The Evolving Role of EMS Routing: What Does This Mean for Me?

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  – Genentech PRISMS Study
  – NoNo, Inc (Brain Canada) FRONTIER (internal safety monitor)
  – ZZ Biotech, LLC (NIH) RHAPSODY(NIH DSMB)

• State and National Organizations
  – AHA/ASA committees and writing groups
  – SC Department of Health Stroke Advisory Committee Chair
  – Joint Commission Technical Advisory Panels
From Bench to Bedside

1. Establish Best Science
2. Determine Best Practice
3. Implement for Your Region
Establish Best Science
Lessons to Learned Over 20 Years

• Reperfusion
  – Singulately important
  – Maximize penumbral salvageability

• Time to reperfusion
  – Strong predicts clinical outcomes
  – Significant tolerance-heterogeneity in populations
  – *Should* drive all system development
Importance of Reducing DTN

**In-hospital Mortality**
- Reduced Symptomatic Intracranial Hemorrhage
- Increased Achievement of Independent Ambulation at Discharge
- Increased Discharge to Home

Improved Outcomes per 15 Minute Decrease in Door to Needle Times

(Saver JL. *JAMA*. 2013;309:2480-2488)
(Hargis M. *Clin Neurol Neurosurg*. 2015;135:79-84)
Time is Brain: EVT

Cases with angiographic reperfusion

30 minutes = 10%!

Cases without reperfusion

Probability of good clinical outcome

Time from symptom onset to angiographic reperfusion (minutes)
Impact of Timely Transfer: STEMI

Figure 1. Distribution of DIDO Times Among 14,821 Patients With STEMI Transferred for Primary Percutaneous Coronary Intervention

Figure 3. Association of DIDO Time With In-Hospital Mortality

(Wang, JAMA. 2011;305(24):2540-2547)
So, If Time Matters

• Focus on what matters, *timely*:
  – Stroke recognition
  – EMS activation and transport
  – Initial reperfusion strategies
  – Initiation of secondary prevention strategies
  – Rehabilitation evaluation
  – Prevention of complications
  – Patient and family involvement
Establish Best Science

Determine Best Practice
Target: Stroke - Strategies

• National QI to increase rates of DTN < 60 mins
  – 1030 GWTG-Stroke Hospitals
  – Pre 2003-2009 / Post 2010-2013

• Interventions
  - EMS prehospital notification
  - Stroke tools and tool kits
  - Rapid triage protocol and stroke team notification
  - Single call activation system
  - Direct transfer to CT scanner
  - Rapid CT and interpretation
  - Rapid laboratory testing / POC
  - Mix alteplase ahead of time
  - Rapid access & rtPA initiation
  - Team-based approach
  - Prompt data feedback

(Fonarow, JAMA. 2014;311:1632-1640)
Optimizing Processes for EVT

Acute Stroke: Door to Intra-Arterial Therapy

Questions? Page x33722 - Neuroendovascular Service

The success of Target Stroke fostered Target Stroke Part II

- Increasingly data driven (GWTG: Stroke)
- Move the needle for IV alteplase
  - Reset the thermostat: Even faster DTN
- Key practices which remain under utilized
  - Alteplase stored in ED (70%)
  - Premixing alteplase (25%)
  - IV alteplase bolus in CT (0%)
  - Patient taken directly to CT scan (40%)
Target: Stroke Part 2

- Participating hospitals:
  - Number beds 308
  - 40% PSC, 7% CSC
  - Annual median IVT 14
  - 16 strategies associated with improved DTN
  - Implementing all strategies could reduce DTN 20 mins (95% CI 15-25)

(Xian, Circ Cardiovasc Qual Outcomes. 2017;10)
Establish Best Science

Determine Best Practice

Implement for Your Region
Now How Best Use These Treatments Trends in Stroke Organization

• Develop regionalization of stroke systems of care based on best practice
  – State-based / regional planning
    • Departments of Health critical to affecting change
    • All stakeholders engaged from the beginning
    • Build on previous regional success (STEMI)
  – Increase hospital capabilities widely
  – Regionalization extends beyond EMS and triage, timely transfers to better equipped hospitals may need to occur
ASA Policy Recommendations

Recommendations for the Establishment of Stroke Systems of Care
Recommendations From the American Stroke Association’s Task Force on the Development of Stroke Systems

Interactions Within Stroke Systems of Care: A Policy Statement From the American Heart Association/American Stroke Association

(Schwamm, Circulation 2005;111:1078-191)
(Higashida, Stroke 2013;44)
# Hospital Stroke Capabilities

**Table 1. Some Characteristics of Typical Acute Inpatient Stroke Care Facilities**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Hospital Type</th>
<th>Non-Stroke Center</th>
<th>ASRH</th>
<th>PSC</th>
<th>CSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical bed count</td>
<td></td>
<td>20–50</td>
<td>30–100</td>
<td>100–400</td>
<td>400–1500</td>
</tr>
<tr>
<td>Annual stroke admissions</td>
<td></td>
<td>10–50</td>
<td>25–50</td>
<td>50–300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Rapid neuroimaging 24/7*</td>
<td>No</td>
<td></td>
<td>Performed and read within 45 min of order</td>
<td>Performed and read within 45 min of order</td>
<td>Performed and read within 45 min of order</td>
</tr>
<tr>
<td>IV tPA capability 24/7</td>
<td>No</td>
<td></td>
<td>60-min door-to-needle time</td>
<td>60-min door-to-needle time</td>
<td>60-min door-to-needle time</td>
</tr>
<tr>
<td>Acute stroke team available</td>
<td>No</td>
<td></td>
<td>At bedside within 15 min</td>
<td>At bedside within 15 min</td>
<td>At bedside within 15 min</td>
</tr>
<tr>
<td>Stroke unit</td>
<td>No</td>
<td>No†</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neurocritical care unit</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Access to neurosurgical services</td>
<td>No</td>
<td>Yes, within 3 h or by transfer‡</td>
<td>Yes, within 2 h, in-house or by transfer</td>
<td>Yes, 24/7 coverage and call schedule</td>
<td></td>
</tr>
</tbody>
</table>

(Higashida, *Stroke* 2013;44)
The Challenge

• Not every patient needs a CSC nor can they get there

• The right place for the right patient the first time
  – CSC for SAH, ICH, severe AIS
  – PSC for AIS and alteplase treatment, as well as stroke unit care
  – ASRH for AIS and timely transfer is essential
  – Ensuring appropriate interactions between system members will benefit our patients
Volume Matters

- Safe Implementation of Thrombolysis in Stroke registry
- “Center volume had more robust effect on DTN than year of treatment, and the shortest DTNs were seen in centers with volumes ≥ 100 patients/year. Earlier enrollment period was also associated with shorter delays.”

(Strbian, *Stroke*. 2015;46:1275-1280)
Volume Matters

- Hospital Morbidity and Mortality Database managed by the Canadian Institute for Health Information

**Results:** Overall, 26,676 patients with ischemic stroke were admitted to 606 hospitals. Seven-day stroke mortality was 7.6% and mortality at discharge was 15.6%. Adverse outcomes were more frequent in patients treated in low-volume facilities (<50 strokes/year) than in those treated in high volume facilities (100 to 199 and >200 strokes patients/year) (for 7-day mortality: 9.5 vs 7.3%, p < 0.001; 9.5 vs 6.0%, p < 0.001; for discharge mortality: 18.2 vs 15.2%, p < 0.001; 18.2 vs 12.8%, p < 0.001). The difference persisted after multivariable adjustment or when hospital volume was divided into quartiles.

**Conclusions:** High annual hospital volume was consistently associated with lower stroke mortality. Our study encourages further research to determine whether this is due to differences in case mix, more organized care in high-volume facilities, or differences in the performance or in the processes of care among facilities.

SEVERITY-BASED STROKE TRIAGE ALGORITHM FOR EMS

ON SCENE
- Interview patient, family members and other witnesses to determine onset known well (OKW) time and time of symptom discovery.
- Attempt to identify possible stroke mimics (e.g., seizures, migraines, intoxication) and determine if patient has pre-existing substantial disability (need for nursing home care or inability to walk without help from others).
- Encourage family to go directly to ED.
- ED if not transported, with patient and obtain mobile number of next of kin and witnesses.
- If Mobile Stroke Unit available—follow Mobile Stroke Unit Protocol.

Each EMS agency should utilize a published and validated stroke screen to assess patients with non-traumatic acute onset neurologic deficits and validated tool to assess possible Large Vessel Occlusion (LVO).
- Patients who are eligible for IV Alteplase if transported to nearest ASRM or PSC should not be remoted to a CSC or EVT-capable Center if doing so would result in a delay that would make them ineligible for IV Alteplase.
- Collect current medications (especially anticoagulants) and co-morbid conditions (e.g. Serious kidney or liver disease, recent surgery, procedures or stroke) that may impact treatment decisions. Do not delay transport in collecting this information.
Transportation Options for Optimal Outcomes

- Statistical probability model comparing Drip ‘n Ship vs Mothership
- Data from ESCAPE and GWTG Stroke
- Assumes patients with LVO identified with LAMS >4

(Holodinsky, *Stroke*. 2017; 48:223-238)
Transportation Options for Optimal Outcomes

<table>
<thead>
<tr>
<th>Actual Data</th>
<th>Ideal Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endovascular Centre</td>
<td>Endovascular Centre</td>
</tr>
<tr>
<td>Non-Endovascular Centre</td>
<td>Non-Endovascular Centre</td>
</tr>
</tbody>
</table>

Model A. Base Model with 60 minute door to needle time and 90 minute (mothership) or 50 minute (drip and ship) door to arterial access time

Model B. Base Model adjusted to decrease door to needle time to 30 minutes and door to arterial access time to 75 minutes (mothership) and 45 minutes (drip and ship)

Legend
- 5-minute concentric travel time circles originating from the non-endovascular centre
- Travel time as the crow flies between non-endovascular centre and endovascular centre
- Mothership model superior
- Drip and Ship model superior

(Holodinsky, *Stroke*. 2017; 48:223-238)
Transportation Options for Optimal Outcomes

- Statistical probability model for California

<table>
<thead>
<tr>
<th></th>
<th>Drip ‘n Ship, min</th>
<th>Mothership, min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset-to-first medical response</td>
<td>30, 60, 90</td>
<td>30, 60, 90</td>
</tr>
<tr>
<td>Time on-scene</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Scene to door</td>
<td>Geographic model</td>
<td>Geographic model</td>
</tr>
<tr>
<td>Door-to-needle</td>
<td>30, 60, 90</td>
<td>30*</td>
</tr>
<tr>
<td>Needle-to-door-out</td>
<td>20</td>
<td>NA</td>
</tr>
<tr>
<td>PSC to CSC</td>
<td>Geographic model</td>
<td>NA</td>
</tr>
<tr>
<td>Door-to-reperfusion</td>
<td>115*</td>
<td>115*</td>
</tr>
</tbody>
</table>

(Milne, *Stroke*. 2017;48)
Transportation Options for Optimal Outcomes

- Does not model accuracy of LVO identification in the field
- Function of DTN and onset times
- **Mothership** best if
  - <30’ triage bypass
  - PSC DTN > 30’

(Milne, *Stroke*. 2017;48)
Limitations to the Models

• Does not address
  – LVO detection in field
  – Impact on transfer delay on remaining eligible for EVT on arrival (CTP, ASPECTS)
  – Geographic circumstances (weather, air/ground transport considerations, ambulance availability)
  – Day of week, time of day variations
  – Economic analyses required as part of the next iteration
So What Will That Look Like?
South Carolina Case Study

- South Carolina
  - Volumes for 3-5 CSC
  - All others could/should be PSC or ASRH by current requirements (PSC+)
  - Rate limiting issue likely personnel
  - Cross state cooperation ideal
  - 96% covered by stroke centers
Average REACH DTN By Year

- 2008: 99 minutes
- 2009: 103 minutes
- 2010: 93 minutes
- 2011: 98 minutes
- 2012: 91 minutes
- 2013: 75 minutes
- 2014: 73 minutes
- 2015: 66 minutes
- 2016: 61 minutes
Treating More Stroke Patients and Keeping More in Their Community

Number of Consultations
McLeod Health
Cheraw, Dillon, Loris & Seacoast

% Transferred to MUSC
McLeod Health
Cheraw, Dillon, Loris & Seacoast
Field Triage of LVO By RACE Score

- RACE comparable with NIHSS to predict LVO (c-statistic, 0.85; 95% CI, 0.81–0.89)
  - RACE > 4
  - Sens 85%, Spec 68%
  - PPV 0.42, NPV 0.94
- Best overall accuracy for the NIHSS scale was achieved for a score of ≥11, with a sensitivity 0.88, specificity 0.72, and overall accuracy 0.76

(Perez, *Stroke*. 2014;45:87-91)
What Would Triage Look Like Here?

15 Minute Drive Time

30 Minute Drive Time
What Could Go Wrong?

• EMS
  – Lack of specificity in LVO tools (FP, FN)
  – Longer transports, especially for rural agencies

• Hospitals
  – CSC over-crowding
  – Impedes PSC evolution to CSC
  – Limit non-CSC experience with severe strokes (non-reperfusion candidates, in-house, etc.)
Take Home Points

• Best science exists, we need to implement
• All hospitals have a role in optimizing stroke care
• Time dependent nature of reperfusion will require aggressive early identification, triage, and treatment
• Measure so you can manage!