<td>32 (20-82)</td>
<td>0.66</td>
</tr>
</tbody>
</table>
STEMI - Mortality

• 30 - day mortality
  – Ambulance (n=262) vs. Helicopter (n=91)
    (6.9 % vs. 2.2%, p=0.10)

• 1 – yr mortality
  – Ambulance (n=262) vs. Helicopter (n=90)
    (9.9 % vs. 6.7%, p=0.35)
Time from ECG to PCI center

+ 30 minutes door-to-ballon

Hesselfeldt et al. Submitted
Webcam from helipad to cath lab
Telemedicine based STEMI-Transfer
Baltic Sea Island

112 - Ambulance Arrival: 15 min
ECG: 7 min
Phone-Calls: 5 min
Helicopter-Flying Time: 42 min
Medication and Out: 10 min
Ambulance to Rønne: 12 min
Waiting for Helicopter: 20 min
Helicopter Transfer: 40 min

ECG to Rigshospitalet: 94 min
Overall median = 331 minutes (n = 94)
## Mortality

<table>
<thead>
<tr>
<th></th>
<th>Bornholm 2005-2011 (n=101)</th>
<th>Capitol region 1998-2008 (n=2774)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 d cardiac mortality</td>
<td>6 (5.9 %)</td>
<td>205 (7.4 %)</td>
</tr>
<tr>
<td>1. Yr cardiac mortality</td>
<td>7 (7.7 %)</td>
<td>233 (8.4 %)</td>
</tr>
<tr>
<td>30 d total mortality</td>
<td>6 (5.9 %)</td>
<td>222 (8 %)</td>
</tr>
<tr>
<td>1. års total mortality</td>
<td>9 (9.9%)</td>
<td>283 (10.2 %)</td>
</tr>
</tbody>
</table>
Conclusions

Telemedicine is pivotal in reducing treatment delays in STEMI networks.

Primary PCI can centralized in well organised "Mega-centers" without negative effects of treatment delays.

Helicopter transfer of STEMI patients significantly reduces treatment delays, effective from a radius of only 80 km (50 miles) from the pPCI hub.
Thank you for your attention
Prehospital ACS Triage

STEMI Patients

Pre-hospital point-of-care

Troponins / FABP / xx

ECHO?

In Cath Lab
Third Universal Definition of Myocardial Infarction

Peter Clemmensen, MD, DMSc, FESC, FSCAI
Department of Cardiology, Rigshospitalet
University of Copenhagen, Denmark

Kristian Thygesen, FESC, FACC, FAHA
Aarhus University Hospital, Aarhus, DK
Co-Chairman of The Global MI Task Force
Universal Definition of Myocardial Infarction
Consensus Documents

2000

2007

2012
Patient with chest pain
Proximal or distal occlusion?

DISTAL LCX OCCLUSION post-OM1
reciprocal ST-depression in aVL

Courtesy of Dr. Kjell Nikus, Tampere
The best way to predict the future is to create it

Peter F. Drucker
Single phone call – Team effort
Conclusions

• *Helicopter transfer for STEMI pts with an estimated ground transport > 30 min. to the pPCI center decreases FMC to Balloon times*

• *Using helicopter transfer for STEMI patients results in more pts being treated within the ESC guideline limits*

• *Our initial experience suggest that Helicopter transfer for STEMI patients is faster than ground transport even at distances down to 80 km (50 miles)*
<table>
<thead>
<tr>
<th></th>
<th>Bornholm 2005-2011 (n=101)</th>
<th>Alle STEMI patienter behandlet på RH med pPCI fra 1998-2008 (n=2774)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>62.2 ± 12.6</td>
<td>62.7 ± 13.1</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>18 (17.8)</td>
<td>788 (28)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>32 (31.7)</td>
<td>788 (33)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>24 (23.8)</td>
<td>468 (32)</td>
</tr>
<tr>
<td>Active or previous smoker</td>
<td>68 (67.3)</td>
<td>1752 (79)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>9 (8.9)</td>
<td>415 (15)</td>
</tr>
<tr>
<td>BMI</td>
<td>27.4 ± 5.3</td>
<td>26.5 ± 4.4</td>
</tr>
<tr>
<td>Culprit artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD</td>
<td>44 (43.6)</td>
<td>1286 (45)</td>
</tr>
<tr>
<td>RCA</td>
<td>42 (41.6)</td>
<td>1117 (41)</td>
</tr>
<tr>
<td>LCX</td>
<td>12 (11.9)</td>
<td>337 (13)</td>
</tr>
<tr>
<td>LM</td>
<td>2 (2)</td>
<td>23 (0.8)</td>
</tr>
<tr>
<td>TIMI 0/I/II/III (%)</td>
<td>55/12/14/19</td>
<td>65/8/14/13</td>
</tr>
<tr>
<td>1/2/3/&gt;3 lesions (%)</td>
<td>77/16/5/2</td>
<td>79/17/3/1</td>
</tr>
</tbody>
</table>
Tele Transmission between 6 Elective PCI or CAG Centers and 4 pPCI University Centers
Age-Adjusted Mortality According to Time to Reperfusion and Type of Therapy

Thrombolysis
- No. of Deaths: 122, 503, 503, 332, 239, 159, 121, 196, 139
- Total No. of Patients: 1248, 4375, 3659, 2199, 1438, 946, 658, 1061

Primary PCI
- No. of Deaths: 7, 61, 81, 50, 43, 37, 17, 41, 31
- Total No. of Patients: 125, 895, 1126, 776, 567, 453, 282, 458, 332

Time to Reperfusion, min
- 0-60, 61-120, 121-180, 181-240, 241-300, 301-360, 361-420, 421-600, 601-900

1-Year Mortality, %
- 0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20
Outcome according to triage of patients
PCI Mega center

Optimal catchment area for pPCI: 250-500,000
Should rarely exceed 1,000,000
Level 1 MI Emergency Department Kit
Going prehospital!

- ASA tablets in package and i.v.
- Prasugrel, Ticagrelor, Clopidogrel tables in package
- Metoprolol bolus x3
- Heparin bolus
- Bivalirudin drip and tubing
- Alcohol swabs
- Calculator
- Standing orders with fibrinolytic calculations
- Blood vials
- PCS forms (Physician Certification Statement for Transfer)
- Transfer datasheet
- Standing orders

Modified after AHJ 2005;150:373
KPI

Call back 90 sec. after incoming ECG
From High Volume to Mega-Center
pPCI Center
Real World Tele-ECG Triage

**STEMI diagnosis**
- PPV 79%
- NPV 94%
- Sensitivity 84%
- Specificity 91%

Ripa et al; Am J Cardiol 2009