Regional Stroke Systems of Care: Pre-hospital Comprehensive Stroke Center Triage Policies

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Organized Stroke Systems

Establishment of stroke systems of care

• Integrate fragmented systems across local, regional, state, and national lines

7 key components

• Primordial and primary prevention
• Community education
• Notification and response of EMS
• Acute stroke treatment
• Subacute stroke treatment and secondary prevention
• Rehabilitation
• Continuous quality improvement

Development of primary and comprehensive stroke center models including telemedicine for rural areas

Schwamm LH 2005
Recommendations for the Establishment of Primary Stroke Centers

Patient care areas

- Acute stroke teams
- Written care protocols
- Emergency medical services
- Emergency department
- Stroke unit*
- Neurosurgical services

Support services

- Commitment and support of medical organization; a stroke center director
- Neuroimaging services
- Laboratory services
- Outcome and quality improvement activities
- Continuing medical education

Alberts MJ JAMA 2000; 2011
Comprehensive Stroke Center

Primary Stroke Center

Acute Stroke Ready Hospital

Academic Medical Center
Tertiary Care facility

Wide range of hospitals;
standard stroke care; stroke unit;
use TPA

Rural hospitals; basic care;
drip and ship;
use tele-technologies

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Expected Benefits

Improved efficiency of patient care

Increased use of acute stroke therapies

Fewer peri-stroke complications

Reduced morbidity and mortality

Improved long-term outcomes

Reduced health care costs
NY State PSC Study

- 30,947 patients with acute ischemic stroke
- 2005-2006
- One year follow-up
- 15,297 admitted to a PSC
- Used 39,000 and 40,000 patients with GI hemorrhage and MI as internal controls

Xian JAMA 2011
Table 3. Mortality at Designated Stroke Centers and Nondesignated Hospitals

<table>
<thead>
<tr>
<th></th>
<th>Designated Stroke Center (n = 15 297)</th>
<th>Nondesignated Hospital (n = 15 650)</th>
<th>Adjusted Mortality Difference (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 d</td>
<td>90 (0.6)</td>
<td>134 (0.9)</td>
<td>−0.3 (−0.6 to −0.0)</td>
<td>.04</td>
</tr>
<tr>
<td>7 d</td>
<td>665 (4.3)</td>
<td>842 (5.4)</td>
<td>−1.3 (−2.1 to −0.6)</td>
<td>.001</td>
</tr>
<tr>
<td>30 d</td>
<td>1543 (10.1)</td>
<td>1951 (12.5)</td>
<td>−2.5 (−3.6 to −1.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>1 y</td>
<td>3412 (22.3)</td>
<td>4067 (26.0)</td>
<td>−3.0 (−4.4 to −1.5)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
**PERFECT Study-Finland**

- Compared outcomes among patients admitted to different types of hospitals
- Used BAC criteria for PSC and CSC
- Adjusted for baseline differences

<table>
<thead>
<tr>
<th>Outcome adjusted for patient demographics, OR (95% CI)</th>
<th>CSC = 20,045</th>
<th>PSC = 10,749</th>
<th>GH = 30,891</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case-fatality by 1 year</td>
<td>0.84 (0.80–0.89)</td>
<td>0.89 (0.84–0.94)</td>
<td>1</td>
</tr>
<tr>
<td>Institutional care at 1 year</td>
<td>0.87 (0.82–0.93)</td>
<td>0.89 (0.83–0.96)</td>
<td>1</td>
</tr>
<tr>
<td>Home at 1 year</td>
<td>1.22 (1.17–1.28)</td>
<td>1.16 (1.10–1.23)</td>
<td>1</td>
</tr>
</tbody>
</table>

Meretoja A, Stroke 2010
Identification of stroke patients and rapid mobilization of stroke teams is now commonplace in US

- Average DTN times < 60 minutes
- Still opportunities exist to achieve radical changes (< 20 minutes)
- Workflow efficiencies were engineered into positive endovascular trials
- Will continue to improve as systems approaches incorporated
### Target Stroke Results

<table>
<thead>
<tr>
<th>Study Period</th>
<th>Preintervention (n = 27319)</th>
<th>Postintervention (n = 43850)</th>
<th>Adjusted Odds Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>tPA DTN time, median (IQR), min</td>
<td>77 (60-98)</td>
<td>67 (51-87)</td>
<td></td>
<td>&lt; .001</td>
</tr>
<tr>
<td>tPA DTN time ≤ 60 min, % (95% CI)</td>
<td>26.5 (26.0-27.1)</td>
<td>41.3 (40.8-41.7)</td>
<td></td>
<td>&lt; .001</td>
</tr>
<tr>
<td>End of each period</td>
<td>29.6 (27.8-31.5)</td>
<td>53.3 (51.5-55.2)</td>
<td></td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Improvement in tPA DTN time ≤ 60 min, % per year (95% CI)</td>
<td>1.36 (1.04-1.67)</td>
<td>6.20 (5.58-6.78)</td>
<td></td>
<td>&lt; .001</td>
</tr>
<tr>
<td>In-hospital all-cause mortality, %</td>
<td>9.93</td>
<td>8.25</td>
<td>0.89 (0.83-0.94)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Discharge to home, %</td>
<td>37.6</td>
<td>42.7</td>
<td>1.14 (1.09-1.19)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Independent ambulatory status, %</td>
<td>42.2</td>
<td>45.4</td>
<td>1.03 (0.97-1.10)</td>
<td>.31</td>
</tr>
<tr>
<td>Symptomatic intracranial hemorrhage within 36 h, %</td>
<td>5.68</td>
<td>4.68</td>
<td>0.83 (0.76-0.91)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

**Time in Calendar Quarter and Year**

Fonarow G JAMA 2014
Pre-hospital Stroke Care

- Time-critical diseases require early response and treatments
- Many diseases have established a golden hour for treatment (trauma, STEMI, even sepsis)
- Golden hour for stroke also critical
  - Better outcomes with earlier thrombolytic therapy
- In the reperfusion era, increasing emphasis on EMS and response to stroke as part of chain of survival
Chain of Survival

- First medical contact increasingly presents opportunities for intervention

- In many ways, clock starts with first medical contact
## Stroke Chain of Survival

<table>
<thead>
<tr>
<th>DETECTION</th>
<th>Recognition of stroke signs and symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DISPATCH</strong></td>
<td>Call 9-1-1 and priority emergency medical services dispatch</td>
</tr>
<tr>
<td>DELIVERY</td>
<td>Prompt transport and prehospital notification to hospital</td>
</tr>
<tr>
<td>DOOR</td>
<td>Immediate emergency department (ED) triage</td>
</tr>
<tr>
<td>DATA</td>
<td>ED evaluation, prompt laboratory studies, and computed tomography imaging</td>
</tr>
<tr>
<td>DECISION</td>
<td>Diagnosis and decision about appropriate therapy</td>
</tr>
<tr>
<td>DRUG</td>
<td>Administration of appropriate drugs or other interventions</td>
</tr>
</tbody>
</table>

EMS Stroke Benchmarks

Dispatcher
- Dispatch all potential strokes as high-priority
- Training in stroke signs/symptoms
- < 60 seconds from call to dispatch of EMS responder

Paramedic
- Arrive on-scene within 9 minutes
- Determine the exact time of onset (LKN)
- Document stroke screening score
- Utilize thrombolytic checklist (short)
- Minimize scene time delays (< 15 minutes)
- Transport to the nearest PSC/CSC
- Pre-notify receiving hospital

Acker Stroke 2007
EMS in Stroke

- About 60% of strokes arrive by EMS in the US

- EMS arriving get tPA twice as often (25 vs. 13%)

Ekundayo Circ Cardiovasc Qual Outcomes 2013
# EMS and Pre-notification

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Door to Dr Evaluation</th>
<th>Door to CT</th>
<th>Door to needle</th>
<th>Chance of Reperfusion Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdullah</td>
<td>2008</td>
<td>--</td>
<td>17% shorter</td>
<td>--</td>
<td>41% vs 21% (among patients &lt;6 hrs)</td>
</tr>
<tr>
<td>Bae</td>
<td>2010</td>
<td>--</td>
<td>34% shorter</td>
<td>29% shorter</td>
<td>--</td>
</tr>
<tr>
<td>Bray</td>
<td>2005</td>
<td>52% shorter</td>
<td>35% shorter</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Goodacre</td>
<td>2004</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Quain</td>
<td>2008</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>21.4% vs. 4.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>EMS Prenotification</th>
<th>No EMS Prenotification</th>
<th>Absolute Difference (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door-to-imaging time, n, median (25th to 75th percentile), min (in patients arriving ≤3 h)</td>
<td>76 459</td>
<td>28 220</td>
<td>235 min</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-imaging time ≤25 min, (in patients arriving ≤3 h), %</td>
<td>26 (16–45)</td>
<td>31 (18–56)</td>
<td>+8.3% (7.6–8.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-imaging time, n, median (25th to 75th percentile), min</td>
<td>230 430</td>
<td>112 580</td>
<td>−13 min</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-imaging time ≤25 min, %</td>
<td>48.8%</td>
<td>40.5%</td>
<td>+8.5% (8.2–8.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-needle time, median (25th to 75th percentile), min</td>
<td>78 (60–100)</td>
<td>80 (60–103)</td>
<td>−2 min</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-needle time ≤60 min, %</td>
<td>27.0%</td>
<td>25.9%</td>
<td>+1.1% (0.0–2.1)</td>
<td>0.0583</td>
</tr>
<tr>
<td>Onset-to-needle time, median (25th to 75th percentile), min</td>
<td>141 (115–169)</td>
<td>145 (116–170)</td>
<td>−4 min</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Onset-to-needle time ≤120 min, %</td>
<td>31.9%</td>
<td>29.5%</td>
<td>+2.4% (1.2–3.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>tPA Rx rate (arrive by 2 h, treat by 3 h), n/n, %</td>
<td>22 305/30 541</td>
<td>7193/11 244</td>
<td>+9.0% (8.0–10.1)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Lin C Circulation 2012
The creation of PSCs is strongly recommended (Class I, Level of Evidence B). The organization of such resources will depend on local variables. The design of several community-based PSCs that provide emergency care and that are closely associated with a CSC, which provides more extensive care, has considerable appeal.

The development of CSC is recommended (Class I, Level of Evidence C).

Certification of stroke centers by an external body, such as JCAHO, is encouraged (Class I, Level of Evidence B). The panel encourages additional medical centers to seek such certification.

For patients with suspected stroke, EMS should bypass hospitals that do not have resources to treat stroke and go to the closest facility capable of treating acute stroke (Class I, Level of Evidence B).
PSC Triage – Houston

tPA use

Hospital 1: Preexisting Stroke Center
13/67 (19.4%)
27/171 (15.8%)

Hospital 2: 2/43 (4.7%)

Hospital 3: 7/103 (6.8%)
15/87 (17.2%)

Hospital 4: 4/28 (14.3%)
6/72 (8.3%)

Hospital 5: Preexisting Stroke Center
5/51 (9.8%)

Hospital 6: 2/34 (5.9%)
4/49 (8.1%)

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PSC Triage – New York City

Gropen T 2006
Table 3. Aggregate Results of Thrombolysis Treatment at Phoenix Metropolitan Matrix of PSCs

<table>
<thead>
<tr>
<th>Category</th>
<th>Patients*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Matrix of PSCs, July 2004 to June 2005</td>
<td>1800</td>
</tr>
<tr>
<td>Patients with ischemic stroke</td>
<td></td>
</tr>
<tr>
<td>Acute ischemic stroke patients (&lt;3 hours)</td>
<td>1104</td>
</tr>
<tr>
<td>Thrombolysis-eligible patients with acute ischemic stroke (&lt;3 hours)</td>
<td>520</td>
</tr>
<tr>
<td>Thrombolyzed patients with ischemic stroke</td>
<td>320</td>
</tr>
<tr>
<td>Patients presenting &lt;3 hours</td>
<td>61%</td>
</tr>
<tr>
<td>Patients thrombolyzed (expressed as a proportion of all hospitalized patients with ischemic stroke)</td>
<td>18%</td>
</tr>
<tr>
<td>Patients thrombolyzed (expressed as a proportion of all tPA-eligible patients with acute ischemic stroke)</td>
<td>62%</td>
</tr>
</tbody>
</table>
Primary Criteria
- < 6 hours from known stroke symptom onset
- Positive CSS (score 1-3)

Consider transport to nearest PSC if:
1. Time of onset < 6 hours
2. Abnormal CSS
3. + Relative criteria

Relative Criteria
- Sudden and persistent alteration of consciousness
- Sudden onset of severe headache in association with vomiting and SBP > 200 mmHg
- Severe and sudden loss of balance
Effect of EMS triage in Chicago

P = 0.830

P < 0.001

P = 0.009

Mar 2010 - Feb 2011

Mar 2011 - Feb 2012

Mar 2012 - Dec 2012

Percentage

Prabhakaran S 2013
Organized Stroke Systems
Organized Stroke Systems

San Mateo County, California
• 6 PSC and 2 CSC
• < 2.5 hr patients → nearest PSC
• 2.5-8 hr patients → nearest CSC
• >8 hr patients → nearest ER

Florida
• 112 PSC and 13 CSC

Massachusetts
• Hub-spoke model using telemedicine

New Jersey
• “Drip and Ship” and Hub-spoke models

New York, Georgia, Michigan, Illinois
A Rational Approach
Organized stroke systems (Hub/Spoke model)

1. PSC and CSC certification by external body
   – Stroke-ready hospitals (ER gives tPA) \(\rightarrow\) drip and ship
   – Telemedicine (rural)

2. Target populations
   – Suspected stroke with abnormal stroke screen (CSS, LAPSS)
   – Transfer policy to PSC/CSC for specific indications such as malignant MCA syndrome, interventional treatment, or complex diagnosis requiring greater expertise

3. Develop model based on specific needs of your city, region, or state
   – Need for external certification
   – Transfer policies and building stroke networks
   – Telemedicine as geography and finances mandate
   – Data collection and quality improvement
CSC Triage Guidelines

- Use validated pre-hospital scales (i.e. CPSS)
- Transport to highest level if < 15-20 minutes transport
- Transfer protocols
- Report outcomes publicly

Higashida RT. Stroke 2013
Integrating Fragmented Systems

Predicted Probability of Attempted IAT by Transfer Time

Prabhakaran S. Stroke 2011
Endovascular Workflow
**Endovascular QI: “P2P”**

### Association of P2P with Good Outcomes

<table>
<thead>
<tr>
<th>P2P Time, min</th>
<th>Patients/Total(%)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 90 )</td>
<td>17/31 (55.8)</td>
<td>Reference</td>
</tr>
<tr>
<td>91-180</td>
<td>24/73 (32.9)</td>
<td>0.30 (0.11-0.81)</td>
</tr>
<tr>
<td>181-270</td>
<td>18/52 (34.6)</td>
<td>0.32 (0.11-0.93)</td>
</tr>
<tr>
<td>&gt;270</td>
<td>10/37 (27.0)</td>
<td>0.18 (0.05-0.64)</td>
</tr>
</tbody>
</table>
Endovascular Workflow

- Similar efforts like Target Stroke for DTN
  - Goal door-to-GP < 90 minutes
- Transfers represent 10-30% of IA cases
  - Goal door-in-door-out time < 30 minutes like STEMI
  - Goal transport time < 60 minutes
- Stroke Systems of Care Modifications
  - Inter-facility transport protocols
  - CSC triage policies
  - Field criteria for large artery occlusion
    - CSS ≥ 2 approximates NIHSS 10
    - LAMS ≥ 4
CSC Field Triage Criteria

- Predictive value of CPSS on IV tPA, IA thrombolysis (You JS, AJEM)
- 284 consecutive AIS patients confirmed by ED diagnosis arriving within 6 hours in South Korea
- CPSS done by EMTs and NIHSS score by ED physicians
- Assessed cut-points of CPSS that predict interventions and NIHSS
- Distribution of CPSS: 146 < 2 (51.4%)

<table>
<thead>
<tr>
<th>Actual IV-tPA usage within 3 h of onset</th>
<th>Cut-off point</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>AUC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual IV-tPA or IA-UK usage within 6 h of onset</td>
<td>2</td>
<td>95.5% (90.4-100.0)</td>
<td>65.6% (59.3-71.9)</td>
<td>0.805 (0.765-0.846)</td>
</tr>
<tr>
<td>Comparison of CPSS and NIHSS score (5-22) within 3 h of onset</td>
<td>2</td>
<td>88.5% (82.3-94.6)</td>
<td>74.4% (68.1-80.8)</td>
<td>0.815 (0.770-0.859)</td>
</tr>
<tr>
<td>Comparison of CPSS and NIHSS (≥5) within 6 h of onset</td>
<td>2</td>
<td>89.2% (83.4-95.0)</td>
<td>77.5% (71.2-83.7)</td>
<td>0.833 (0.791-0.876)</td>
</tr>
</tbody>
</table>

Youden’s index = sensitivity + specificity - 1; AUC. area under the curve.

Table 2
Clinical outcomes of patients with ischemic stroke according to CPSS score

<table>
<thead>
<tr>
<th>CPSS score &lt;2 (n = 146)</th>
<th>CPSS score ≥2 (n = 138)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>85 (58.2%)</td>
<td>128 (92.8%)</td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>61 (41.8%)</td>
<td>10 (7.2%)</td>
</tr>
<tr>
<td>Actual therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV-tPA</td>
<td>2 (1.4%)</td>
<td>50 (36.2%)</td>
</tr>
<tr>
<td>IA-UK</td>
<td>1 (0.7%)</td>
<td>24 (17.4%)</td>
</tr>
<tr>
<td>IV-tPA or IA-UK</td>
<td>3 (2.1%)</td>
<td>63 (45.7%)</td>
</tr>
<tr>
<td>Median NIHSS (IQR)</td>
<td>1.0 (0.0-2.0)</td>
<td>10.5 (4.0-17.0)</td>
</tr>
<tr>
<td>NIHSS score 5-22</td>
<td>12 (8.2%)</td>
<td>92 (66.7%)</td>
</tr>
<tr>
<td>NIHSS score ≥5</td>
<td>12 (8.2%)</td>
<td>99 (71.7%)</td>
</tr>
</tbody>
</table>

Results are expressed as n (%) or median (IQR).
CSC Field Triage Criteria

- New specific scales being developed such as the Cincinnati Prehospital Stroke Severity Scale (CPSSS)

Cincinnati Prehospital Stroke Severity Scale

- 2 points: Conjugate gaze deviation (≥ 1 on NIHSS)
- 1 point: Incorrectly answers at least one of two level questions on NIHSS (age or current month) and do of two commands (close eyes, open and close hand for Level of Consciousness 1b and 1c)
- 1 point: Cannot hold arm (either right, left or both) before arm(s) falls to bed (≥ 2 on the NIHSS item)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Data Set</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PLR</th>
<th>NLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke severity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe (NIHSS≥15)</td>
<td>Derivation</td>
<td>89%</td>
<td>73%</td>
<td>3.30</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Validation</td>
<td>92%</td>
<td>51%</td>
<td>1.89</td>
<td>0.16</td>
</tr>
<tr>
<td>Moderate (NIHSS≥10)</td>
<td>Derivation</td>
<td>75%</td>
<td>85%</td>
<td>5.00</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Validation</td>
<td>79%</td>
<td>89%</td>
<td>7.18</td>
<td>0.24</td>
</tr>
<tr>
<td>LVO</td>
<td>Validation</td>
<td>83%</td>
<td>40%</td>
<td>1.38</td>
<td>0.42</td>
</tr>
</tbody>
</table>

LVO defined as occlusion sites of internal carotid artery, M1, tandem cervical internal carotid artery plus M2, or basilar arteries. LVO indicates large vessel occlusion; NIHSS, National Institutes of Health Stroke Scale; NLR, negative likelihood ratio; and PLR, positive likelihood ratio.

Katz B. Stroke 2015
Summary

- We are in a new era of stroke reperfusion therapy
- PSCs and CSCs improve outcomes
- Pre-hospital identification of CSC-appropriate patients is needed
  - Development of novel triage criteria underway
- Regional assessment of needs and CSC geospatial spread is required
  - 15-20 minutes of extra transport time is reasonable
  - Avoids lengthy intra-hospital transfer delays
  - Potential for over-triage however (false-positives)
- Continual quality improvement in stroke system of care is needed