Mobile Stroke Treatment Units: Myth or Reality?

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Director, Cerebrovascular Center
Associate Professor Surgery (Neurosurgery)
Medical Director of Distance Health
Disclosures – last 12 months

• Financial Interest:
  – Blockade Medical
  – Perflow Medical

• Scientific Advisory Boards
  – Blockade Medical
  – Medtronic Neurosurgery
  – Perflow Medical
  – Stryker Neurovascular

• Institutional/Group/Research and Educational Support:
  – ev3/Covidien
  – Penumbra Medical
  – Codman/J & J

• Immediate Past President – Society of Neurointerventional Surgery
Neurosurgeon’s Role in Stroke

• Brain aneurysms
• Brain AVMs
• ICH – medical and surgical and minimally invasive
• Carotid stenosis – CEA and CAS
• Hemicraniectomy
• EC-IC Bypass
• Endovascular management of acute and chronic ischemia (ICAD)
• Programmatic leader in your hospital/health system/community
There are Effective Treatments for Acute Stroke

Figure 2. Outcome at Three Months in Part 2 of the Study, According to Treatment.

NIHSS
Placebo 0-1 2-8 ≥9 Death
0 20 32 27 21
0 31 30 22 17

Barthel Index
Placebo 95-100 55-90 0-50 Death
0 38 23 18 21
0 50 16 17 17

Modified Rankin Scale
Placebo 0-1 2-3 4-5 Death
0 26 25 27 21
0 39 21 23 17

Glasgow Outcome Scale
Placebo 1 2 3-4 Death
0 32 22 25 21
0 44 17 22 17

A Intention-to-Treat Population
Score 0 1 2 3 4 5 6
Alteplase (N=418) 27.5 24.9 14.1 9.3 9.3 8.1 6.7
Placebo (N=403) 21.8 23.3 16.4 11.4 13.7 5.2 3.2

B Per-Protocol Population
Score 0 1 2 3 4 5 6
Alteplase (N=375) 29.1 25.9 14.4 10.1 8.8 5.6 6.1
Placebo (N=355) 22.3 23.1 16.9 11.8 14.9 4.2 6.8

MR CLEAN
A Multicenter Randomized Clinical trial of Endovascular treatment for Acute Ischemic stroke in the Netherlands

Cleveland Clinic
What is the most effective treatment for ischemic stroke?

<table>
<thead>
<tr>
<th>Treatment/Technique</th>
<th>NNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx’ment chronic hypertension</td>
<td>29</td>
</tr>
<tr>
<td>Stroke Units</td>
<td>18</td>
</tr>
<tr>
<td>IV tPA</td>
<td></td>
</tr>
<tr>
<td>0 - 90 min</td>
<td>3.6</td>
</tr>
<tr>
<td>91 – 180</td>
<td>4.3</td>
</tr>
<tr>
<td>181 – 270</td>
<td>5.9</td>
</tr>
<tr>
<td>CEA/CAS for Asx stenosis</td>
<td>19</td>
</tr>
<tr>
<td>Aspirin</td>
<td>100</td>
</tr>
<tr>
<td>CEA/CAS for Sx stenosis</td>
<td>6 - 15</td>
</tr>
</tbody>
</table>
Time=Brain and the IV tPA Time Window

Figure 3: Model estimating odds ratio for favourable outcome at 3 months in rt-PA-treated patients compared with controls by OTT. Adjusted for age, baseline glucose concentration, baseline NIHSS measurement, baseline diastolic blood pressure, previous hypertension, and interaction between age and baseline NIHSS measurement.

Patient Outcome vs. ΔTime (Onset to Treatment)

- ICAT, M1, and M2 Cases with Reperfusion with 95% confidence bands (p=0.0045)
- ICAT, M1, and M2 Cases without Reperfusion (10%; 95% CI 0.03-0.18)

Reperfusion vs No Reperfusion
- Mean age
  - 66.2 vs 65.6
- Median NIHSS
  - 18 vs 17
- ASPECTS >4
  - 85.5% vs 84.2%
- mRS 2
  - 40.1% vs 10.3%

Further analysis pending

Khatri, IMS3, ISC 2013
# Time is Brain!

<table>
<thead>
<tr>
<th>Event</th>
<th>Neurons Lost</th>
<th>Synapses Lost</th>
<th>Accelerated Aging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Stroke</td>
<td>1.2 billion</td>
<td>8.3 trillion</td>
<td>36 yrs</td>
</tr>
<tr>
<td>Per Hour</td>
<td>120 million</td>
<td>830 billion</td>
<td>3.6 yrs</td>
</tr>
<tr>
<td>Per Minute</td>
<td>1.9 million</td>
<td>14 billion</td>
<td>3.1 weeks</td>
</tr>
<tr>
<td>Per Second</td>
<td>32,000</td>
<td>230 million</td>
<td>8.7 hrs</td>
</tr>
</tbody>
</table>

(Total number of neurons in the average human brain is 130 billion)

*Stroke 2006;37:263-266*
Target: Stroke Outcomes
(15 min reduction in IV tPA DTN times)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pre-Target: Stroke (n=27,319)</th>
<th>Post-Target: Stroke (n=43,850)</th>
<th>Difference Pre and Post</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Hospital Mortality</td>
<td>9.93%</td>
<td>8.25%</td>
<td>-1.68%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Discharge Home</td>
<td>37.6%</td>
<td>42.7%</td>
<td>+5.1%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ambulatory Status Independent</td>
<td>42.2%</td>
<td>45.4%</td>
<td>+3.2%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Symptomatic ICH</td>
<td>5.68%</td>
<td>4.68%</td>
<td>-1.00%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Any tPA Complications</td>
<td>6.68%</td>
<td>5.50%</td>
<td>-1.18%</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Cleveland Clinic Stroke System

Lakewood Hospital
Regional Hub

Fairview

Lutheran

Medina Hosp

CCT

Hillcrest Hospital
Regional Hub

Marymount

South Pointe Hosp

Ashtabula County Med Center

Euclid Hosp

CCF

Florida

* Primary Stroke Center

Telestroke Spoke

Hospital Transfer ➔ Return to PCP

Regional Administrative Infrastructure
## Stroke – Impact and CCF Overview 2013

### Devastating Problem

<table>
<thead>
<tr>
<th></th>
<th>Yearly Discharge Volume</th>
<th>Adult Prevalence</th>
<th>Yearly Mortality</th>
<th>Stroke Mortality Rank</th>
<th>5 Yr Projected IP Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuyahoga County</td>
<td>5,600</td>
<td>3.2%</td>
<td>730</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>3%</td>
</tr>
</tbody>
</table>

### CC Slow to Improve

<table>
<thead>
<tr>
<th></th>
<th>MC</th>
<th>HC</th>
<th>FVW</th>
<th>MYMT</th>
<th>LKWD</th>
<th>SP</th>
<th>Medina</th>
<th>Euclid</th>
<th>Luth</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVtPA delivery rate</td>
<td>17%</td>
<td>10%</td>
<td>11%</td>
<td>4%</td>
<td>7%</td>
<td>6%</td>
<td>18%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Door to Drug in 60 min</td>
<td>56</td>
<td>67</td>
<td>109</td>
<td>107</td>
<td>74</td>
<td>-</td>
<td>78</td>
<td>88</td>
<td>-</td>
</tr>
</tbody>
</table>
Global IVtPA Underuse

- Modeling indicates that 23% can be achieved with pre-alert, 4.5hrs, > 80 yrs UK, 24% achieved in Sweden
  - Monks et al. Stroke 2012; Bergland, Stroke 2012
  - Improved DTN crucial; Foranow Stroke 2011. Meratoja, Neurology 2012

- Estimated 4.5% to 5.2% USA (Boehringer Ingelheim; Adeoye Stroke 2011; Foranow Stroke 2011)

- Huge Variation in Europe
  - Finland 16% (Meratoja 2012), Germany 11.7% (Minnerup Stroke 2011), Sweden 6.6% (Eriksson Stroke 2010), UK 5.8%, France 3%, Italy 1.2% (T Fischer Pers com 2013 Boehringer Ingelheim)

- Much lower rates in developing world <1%
We cannot expect the patient’s disease biology to match our systems. Because the time window to treatment for stroke with most is so short, we must match our systems to the biology.

Michael Hill, MD
Stroke Neurologist
Univ of Calgary
Stroke Treatment Decisions Hinge on the CT Scan

BP control <140
Warfarin reversal
Mannitol
Anti-epileptic medications
Transport to Comprehensive Stroke Center

BP control <180
IV tPA (clot buster)
Transport to Primary Stroke Center
Kostopoulous *et al.* *Neurology* 2012

- Decision made in ambulance
- ER Target: door to needle time = 60 minutes

<table>
<thead>
<tr>
<th>Table</th>
<th>Timing of prehospital diagnostic stroke workup and decision making (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key stroke management times</td>
<td>Patient 1</td>
</tr>
<tr>
<td>Call to MSU arrival</td>
<td>13</td>
</tr>
<tr>
<td>Call to end of laboratory examination</td>
<td>25</td>
</tr>
<tr>
<td>Call to end of CT time</td>
<td>38</td>
</tr>
<tr>
<td>Call to therapy decision times</td>
<td>38</td>
</tr>
<tr>
<td>Call to hospital admission time(^a)</td>
<td>67</td>
</tr>
<tr>
<td>Symptom onset to call time</td>
<td>60</td>
</tr>
</tbody>
</table>

Abbreviation: MSU = mobile stroke unit.

\(^a\) Mean standard call to hospital admission times to the Department of Neurology of the University Clinic of the Saarland (n = 134) in a recent study\(^a\) were 49 ± 29 minutes.
Berlin: Call to Needle Times

The diagram shows the distribution of call-to-needle times for two different scenarios:

- **tPA in STEMO**: The median call-to-needle time is 62 minutes, with a range of approximately 40 to 80 minutes.
- **tPA in hospital**: The median call-to-needle time is 98 minutes, with a range of approximately 70 to 120 minutes.

The box plots indicate that the time for tPA administration in hospital settings is generally longer compared to in STEMOs.
Diagnosis and treatment of patients with stroke in a mobile stroke unit versus in hospital: a randomised controlled trial

Silke Walter, Panagiotis Kostopoulos, Anton Haass, Isabel Keller, Martin Lesmeister, Thomas Schlechtriemen, Christian Roth, Panagiotis Papanagiotou, Iris Grunwald, Helmut Schumacher, Stephan Helwig, Julio Viera, Heiko Körner, Maria Alexandrou, Umut Yilmaz, Karin Ziegler, Kathrin Schmidt, Rainer Dabew, Darius Kubulus, Yang Liu, Thomas Volk, Kai Kronfeld, Christian Rückes, Thomas Bertsch, Wolfgang Reith, Klaus Fassbender

- Randomized, single center
- Week on, week off
- Primary endpoint – alarm to therapy decision
- Secondary – alarm to end of CT, alarm to lab analysis, # pts IV tPA, 7 day neurological outcome (NIHSS)
• Week on, week off randomization
• Compared STEMO deployment vs. STEMO weeks vs. control weeks
• tPA utilization improved to 33% (vs. 21% in control weeks)

<table>
<thead>
<tr>
<th>Primary end point</th>
<th>Patients With STEMO Deployment</th>
<th>P Value</th>
<th>Patients During STEMO Weeks</th>
<th>P Value</th>
<th>Patients During Control Weeks</th>
</tr>
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<tbody>
<tr>
<td>Alarm to treatment (1 missing), mean (95% CI), min</td>
<td>51.8 (49.0-54.6)</td>
<td>&lt;.001</td>
<td>61.4 (58.7-64.0)</td>
<td>&lt;.001</td>
<td>76.3 (73.2-79.3)</td>
</tr>
<tr>
<td>Median (IQR), min</td>
<td>48 (39-56)</td>
<td></td>
<td>55 (44-75)</td>
<td></td>
<td>72 (62-85)</td>
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## Cleveland Clinic Stroke System

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</table>
Realization that we need to make a systems change

- US facing a health care crisis
  - Costs too high
  - Access too low

- Need to constantly innovate our care delivery model

- Need to increase revenues

- Need to decrease costs
  - Most cost of stroke patient is after acute hospitalization – Need to reduce these costs

- Best way to reduce rehabilitation/disability costs is to reduce neurologic deficit

- Need to increase IV tPA delivery and access to endovascular therapy

- Need to bring highest possible level of care directly to the patient as soon as possible
Collaboration with Local Government and Health Systems

• Requires collaboration with local government
• Go to the mayor
• Collaborative effort with the community
• Requires collaboration with local government
• Need to get out and “sell”
• Build excitement
• Change hearts and minds….
Mobile Stroke Treatment Unit: Diagnosis and Emergency Care

- Don’t wait for the patient to get to the ED
- Bring the CT and stroke expertise to the patient
- Initiate treatment at the scene
- Dramatically cut time-to-treatment decisions
- Triage patient to appropriate stroke resource
Portable CT Technology

• CereTom (Neurologica, Danvers, MA)

• 8 slice CT
  – CTA/CTP capable

• Able to scan head

• Used for a number of years in our NICU
  – Reasonable quality
Telemedicine

• Inter-rater reliability reasonable to in person assessment
  — Berlin kappa 0.69
  — Houston with mock patient 0.997 absolute agreement
  — Well-proven in Telestroke networks

• Reliable Broadband has been limiting step in Germany
  — Berlin: only 18/30 technically successful connections

• Verizon 4GLTE
Distribution of 911 calls for Stroke by Hour of Day
Operations

• Stroke patient calls 911 – activates Emergency Medical System
• Municipal ambulance dispatched simultaneously with MSTU (8a-8p)
• Local ambulance arrives first – usual assessment, IV, \( O_2 \), draws blood samples
• MSTU arrives – mutual care/hand off of care
• CT(A) head performed -> transmitted for neuroradiologist and neurologist review
• Point of Care Testing for CBC, INR, creatinine, glucose
• Telestroke System -> vascular neurologist “virtually” with the patient and team, Initiate IV tPA or other care as appropriate
• Triage to appropriate hospital (level of care) in stroke system
Telemedicine

• Has been very reliable

• Review of 108 transports, 5 drop outs
  – 3 brief (< 30 seconds), did not affect clinical care
  – 2 longer (> 30 seconds), truck moved 10 feet and signal returned
  – 1 unable to restore connection
    – Stroke neurologist communicated by telephone with critical care transport nurse, determined cause to be seizure, transported to closest ED.

• Relationship w Verizon
  – Wireless VPN
**Program Operations – Patient Transport Algorithm**

- **Patient Condition identifies Hospital resources needed to effectuate subsequent care**
  - Patient Transport effectuated to nearest Hospital with clinical resources available to meet care needs
  - Patient request will override the default mechanism (Care Continuity, Community Preference)

**Level 1 Hospital**
Hospital with Specific Neuro-Intensive Care Unit and Stroke – Intervention Capabilities

**Level 2 Hospital**
Hospital with Stroke Intervention Capabilities

**Level 3 Hospital**
Primary Stroke Center

**Level 4 Hospital**
Any hospital facility
Treatment Paradigm of the Future?

• 43 y.o. with prior history of drug abuse, CHF
• Was with girlfriend who left briefly, came back 10 minutes later to find him with left hemiplegia
• Called 911
• EMS and MSTU dispatched
• MSTU arrived 40 minutes last known well
MSTU Telemedicine

• Stroke Neurologist signed in to see patient with dense left sided weakness and altered LOC, difficulty speaking

• NIHSS 20
Non contrast CT
Treatment Initiated

• *IV tPA initiated at 11 minutes after patient on board MSTU!* (Door to needle)

• Transferred to Cleveland Clinic Main Campus for consideration of intra-arterial stroke therapy (due to high NIHSS, hyperdense MCA sign)
Initial runs – right M1 MCA occlusion
One pass with aspiration cath – M1 recanalized, M3 thrombus (angular branch remaining)
Patient Course

• Improved next day with near resolution, only facial droop remained (NIHSS 1)
• Stroke due to underlying CHF (EF 10%)
• Discharged home on hospital day 4
## Pre-hospital Stroke Treatments

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dispatches</strong></td>
<td>539</td>
<td>1247</td>
</tr>
<tr>
<td><strong>Transports</strong></td>
<td>156</td>
<td>312</td>
</tr>
<tr>
<td><strong>IVtPA Tx</strong></td>
<td>26</td>
<td>44</td>
</tr>
<tr>
<td><strong>Hemorrhagic strokes</strong></td>
<td>7</td>
<td>19</td>
</tr>
</tbody>
</table>
## Advanced Therapy Treatment

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-hospital CTA Imaging</td>
<td>--</td>
<td>12</td>
</tr>
<tr>
<td>Potential Endovascular Candidate</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Endovascular Tx</td>
<td>6</td>
<td>6 (7)</td>
</tr>
</tbody>
</table>
Methods – Case Control Study

• MSTU quality data prospectively collected and maintained in a Redcap database

• Enterprise Stroke system data collected and maintained in separate Redcap database

• Comparison of MSTU patients with patients presenting to Cleveland Clinic Enterprise Hospitals within or adjacent to City of Cleveland border from January 1, 2014 to December 31, 2014
  – Must have had stroke alert called within 30 minutes of arrival to hospital.
  – Control patients presenting to hospital from 8am – 8pm

• Statistical analysis: Comparison of medians by Wilcoxon Rank Sum, proportions by Pearson’s Chi squared (JMP software)
Primary Stroke Metrics

<table>
<thead>
<tr>
<th></th>
<th>MSTU (100)</th>
<th>CONTROLS (53)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOOR TO CT COMPLETED</td>
<td>13 (IQR 9-21)</td>
<td>18 (IQR 12-26)</td>
<td>0.0072</td>
</tr>
<tr>
<td>DOOR TO INR RESULT</td>
<td>13 (IQR 7-18)</td>
<td>44 (IQR 35-61)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>DOOR TO IV TPA</td>
<td>31.5 (IQR 24-47)</td>
<td>58 (IQR 52-66)</td>
<td>0.0012</td>
</tr>
</tbody>
</table>
911 Alarm to …..

<table>
<thead>
<tr>
<th></th>
<th>MSTU (100)</th>
<th>CONTROLS (53)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM TO CT COMPLETED</td>
<td>33 (IQR 29-41)</td>
<td>56 (IQR 47-68)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ALARM TO CT READ</td>
<td>44 (IQR 39-52)</td>
<td>64 (IQR 54-76)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ALARM TO INR RESULT</td>
<td>25 (IQR 22-34)</td>
<td>79 (IQR 70-105)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ALARM TO IV tPA</td>
<td>55.5 (IQR 46-65)</td>
<td>94 (IQR 78-104)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LKW to IV tPA</td>
<td>97 (61-144)</td>
<td>122.5 (110-176)</td>
<td>0.0886</td>
</tr>
</tbody>
</table>

~45 min saved = 15% more patients d/c’d home  
$12k v. $40k cost for first 90 days of care…..
911 Alarm to Drug Administration

National Target for Drug Administration

<table>
<thead>
<tr>
<th>Month</th>
<th>911 to scene</th>
<th>Door to drug</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Aug</td>
<td>9</td>
<td>43</td>
</tr>
<tr>
<td>Sep</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>Oct</td>
<td>9</td>
<td>31</td>
</tr>
</tbody>
</table>
MSTU Thrombolysis Rate

• Thrombolysis Rate:

• Based on MSTU encounter Dx (n=100 patients)
  – IV tPA given for 100 MSTU runs: 16%
  – Rate in probable stroke = 16/33 = 48.4%

• Based on Final Dx (known for 87 pts)
  – Rate in AIS: 9/29 = 31.0%
  – Rate in AIS + clinical TIA = 11/41 = 26.8%
Hospital Discharge Diagnosis MSTU Patients

<table>
<thead>
<tr>
<th>FINAL Diagnosis of MSTU patients on discharge (n=87 pts)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS</td>
<td>29 (33.3)</td>
</tr>
<tr>
<td>TIA</td>
<td>12 (13.7)</td>
</tr>
<tr>
<td>ICH</td>
<td>5 (5.7)</td>
</tr>
<tr>
<td>Noncerebrovascular</td>
<td>41 (47.1)</td>
</tr>
<tr>
<td>- Neurological</td>
<td>21 (51.2)</td>
</tr>
<tr>
<td>- Non-neurological</td>
<td>20 (48.8)</td>
</tr>
</tbody>
</table>
Transport Destinations: First 155 Patients

- Cleveland Clinic: 69
- Metro Hospital: 27
- University Hospital: 19
- Lakewood Hospital: 11
- Euclid Hospital: 7
- Marymount Hospital: 5
- Fairview Hospital: 5
- South Pointe Hospital: 4
- Parma Hospital: 3
- Southwest General Hospital: 2
- St. Vincent Charity: 1
- Lutheran Hospital: 1
- Hillcrest Hospital: 1

Data as of 12/31/2014
## Pre-hospital treatments

- **Hemorrhagic strokes transported:** 7
  - 1 Kcentra-coumadin coagulopathy patient treated in the field

<table>
<thead>
<tr>
<th></th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch to Scene Arrival</td>
<td>13 mins</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>MSTU Door to Doctor</td>
<td>12</td>
<td>13</td>
<td>11</td>
<td>12</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>MSTU Door to CT complete</td>
<td>22</td>
<td>19</td>
<td>11</td>
<td>11</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>MSTU Door to CT Read</td>
<td>32</td>
<td>27</td>
<td>24</td>
<td>22</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>MSTU Door to Lab Results</td>
<td>15</td>
<td>10</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>MSTU Door to Drug</td>
<td>48</td>
<td>41</td>
<td>19</td>
<td>28</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>Total Time on Scene</td>
<td>52</td>
<td>46</td>
<td>39</td>
<td>40</td>
<td>43</td>
<td>40</td>
</tr>
</tbody>
</table>

Data as of 12/31/2014
## MSTU comparison to CCHS EDs

<table>
<thead>
<tr>
<th></th>
<th>MSTU</th>
<th>HC</th>
<th>MC</th>
<th>Fairview</th>
<th>Medina</th>
<th>MYMT</th>
<th>AMC</th>
<th>LKWD</th>
<th>SP</th>
</tr>
</thead>
<tbody>
<tr>
<td># IV tPA Administration in ED</td>
<td>26</td>
<td>39</td>
<td>33</td>
<td>13</td>
<td>12</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Door to Drug (Target &lt;60 min)</td>
<td>33</td>
<td>75</td>
<td>64</td>
<td>71</td>
<td>60</td>
<td>88</td>
<td>57</td>
<td>56</td>
<td>67</td>
</tr>
</tbody>
</table>

6 month data
12 hrs/day operation

12 month data
MSTU Programs Comparison Worldwide
Number of Patients Who Benefit and Are Harmed per 100 Patients tPA Treated in Each Time Window

<table>
<thead>
<tr>
<th>Time Window</th>
<th>Benefit</th>
<th>Harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 hr</td>
<td>27.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1-2 hr</td>
<td>22.2</td>
<td>5.0</td>
</tr>
<tr>
<td>2-3 hr</td>
<td>15.9</td>
<td>5.0</td>
</tr>
<tr>
<td>3-4.5 hr</td>
<td>5.0</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Lansberg et al, Stroke 2009
Figure 2. Thrombolysis Rates in 60-Minute Intervals

- **STEMO care**
- **Conventional care**

**Patients, %**

<table>
<thead>
<tr>
<th>Time From Symptom Onset to Thrombolysis, min</th>
<th>Patients %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-60</td>
<td>10-12</td>
</tr>
<tr>
<td>61-120</td>
<td>14</td>
</tr>
<tr>
<td>121-180</td>
<td>5-6</td>
</tr>
<tr>
<td>181-240</td>
<td>3</td>
</tr>
<tr>
<td>241-270</td>
<td>1-2</td>
</tr>
</tbody>
</table>
Pre-hospital ICH

- Hemorrhagic strokes transported: 7
- Can offer BP control, anticoagulation reversal
  - 1st patient ever treated with K-centra (4 factor PCC) in the field
    - INR 3.2 on POC in MSTU
    - On arrival to NICU, INR normalized (1.1)
- Triage directly to neurosurgical center
Right Patient, Right Place, the First Time

Prior to MSTU

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch to Door</td>
<td>0:34</td>
</tr>
<tr>
<td>Door to CT</td>
<td>0:20</td>
</tr>
<tr>
<td>CT to IAT</td>
<td>4:04</td>
</tr>
<tr>
<td>Door to PSC departure</td>
<td>1:47</td>
</tr>
</tbody>
</table>

Mobile Stroke Treatment Unit

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatch to Door</td>
<td>0:19</td>
</tr>
<tr>
<td>Door to CT</td>
<td>0:12</td>
</tr>
<tr>
<td>CT to IAT</td>
<td>1:18</td>
</tr>
<tr>
<td>Door to MSTU departure</td>
<td>0:27</td>
</tr>
</tbody>
</table>

Thus far, no patients have required a second transfer
Concerns?

- Cost
- Traffic
- Politics
- Never work in my market
- No one will work together…
- Excuses! Don’t be pusillanimous!
Cost of a Mobile Stroke Treatment Unit

- Portable CT scanner: ~$400k
- Truck Chassis: $60-110k
- Ambulance Box: ~$150k
- Total Cost: ~$750k
- Personnel: ~$500k/yr

- One MSTU can service ~1M citizens
- ~10-15 year life expectancy
Specialized ambulances expedite stroke treatment

By Adam Rubenthr | January 4, 2016

Cleveland Clinic and the University of Texas Health Science Center at Houston have been leading clinical trials of mobile stroke unit vehicles, which enable hospitals to treat patients 40 minutes faster than traditional methods.

Armed with on-board imaging equipment, telemedicine equipment and lifesaving drugs, the ambulances provide faster treatment for stroke, which can cause brain damage with every passing moment. Experts say strokes often aren’t treated quickly enough.

"It’s about being responsible not only for the inpatient but what happens to that patient (before they arrive and) after they leave. When we thought about these topics we were thinking about that continuum," said Diane Robertson, director of health technology assessment information services at ECRI, ECRI, a membership organization that evaluates medical technologies.

The vehicles—which were pioneered in Germany—made ECRI Institute's Top 10 Hospital C-Suite Watch list for 2016. Many of the items help providers reduce costs and curb readmissions such as warm perfusion systems for donor organs, miniature leadless pacemakers and blue-violet LED light fixtures that kill bacteria.

MSUs are modified ambulances that include a mobile blood lab, a heads-only CT scanner and telemedicine equipment that can send diagnostic images and help first responders communicate with neurologists at the hospital. UT and Cleveland Clinic each launched a single vehicle in 2014 and exclusively used them for stroke cases. Care teams are dispatched by a 911 operator when it's believed a patient is having a stroke.

Workers on the units normally include a critical-care nurse, a CT technologist, a paramedic and a driver. Normally, the crew will perform CT scans and blood testing at the scene and begin transporting the patient while a diagnosis is made.
Telestroke was initiated in Fairview and Medina Hospitals in 2014. Their specific cumulative IVtPA experience before and after initiation of Telestroke capabilities are represented by the Pre-Telestroke and Post-Telestroke labels above.

The MSTU began operations in 2014; the data represents its IVtPA administration rate during its first year of operations.
CLE Old Stroke System of Care

With or without Telestroke…
CLE Current/Future Stroke System of Care

CSC Hub

EMS

PSC Spoke

With Telestroke…

Cleveland Clinic
Future Stroke System of Care?

CSC Hub

EMS

PSC Spoke

MSTU

PSC Spoke

PSC Spoke

PSC Spoke
Worldwide MSTU Programs

Denver and Toledo

Cleveland Clinic
Mobile Stroke Treatment Units: Popping Up All Over the Place!
Patients First

- the Rest will follow…
Summary - The “Right” Reasons to do this….

- No doubt about role of time in therapy… initiate treatment as fast as possible
- Low rates of IV tPA administration (and now IA therapy) despite stroke units and Joint Commission accreditation demand change to the System
- Brings highest level of expertise as soon as possible
- Intelligent triage decisions to maximize use of scarce resources
- Patients first: Will decrease neurologic deficit, disability and costs to society
- MSTUs are here to stay – will be a part of US stroke systems broadly
Acknowledgements

- City of Cleveland – Mayor Jackson/Marty Sweeney
- Cerebrovascular Center and Critical Care Transport
  - Michael Modic and Robert Wyllie
- Matt Stanton/Brian Perse (CV Center Administrators)
- Stacey Winners (MSTU Program Manager)
- Cleveland Pre-Hospital Acute Stroke Treatment (PHAST) Study Group
Cleveland Clinic

2016 International Mobile Stroke Summit: Transforming Stroke Care Through Innovative Stroke Systems

May 20-21, 2016
InterContinental Hotel and Conference Center
9801 Carnegie Ave
Cleveland, OH

For more information, including online registration, visit www.cccme.org/MobileStroke16
Cleveland Clinic

Every life deserves world class care.