I, Thomas Alexander, DO NOT have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.
Mr.V, 65 year old farmer. A diabetic for 14 years and a hypertensive for 10 years.

His diabetes has been very poorly controlled with HBA1C levels consistently above 8.0.

Past smoker, stopped after his CABG but restarted for the last 3 years.

Had an Inferior wall MI, thrombolysed with SK 1997. Well till 1999 when he was evaluated for Class III angina.

CART at that time showed a CTO of the RCA, 80% stenosis of the ostium of the circumflex and a 70% stenosis of a large D1. His LAD had minor proximal disease.

He underwent CABG with SVG grafts to OM1, PDA and DI and was relatively well till 2 year ago. Cost paid by the Government health insurance.
For the last two years his effort tolerance has come down and for the last 6 months his activities have been markedly restricted. Being seen by the local GP and on medications but was unwilling to travel to the major referral hospital for further evaluation - a 4 hour drive away.
On the 8th of September, he woke up at 6.30am with a heavy sensation in his chest. Soon this became severe and he began perspiring profusely. He was given a hot drink and told to lie down. He initially felt better and drifted off to sleep. He woke up again at 7.30, but the pain soon returned. This time worse.

A cab was hailed and taken to the local hospital 20 km away. A drive of 45 minutes over a potholed road. The pain was getting worse. The hospital, a 20 bed private facility was run by the local GP. He was quickly hooked on to a monitor. His blood pressure was 90/60

This hospital was a spoke of a recently developed ‘STEMI Cluster’ and connected to a Hub hospital 130KM away. 
ECG was done and transmitted to the hub hospital using a multi-functional ECG device
Coimbatore Cluster
Multi-functional STEMI Device
ECG confirmed as extensive anterior wall MI

Started on Streptokinase at 10.30am. 4 hours after onset of chest pain.
- Patient continued to remain restless.
- Blood pressure 80/50 and HR of 120/mt. SPO2 of 88%. Extensive bilateral crepitations
- Started on 0.1mic/Kg of NA. Inj Lasix 40mg IV. CPAP
- ECG at 12noon and transmitted to Hub hospital
- Decision to transfer the patient immediately to the Hub hospital
- Blood results
  - Hb - 8.8gm/dl
  - RBS - 450mg/dl
  - Creatinine - 2.4mg/dl
  - K - 5.2meq/l
- Patient transported on ambulance on CPAP, NA infusion
Prognostic Indicators

1. LV dysfunction - Old Inferior and Acute Anterior wall MI
2. STEMI vs NSTEMI
3. Delayed reperfusion
4. LM>LAD>RCA>Cx - Caveat for RCA - CHB, RV Infarction and MR
5. Renal dysfunction and oliguria
6. Co-morbid conditions - uncontrolled diabetes
Clinical Definition

- CS caused by systemic output resulting from inadequate tissue perfusion in the presence of adequate intravascular volume

Hemodynamic definition

- Condition causing sustained systolic BP < 90 mm Hg, cardiac index < 2.2 L/min/m², PCWP >15 mm Hg
1. Systemic Hypotension
   systolic arterial pressure < 80 mm of Hg

2. Persistent Hypotension
   at least 30 minutes

3. Reduced Systolic Cardiac Function
   cardiac index < 1.8 x m sq / min without support

4. Tissue Hypoperfusion
   oliguria, cold extremities, confusion

5. Increased Left Ventricular Filling
   pulmonary capillary wedge pressure > 18 mm Hg
Frequently, shock develops after presentation for myocardial infarction.

- **SHOCK Registry**
  - At presentation: 25% in shock
  - Within 24 hours: 75%
    (median delay = 7 hours)

- **GUSTO Trial**
  - At presentation: 11% in shock
  - After admission: 89%
Cardiogenic shock IS NOT simply the result of severe depression of LV function due to extensive myocardial ischemia/injury.

Depressed Myocardial Contractility combined with Inadequate Systemic Vasoconstriction resulting from a systemic inflammatory response syndrome (SIRS) to extensive myocardial ischemia/injury results in cardiogenic shock.
Evaluation in ER

- Clinical
- Echo
- CVP
- PCWP
- Arterial line
Clinical

- Heart Rate -> 60/min
- BP < 80mm Hg
- JVP - Elevation - LV/RV
- Extremities
- Lung fields - LV/RV
ECHO

- Area of infarction
- Wall motion of non infarcted area.
- LVEF
- Significant dyskinesis.
- Mechanical Complication: VSD
  - MR
  - Rupture
  - Effusion
CVP

- Does not correlate with PCWP
- Not a good indication of tissue perfusion
- Does not correlate with circulating volumes
CS - management

- Medical
- Ventilation
- General critical care
Medical

- Thrombolysis.
- Vasopressor
- Inotropes
- Miscellaneous
THROMBOLYSIS

- Time, Duration, Clinical parameters.
- Bolus Thrombolytic preferred.

- Rates of Reperfusion Lower, and
- Rates of Reocclusion Higher than in non-shock pts
- Possible Reason:
  • Diffusion of *thrombolytic agent* into the thrombus
  • may be PRESSURE DEPENDENT.
Any Randomized Trials of Thrombolysis in Cardiogenic Shock???

• Most thrombolytic trials specifically excluded patients in cardiogenic shock

• The only large placebo-controlled thrombolytic study specifically examining Pts. presenting with shock was **GISSI-1**
  
  • Streptokinase

=> No Benefit
Vasopressor and Inotrope

- Norepinephrine – Vasopressor of choice.
- Dobutamine – inotrope of choice
- Levosimandand – Catecholamine resistent shock.
- Phosphodiesterose III inhibitors – patients with B-blockers.
Ventilation

- Low threshold for Noninvasive ventilation
- Invasive ventilation
  - Hypoxic state
  - Recurrent arrhythmias
  - Restless patient
General critical care

- Optimize Lab parameters - correct anemia
- Treat Diabetes with insulin Infusion
- Avoid / treat sepsis
- Watch renal function
- Anticipate / treat arrhythmia
Summary

- Anticipate & start treatment early
- Maintain hemodynamics
- Avoid further ischemic insult
- Prevent multiorgan damage
- Discuss transport issues and logistics
Arrives at the Hub hospital at 4.00 PM
Intubated in the ER and transferred immediately to the cath lab
Early Revascularisation in AMI complicated by Cardiogenic Shock

SHOCK Trial

Acute Myocardial Infarction

≤ 36 hrs

Shock

≤ 12 hrs

Randomization

Emergency Revascularization
- IABP/Pharmacologic Support
- Possible Prior Thrombolysis
- Emergency Early PTCA/CABG ≤ 6 hrs

Initial Medical Stabilization
- IABP/Pharmacologic Support
- Thrombolysis Unless Absolute Contraindication
- Possible Delayed Revascularization > 54 hrs

Hochman, AHJ 137: 313, 1999
Shock Trial
Long-Term Outcomes

- Early revascularization, compared to initial medical stabilization, resulted in 13.2% absolute improvement in 6-year survival
- 8 patients needed to be treated to save 1 life

PCI in Cardiogenic Shock
Importance of Time to Reperfusion

Zeymer, EHJ 2004;25:322-8
Brodie, AHJ 2003;145:708-15
Clinical Significance of Post-Procedural TIMI Flow in Patients With Cardiogenic Shock Undergoing Primary PCI

TIMI Flow Grade and Mortality

Intra Aortic Balloon Pump

- Improvement of coronary perfusion
- Reduction afterload
- Myocardial $O_2$-consumption reduced

Diastolic Augmentation

**Non-assisted Systole**

**Non-assisted Aortic Pressure**

**Balloon-inflation**

**Assisted Systole**

**Assisted ed Aortic Pressure**

**Systole**

**Diastole**
A systematic review and meta-analysis of IABP therapy in STEMI: should we change the guidelines?

Meta-analysis of cohort studies of IABP therapy in STEMI complicated by cardiogenic shock.

<table>
<thead>
<tr>
<th>Trial</th>
<th>IABP</th>
<th>no IABP</th>
<th>30-day mortality risk difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reperfusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moloupoulos</td>
<td>24/34</td>
<td>15/15</td>
<td>-0.29 (-0.47 to -0.12)</td>
</tr>
<tr>
<td>Overall</td>
<td>24/34</td>
<td>15/15</td>
<td></td>
</tr>
<tr>
<td>Thrombolysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomel</td>
<td>28/51</td>
<td>10/13</td>
<td></td>
</tr>
<tr>
<td>Kovack</td>
<td>10/27</td>
<td>13/19</td>
<td></td>
</tr>
<tr>
<td>Bengtson</td>
<td>48/99</td>
<td>58/101</td>
<td></td>
</tr>
<tr>
<td>Waksman</td>
<td>11/20</td>
<td>17/21</td>
<td></td>
</tr>
<tr>
<td>GUSTO-1</td>
<td>30/62</td>
<td>146/248</td>
<td></td>
</tr>
<tr>
<td>SHOCK registry</td>
<td>220/439</td>
<td>300/417</td>
<td></td>
</tr>
<tr>
<td>NRMI-2 TT</td>
<td>1068/2180</td>
<td>2346/3501</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>1415/2878</td>
<td>2890/4320</td>
<td></td>
</tr>
<tr>
<td>Primary PCI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRMI-2 PCI</td>
<td>956/2035</td>
<td>401/955</td>
<td>-0.18 (-0.20 to -0.16)</td>
</tr>
<tr>
<td>AMC CS</td>
<td>93/199</td>
<td>26/93</td>
<td>0.06 (0.03 to 0.10)</td>
</tr>
<tr>
<td>Overall</td>
<td>1049/2234</td>
<td>427/1048</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>2488/5146</td>
<td>3332/5383</td>
<td>-0.11 (-0.13 to -0.09)</td>
</tr>
</tbody>
</table>

\[
P_{\text{heterogeneity}}<0.0001 \quad I^2=93.6\% \quad P_{\text{overall effect}}<0.0001
\]
• **IABP-SHOCK II trial** *(PMID-22920912) (NEJM 2012)*
  - 600 patients with cardiogenic shock complicating STEMI
  - IABP in 300, no IABP in 298
  - All patients were expected to undergo early revascularization

• Recommendation for IABP in STEMI with cardiogenic shock
  - ACC/AHA 2004- class I (LOE B)
  - ACC/AHA 2013- class II a
  - ESC 2012- class II b

• Downgratation is based on-
  - IABP SHOCK II trial (2012)
Evolution of Cardiac Support in Cath lab

- ECMO
- IABP
- CPS
- Hemopump
- TandemHeart
- Impella

70’s  80’s  90’s  00’s
## Randomized Trials Cardiogenic Shock

### Revascularization

<table>
<thead>
<tr>
<th>Trial</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk Mortality 95% CI</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHOCK</td>
<td>1 year</td>
<td>81/152</td>
<td>100/150</td>
<td></td>
<td>0.72 (0.54, 0.95)</td>
</tr>
<tr>
<td>SMASH</td>
<td>30 days</td>
<td>22/352</td>
<td>18/23</td>
<td></td>
<td>0.87 (0.66, 1.29)</td>
</tr>
<tr>
<td>Total</td>
<td>103/184</td>
<td>118/173</td>
<td></td>
<td></td>
<td>0.82 (0.69, 0.97)</td>
</tr>
</tbody>
</table>

### Vasopressors

<table>
<thead>
<tr>
<th>Group</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOAP-2 (CS subgroup)</td>
<td>28 days</td>
<td>64/145</td>
<td>50/135</td>
<td>0.75 (0.55, 0.93)</td>
</tr>
</tbody>
</table>

### Inotropes

<table>
<thead>
<tr>
<th>Group</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unverzagt et al.</td>
<td>30 days</td>
<td>5/16</td>
<td>10/16</td>
<td>0.33 (0.11, 0.97)</td>
</tr>
</tbody>
</table>

### Glycoprotein IIb/IIa inhibitors

<table>
<thead>
<tr>
<th>Group</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRAGUE I-18</td>
<td>In-hospital</td>
<td>15/40</td>
<td>13/40</td>
<td>1.15 (0.59, 2.27)</td>
</tr>
</tbody>
</table>

### NO synthase inhibitors

<table>
<thead>
<tr>
<th>Group</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRIUMPH</td>
<td>30 days</td>
<td>97/201</td>
<td>76/180</td>
<td>1.14 (0.91, 1.45)</td>
</tr>
<tr>
<td>SHOCK II</td>
<td>30 days</td>
<td>24/59</td>
<td>7/20</td>
<td>1.16 (0.59, 2.69)</td>
</tr>
<tr>
<td>Cotter et al.</td>
<td>30 days</td>
<td>4/15</td>
<td>10/15</td>
<td>0.40 (0.13, 1.05)</td>
</tr>
<tr>
<td>Total</td>
<td>128/275</td>
<td>93/215</td>
<td></td>
<td>1.05 (0.85, 1.30)</td>
</tr>
</tbody>
</table>

### IABP

<table>
<thead>
<tr>
<th>Group</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>IABP-SHOCK I</td>
<td>30 days</td>
<td>7/19</td>
<td>6/21</td>
<td>1.28 (0.45, 3.72)</td>
</tr>
<tr>
<td>IABP-SHOCK II</td>
<td>30 days</td>
<td>119/300</td>
<td>123/298</td>
<td>0.96 (0.79, 1.17)</td>
</tr>
<tr>
<td>Total</td>
<td>126/319</td>
<td>129/319</td>
<td></td>
<td>0.98 (0.81, 1.18)</td>
</tr>
</tbody>
</table>

### LVAD

<table>
<thead>
<tr>
<th>Group</th>
<th>Follow-up</th>
<th>n/N</th>
<th>n/N</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiele et al.</td>
<td>30 days</td>
<td>9/21</td>
<td>9/20</td>
<td>0.95 (0.48, 1.90)</td>
</tr>
<tr>
<td>Burkoff et al.</td>
<td>30 days</td>
<td>9/19</td>
<td>5/14</td>
<td>1.33 (0.57, 3.10)</td>
</tr>
<tr>
<td>iSAP-SHOCK</td>
<td>30 days</td>
<td>6/13</td>
<td>6/13</td>
<td>1.00 (0.44, 2.29)</td>
</tr>
<tr>
<td>IMPRESS in Severe Shock</td>
<td>30 days</td>
<td>11/24</td>
<td>12/24</td>
<td>0.92 (0.51, 1.66)</td>
</tr>
<tr>
<td>Total</td>
<td>35/77</td>
<td>32/71</td>
<td></td>
<td>1.01 (0.70, 1.44)</td>
</tr>
</tbody>
</table>
Multivessel PCI in Cardiogenic Shock?

Metaanalysis Mortality – Registry-Data

<table>
<thead>
<tr>
<th>Study</th>
<th>MV-PCI Events</th>
<th>MV-PCI Total</th>
<th>C-PCI Events</th>
<th>C-PCI Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IABP-SHOCK II</td>
<td>75</td>
<td>167</td>
<td>119</td>
<td>284</td>
</tr>
<tr>
<td>ALKK</td>
<td>81</td>
<td>173</td>
<td>201</td>
<td>562</td>
</tr>
<tr>
<td>KAMIR</td>
<td>13</td>
<td>124</td>
<td>56</td>
<td>386</td>
</tr>
<tr>
<td>Yang et al.</td>
<td>19</td>
<td>60</td>
<td>68</td>
<td>279</td>
</tr>
<tr>
<td>Cavender et al.</td>
<td>20</td>
<td>43</td>
<td>42</td>
<td>156</td>
</tr>
<tr>
<td>EHS-PCI</td>
<td>40</td>
<td>82</td>
<td>95</td>
<td>254</td>
</tr>
<tr>
<td>NCDR</td>
<td>158</td>
<td>433</td>
<td>737</td>
<td>2654</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>406</strong></td>
<td><strong>1082</strong></td>
<td><strong>1318</strong></td>
<td><strong>4574</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: $I^2=0.007$, $P=31.0\%$, $p=0.19$
Test for overall effect: $p=0.001$

<table>
<thead>
<tr>
<th>Study</th>
<th>MV-PCI Events</th>
<th>MV-PCI Total</th>
<th>C-PCI Events</th>
<th>C-PCI Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IABP-SHOCK II</td>
<td>91</td>
<td>167</td>
<td>149</td>
<td>284</td>
</tr>
<tr>
<td>KAMIR</td>
<td>16</td>
<td>124</td>
<td>69</td>
<td>386</td>
</tr>
<tr>
<td>Yang et al.</td>
<td>21</td>
<td>60</td>
<td>85</td>
<td>279</td>
</tr>
<tr>
<td>Cavender et al.</td>
<td>32</td>
<td>43</td>
<td>101</td>
<td>156</td>
</tr>
<tr>
<td>Mylotte et al.</td>
<td>37</td>
<td>66</td>
<td>82</td>
<td>103</td>
</tr>
<tr>
<td>van der Schaaf et al.</td>
<td>22</td>
<td>37</td>
<td>66</td>
<td>124</td>
</tr>
<tr>
<td><strong>SHOCK</strong></td>
<td><strong>7</strong></td>
<td><strong>9</strong></td>
<td><strong>26</strong></td>
<td><strong>57</strong></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>226</strong></td>
<td><strong>506</strong></td>
<td><strong>578</strong></td>
<td><strong>1387</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: $I^2=0.043$, $I^2=47.8\%$, $p=0.005$
Test for overall effect: $p=0.77$

Short-term follow-up

RR: 1.07 [0.86-1.33]
RR: 1.31 [1.08-1.53]
RR: 0.72 [0.41-1.28]
RR: 1.29 [0.85-1.96]
RR: 1.73 [1.14-2.61]
RR: 1.30 [0.96-1.71]
RR: 1.31 [1.14-1.51]

Multivessel PCI better
Culprit only PCI better

Long-term follow-up

RR: 1.04 [0.87-1.24]
RR: 0.72 [0.43-1.19]
RR: 1.14 [0.78-1.66]
RR: 1.15 [0.93-1.42]
RR: 0.70 [0.56-0.89]
RR: 1.12 [0.82-1.53]
RR: 1.71 [1.09-2.67]

Multivessel PCI better
Culprit only PCI better

de Waha et al. Eur Heart J Acute Cardiovasc Care. 2017; epub
## Treatment

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Culprit only PCI (n=344)</th>
<th>Multivessel PCI (n=342)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral access; n/total (%)</td>
<td>287/343 (83.7)</td>
<td>277/342 (81.0)</td>
<td>0.36</td>
</tr>
<tr>
<td>Radial access; n/total (%)</td>
<td>61/343 (17.8)</td>
<td>66/342 (19.3)</td>
<td>0.61</td>
</tr>
<tr>
<td>Stent implanted in culprit lesion; n/total (%)</td>
<td>326/343 (95.0)</td>
<td>324/342 (94.7)</td>
<td>0.86</td>
</tr>
<tr>
<td>Drug-eluting stent in culprit lesion; n/total (%)</td>
<td>305/326 (93.6)</td>
<td>308/324 (95.1)</td>
<td>0.41</td>
</tr>
<tr>
<td>TIMI-flow III post PCI of culprit lesion; n/total (%)</td>
<td>289/342 (84.5)</td>
<td>293/338 (86.7)</td>
<td>0.46</td>
</tr>
<tr>
<td>Immediate PCI of non-culprit lesions; n/total (%)</td>
<td>43/344 (12.5)</td>
<td>310/342 (90.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Immediate complete revascularization; n/total (%)</td>
<td>26/344 (7.6)</td>
<td>277/342 (81.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total amount of contrast agent (ml); median (IQR)</td>
<td>190 (140-250)</td>
<td>250 (200-350)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Staged PCI of non-culprit lesions; n/total (%)</td>
<td>60/344 (17.4)</td>
<td>8/341 (2.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Staged coronary artery bypass surgery; n/total (%)</td>
<td>1/344 (0.3)</td>
<td>0/341 (0)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Mechanical circulatory support; n/total (%)</td>
<td>99/344 (28.8)</td>
<td>95/342 (27.8)</td>
<td>0.77</td>
</tr>
<tr>
<td>Intraaortic balloon pump; n/total (%)</td>
<td>25/99 (25.3)</td>
<td>26/95 (27.4)</td>
<td>0.74</td>
</tr>
<tr>
<td>Impella 2.5; n/total (%)</td>
<td>16/99 (16.2)</td>
<td>18/95 (18.9)</td>
<td>0.61</td>
</tr>
<tr>
<td>Impella CP; n/total (%)</td>
<td>30/99 (30.3)</td>
<td>18/95 (18.9)</td>
<td>0.07</td>
</tr>
<tr>
<td>TandemHeart; n/total (%)</td>
<td>2/99 (2.0)</td>
<td>0/95</td>
<td>0.50</td>
</tr>
<tr>
<td>ECMO; n/total (%)</td>
<td>18/99 (18.2)</td>
<td>27/95 (28.4)</td>
<td>0.09</td>
</tr>
<tr>
<td>Mild hypothermia; n/total (%)</td>
<td>111/344 (32.3)</td>
<td>118/340 (34.7)</td>
<td>0.50</td>
</tr>
<tr>
<td>Mechanical ventilation; n/total (%)</td>
<td>273/344 (79.4)</td>
<td>282/339 (83.2)</td>
<td>0.20</td>
</tr>
<tr>
<td>Duration of mechanical ventilation (days); median (IQR)</td>
<td>3 (1-7)</td>
<td>3 (1-7)</td>
<td>0.97</td>
</tr>
<tr>
<td>Duration of intensive care treatment (days); median (IQR)</td>
<td>5 (2-12)</td>
<td>5 (2-11)</td>
<td>0.61</td>
</tr>
</tbody>
</table>
- Patient shifted to ICU
- Ventillated, IABP, required 2 dialysis
- Transferred out after 7 days
- Lvef 25%
- Decisions to be made - PCI to Cx/CTO of RCA (viability study)
  - ICD