Stroke Systems of Care and Optimizing Acute Stroke Care for All Patients

Edward C. Jauch, MD, MS
Professor, Director, Division of Emergency Medicine
Professor, Department of Neurosciences
Medical University of South Carolina
Professor, Department of Bioengineering
Clemson University
Disclosures

• Research support
  – NIH/NINDS SC-CoAST / StrokeNet (hub); NETT (spoke)
  – Genentech PRISMS Study Executive Committee
  – Ischemia Technologies BASES Study
  – Covidien, Penumbra POSITIVE Study Executive Committee
  – NoNo, Inc (Brain Canada) FRONTIER Study (internal safety monitor)
  – ZZ Biotech (NIH) RHAPSODY Trial (DSMB)

• Consultant
  – Pulse Therapeutics Magnetic nanoparticles for stroke

• State and National Organizations
  – AHA/ASA committees and writing groups
  – Chair, SC Department of Health Stroke Oversight Committee
  – Joint Commission ASRH, PSC, and CSC Technical Advisory Panels
Objectives

• Review and highlight current standard of care for stroke, especially new advances in large vessel occlusions
• Discuss creating regional stroke systems of care to optimize patient care
• Identify challenges and opportunities for addressing barriers to acute stroke care
• Discuss the near future of stroke care and how we will be measured
The Why: Global Stroke Mortality

- Global burden

<table>
<thead>
<tr>
<th></th>
<th>Incidence</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>250</td>
<td>25.94</td>
</tr>
<tr>
<td>SC</td>
<td></td>
<td>47.5</td>
</tr>
<tr>
<td>KSA</td>
<td>29.8*</td>
<td>126.77</td>
</tr>
<tr>
<td>Indonesia</td>
<td>200.2</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>21.2</td>
<td></td>
</tr>
</tbody>
</table>

(Mozaffarian *Circulation*. 2015;131:e29-e322)
The Why:
Patient Aversion to Outcomes

- Language deficits
- Cognitive deficits
- Motor deficits
- Death

Mild
Moderate
Severe

(Solomon, Stroke. 1994)
Science Translation: From Bench to Bedside

1. Establish Best Science
2. Determine Best Practice
3. Implement for Your Region
Establish Best Science
What Does this Mean in Stroke – What is Our Window?

CBF Thresholds for Preservation of Function and Structure

- Normal function
- Functional impairment: biochem, alterations, suppression of EEG and EP, cessation of single cell activity
- Membrane failure
- Single cell necrosis
- Viable tissue
- "Penumbra"
- Infarction

CBF (ml/100g/min)

0 10 20 30 40 50

0 30 60 90 120 min

0 4 5 6 24 48 h
Lessons to Learned Over 20 Years

• Reperfusion critical
  – Minimize delay
  – Maximize penumbral salvageability
    • Collateral flow
    • Physiologic optimization

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

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)
Other Time Dependent Neurologic Emergencies Requiring Systems

- Altered Mental Status
- Coma / Cardiac Arrest
- Stroke / TIA
- Weak & Dizzy
- Traumatic Brain Injury
Time is Brain: Intracerebral Hemorrhage

- **ICH (N=188)**
  - **Overall mortality**: 44%
  - **0-29 cm³**: Mortality 19%
  - **30-60 cm³**: Mortality 20%-55%
  - **≥60 cm³**: Mortality 91%

Only 1 of 71 patients with ICH volume ≥30 cm³ functioned independently at 30 days (Oxford Handicap Score ≤3) (Broderick, Stroke. 1993;24:987-993)

**Ping-pong ball vs Golf ball**
- Ping-pong ball: 28.0 mL
- Golf ball: 40.8 ml
Cool strategy saves runner

Therapeutic hypothermia used after 74-year-old collapses

By David Quick
The Post and Courier
Tuesday, June 16, 2009

Herb Rawlings doesn't remember much about this year's Cooper River Bridge Run after he, his younger daughter and her husband split up at the base of bridge's incline.

But minutes later, nearing the crest, the 74-year-old Mount Pleasant man collapsed, suffering his second of two heart attacks in nearly nine years. Luckily, he was near emergency medical crews and received immediate treatment.
So, If Time Matters for the Brain

• 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
Stroke Chain of Survival

- Detection: Early recognition
- Dispatch: Early EMS activation
- Delivery: Transport & management
- Door: ED triage
- Data: ED evaluation & management
- Decision: Neurology input, therapy selection
- Drug: Thrombolytic & future agents
- Disposition: Admission or transfer
Dispatch: 911
Delivery: Transport & Management
Door: Triage

- 911 dispatch / EMD
- EMS prehospital interventions
  - Neurologic evaluation
  - Time of onset / LKN
  - Glucose
  - Early prehospital notification
  - Means of transport (air medical?)
  - Transport family

- Triage to the *appropriate* stroke center

(Silliman Stroke. 2003;34:729 –733)
Door:  Emergent Triage
Data:  Emergent Evaluation
NINDS Recommendations and ACLS Guidelines

- Door-to-MD: 10 minutes
- Door-to-Stroke: 15 minutes

Team notification:

- Door-to-CT scan: 25 minutes (80% compliance)
- Door-to-Drug: 60 minutes
- Door-to-Admission: 3 hours

(Jauch, ACLS Stroke 2010)

(European Stroke Initiative Executive Committee, *Cerebrovasc Dis* 2003;16:311–337)

(NINDS National Symposium on Acute Stroke, 2003)
Decision: Team Approach
Drug: IV, IA, Mechanical, Other
Recanalization Strategies

- FDA cleared interventions:
  - IV tPA (0-3 hours)  Approved 1996
  - IV tPA (3-4.5 hours)  Denied request 2012
  - Thrombectomy devices  Cleared for clot removal
  - Second generation EVT  New guidelines for 2015

<table>
<thead>
<tr>
<th>Time Window</th>
<th>0-3 hrs</th>
<th>3-4.5 hrs</th>
<th>4.5-6 hrs</th>
<th>&gt; 6 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Options</td>
<td>IV tPA</td>
<td>IV tPA</td>
<td>Device</td>
<td>Device?</td>
</tr>
<tr>
<td></td>
<td>Device</td>
<td>Device</td>
<td></td>
<td>Penumbra-based</td>
</tr>
</tbody>
</table>
Disposition (Care Transition)

- **Hyperacute Patient: Ischemic Stroke**
  - ED Care
  - Emergent Imaging
  - Dx and Rx
  - Possible IV tPA

- **Transfer to Stroke Unit**
  - Continue evaluation
  - Monitoring for progression and bleeding

- **Transfer to Floor**
  - Begin prevention measures
  - Prepare for rehabilitation

- **Hyperacute Patient: Large Ischemic Stroke**
  - ED Care
  - Dx and Rx
  - Advanced Imaging
  - Possible IV tPA

- **Transfer to Endovascular Suite**
  - IV tPA
  - Endovascular Therapy
  - Anesthesia support

- **Transfer to NICU**
  - Ongoing Care
  - Monitor for Complications

- **Hyperacute Patient with ICH/SAH**
  - ED Dx and Care
  - Begin imaging
  - Control/reverse bleeding

- **Transfer to OR for surgery**
  - Hematoma removal
  - Aneurysm clipping
  - Hemicraniectomy

- **Transfer to NICU**
  - Post-CP care
  - Monitor for complications
Other Considerations:
Why EM is Neurology’s Friend

• Comorbidity management
  CHF  AMI  Aortic dissection

• Complication management
  – Angioedema
  – Respiratory compromise
  – Bleeding / hypotension
  – Malignant cerebral edema

• No inpatient beds, transfers
Establish Best Science

Determine Best Practice

Implement for Your Region
Stroke Care in 2016

• It is simple
  – Build a system
    • All stakeholders
  – Do it fast
  – Do it safely
  – Do it as a team
    • Regional system, EMS, in hospital
<table>
<thead>
<tr>
<th>Teamwork competencies</th>
<th>Definition</th>
<th>Behavioural examples</th>
</tr>
</thead>
</table>
| Team leadership       | Ability to direct and coordinate the activities of other team members, assess team performance, assign tasks, develop team KSA's, motivate team members, plan and organise, and establish a positive atmosphere. | Facilitate team problem solving  
Provide performance expectations and acceptable interaction patterns  
Synchronise and combine individual team member contributions  
Seek and evaluate information that impacts team functioning  
Clarify team member roles  
Engage in preparatory meetings and feedback sessions with the team |
| Mutual performance monitoring | Ability to develop common understandings of the team environment and apply appropriate task strategies in order to accurately monitor team mate performance. | Identifying mistakes and lapses in other team members actions  
Providing feedback regarding team member actions in order to facilitate self correction |
| Backup behaviour       | Ability to anticipate other team members’ needs through accurate knowledge about their responsibilities. Includes the ability to shift workload among members to achieve balance during high periods of workload or pressure. | Recognition by potential back up providers that there is a workload distribution problem in their team  
Shifting of work responsibilities to underutilised team members  
Completion of the whole task or parts of tasks by other team members |
| Adaptability/flexibility | Ability to adjust strategies based on information gathered from the environment through the use of compensatory behaviour and reallocation of intrateam resources; altering a course of action or team repertoire in response to changing conditions (internal or external). | Identify cues that a change has occurred, assign meaning to that change, and develop a new plan to deal with the changes  
Identify opportunities for improvement and innovation for habitual or routine practices  
Remain vigilant to changes in the internal and external environment of the team |
| Team/collective orientation | Propensity to take others’ behaviour into account during group interaction and the belief in the importance of team goal’s over individual member’s goals. | Taking into account alternative solutions provided by team mates and appraising that input to determine what is most correct  
Increased task involvement, information sharing, strategising, and participatory goal setting |

(Burke, Qual Saf Health Care 2004;13(Suppl 1):i96–i104)
Create an *Expert Team*
Hospital Stroke Capabilities
You will work in one of these

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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Non-Stroke Center</th>
<th>ASRH</th>
<th>PSC</th>
<th>TSC</th>
<th>CSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical bed count</td>
<td>20–50</td>
<td>30–100</td>
<td>100–400</td>
<td></td>
<td>400–1500</td>
</tr>
<tr>
<td>Annual stroke admissions</td>
<td>10–50</td>
<td>25–50</td>
<td>50–300</td>
<td></td>
<td>&gt;300</td>
</tr>
<tr>
<td>Rapid neuroimaging 24/7*</td>
<td>No</td>
<td>Performed and read within 45 min of order</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV tPA capability 24/7</td>
<td>No</td>
<td>60-min door-to-needle time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute stroke team available</td>
<td>No</td>
<td>At bedside within 15 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke unit</td>
<td>No</td>
<td>No†</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurocritical care unit</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td></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>
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.

(Saposnik, Neurology. 2011;69:1142-1151)
Benefits of Quality Improvement

• Studies suggest improved processes of care in GWTG-Stroke–participating hospitals

• This improved care now shown to translate into improved *clinical outcomes* compared with nonparticipating hospitals
  – 366 GWTG-Stroke hospitals, 88584 patients
  – 366 non–GWTG-Stroke hospitals 85401 patients

(Song, *Stroke*. 2016;47:1-9)
Figure 2. Ratio of changes in outcomes, from Pre time period to Run-Up, Warm-Up, and Sustained time periods, at Get With The Guidelines (GWTG)-Stroke hospitals vs matched non-GWTG-Stroke hospitals, for outcomes of discharge to home (A), 30-day mortality (B), and 1-year mortality (C).
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)
The Challenge

• Not every patient needs a CSC
• Goal: right place for the right patient the first time
  – CSC for SAH, ICH, severe AIS
  – “TSC” for regions without CSC
  – 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
CSC Care Is Not Just EVT!

- Don’t be mesmerized solely on EVT
- EVT is a great advance but
  - 10-20% eligible
  - Not all reperfuse
  - Not all do well
  - Many require NSICU
  - Global care, expert team and practice make the difference
Maximizing Pre-hospital Processes

- Real time evaluation, monitoring & tracking by app of mobile stroke unit to hospital
- Bypass to CSC if high NIHSS
- Direct ED door to CTA or angio suite
- Delivery of tPA in the field by mobile unit teleneurology / teleradiology, point-of-care lab & CT scanner
- Administration of other prehospital interventions (TEMPO-EMS)
Potential Impact of EMS Triage

- Extra EMS time made up by faster DTN
- Faster DTG without additional imaging and transfer
# Stroke Clinical Tools for EMS

## Stroke Scales
- Cincinnati Prehospital Stroke Scale (CPSS / FAST)
- Los Angeles Prehospital Stroke Screen (LAPSS)
- Melbourne Ambulance Stroke Screen (MASS)
- Miami Emergency Neurologic Deficit (MEND)
- Recognition of Stroke in the Emergency Room Score (ROSIER)

## Stroke Scores
- National Institute of Health Stroke Scale (NIHSS)
- sNIHSS -5 / 8
- Cincinnati Prehospital Stroke Severity Screen (CPSSS)
- Field Assessment Stroke Triage for Emergency Destination (FAST-ED)
- Los Angeles Motor Scale (LAMS)
- Rapid Arterial Occlusion Evaluation Score (RACE)
- Three Item Stroke Scale (3ISS)
So Where Do I Go?
SEVERITY-BASED STROKE TRIAGE ALGORITHM FOR EMS

Upon arrival, provide any needed ABC interventions then dispatch to the next level of provider if necessary for unstable patients and/or intubated patient, family and other witnesses.

Perform and document results of pre-hospital stroke identification screens (HESS, LAPS2, etc.) and POC blood glucose.

STRIKE SCREEN POSITIVE: STROKE SUSPECTED?

YES

No (stroke is ruled out or not suspected)

Transport to CSC will not precede use of IV alteplase?

YES

Transport to CSC will not precede use of IV alteplase?

NO

Direct transport to CSC within less than or equal to 60 minutes?

YES

Call stroke alert, pre-notify receiving facility and transport to the closest appropriate stroke center (ASB, PSC, CSC) per your regional stroke system of care policy.

NO

Identify and document time last known well & time of symptom discovery.

LION LESS THAN 6 HOURS?

YES

NO

LION 6 HOURS?

YES

NO

UVO SUSPECTED?

YES

NO

Perform and Document results from severity tool used to assess potential UVO (IAMS, RACE, CSTAT, FAST-ED, etc.)

Call Stroke Alert, pre-notify receiving facility and transport to the closest appropriate stroke center (ASB, PSC, CSC) per your regional stroke system of care policy.

ON SCENE

- Interview patients, family members and other witnesses to determine last known well (LKW) time and time of symptom discovery
- Attempt to identify possible stroke warning signs, symptoms, intubation and determine if patient has pre-existing cardiovascular disease (not for nursing home or instability to work with help from others)
- Encourage family to go directly to E.R.
- ED if not transported with patient and obtain mobile number of next of kin and witness
- 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 onset of focal neurological deficits and validated tool to assess possible Large Vessel Occlusion (LVO)
- Patients who are eligible for IV Alteplase if transported to nearest ASB or PSC should not be transported to a CSC or IVT-capable Center if doing so would result in a delay that would make them ineligible for IV Alteplase
- Collect current medications (especially anticoagulants and anti-platelets) cardiac history or other diseases, acute surgery, procedures or stroke that may impact treatment decisions. Do not delay transport in collecting the 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>30 mins between Endovascular Capable and Non-Endovascular Capable</td>
<td></td>
</tr>
<tr>
<td>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</td>
<td>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)</td>
</tr>
</tbody>
</table>

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>Table. List of Time Assumptions Made in the Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Onset-to-first medical response</td>
</tr>
<tr>
<td>Time on-scene</td>
</tr>
<tr>
<td>Scene to door</td>
</tr>
<tr>
<td>Door-to-needle</td>
</tr>
<tr>
<td>Needle-to-door-out</td>
</tr>
<tr>
<td>PSC to CSC</td>
</tr>
<tr>
<td>Door-to-reperfusion</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
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 (nonreperfusion candidates, in-house, etc)
Maximize Resources, Predefined Roles, Parallel Processing

Code Stroke

Admitting
- Patient ID
- Registration
- Room assign

CT tech
- CT scan

Nurse #1
- IV placement
- Monitor hook-up
- Vital sign monitoring
- Blood glucose
- Lab draw
- Weight estimate

Nurse #2
- History
- Meds/allergies
- Order r-tPA

ED resident
- NIHSS
- Neuro exam

Neurology resident
- ID witness
- Time of onset

Social worker
- Emergent transport of bloods to lab

ED tech
- Calculate r-tPA dose
- Prepare r-tPA

Pharmacist

Decision

Bolus and infuse r-tPA

(Ford Stroke. 2012;43:3395-3398)
Learn From Industry – Toyota Value Stream Analysis

A Pre-VSA Acute Stroke Protocol

Patient Arrival

Trauma Bay
- Neuro MD*: Brief Hx/Begins NIHSS
- RN: IV, STAT CBC/INR/PTT
- Tech: Vitals, ECG

Head CT*

Trauma Bay
- Neuro MD*: Completes NIHSS, Obtains witness for time of onset, calls Chief Resident to make decision
- RN*: BP med administration, Calculates dose and prepares tPA

TPA Delivery

B Post-VSA Acute Stroke Protocol

Patient Arrival

Head CT*

Trauma Bay
- ED and Neuro MDs*: Time of Onset/NIHSS
- RN: IV, POC INR®, STAT CBC/PTT, BP Med administration
- Tech: Vitals, ECG
- Pharmacist*: calculates dose and prepares tPA
- Social Worker*: obtains witness for time of onset
- Neuro MD: Calls Chief Resident to make decision*

TPA Delivery

Table 2. Protocol Metrics and Outcomes Pre- and Post-VSA

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Door-to-needle time, min*</td>
<td>60 [46–73]</td>
<td>39 [28–56]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Percent patients with DNT ≤ 60 min</td>
<td>52%</td>
<td>78%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Onset-to-needle time, min*</td>
<td>131 [105–165]</td>
<td>111 [80–158]</td>
<td>0.016</td>
</tr>
<tr>
<td>Door-to-CT time, min*</td>
<td>16 [10–22]</td>
<td>1 [0–4]</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-CBC time, min*</td>
<td>22 [16–29]</td>
<td>24 [17–34]</td>
<td>0.13</td>
</tr>
<tr>
<td>Door-to-PTT time, min*</td>
<td>34 [29–42]</td>
<td>40 [31–47]</td>
<td>0.14</td>
</tr>
<tr>
<td>Symptomatic ICH</td>
<td>3.0%</td>
<td>3.4%</td>
<td>1.0</td>
</tr>
<tr>
<td>Favorable discharge location‡</td>
<td>76%</td>
<td>83%</td>
<td>0.24</td>
</tr>
<tr>
<td>90-d mRS 0 to 2§</td>
<td>49%</td>
<td>43%</td>
<td>0.34</td>
</tr>
<tr>
<td>Stroke mimic</td>
<td>6.8%</td>
<td>11.5%</td>
<td>0.33</td>
</tr>
</tbody>
</table>

(Ford Stroke. 2012;43:3395-3398)
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)
### Target: Stroke

![Logo](TARGETSTROKE.png)

<table>
<thead>
<tr>
<th>Study Period</th>
<th>Preintervention (n = 27,319)</th>
<th>Postintervention (n = 43,850)</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><strong>5.68</strong></td>
<td><strong>4.68</strong></td>
<td>0.83 (0.76-0.91)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

(Fonarow, *JAMA*. 2014;311:1632-1640)
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

<table>
<thead>
<tr>
<th>DIDO Time, min</th>
<th>Mortality, No. of Patients/Total (%)</th>
<th>Adjusted Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤30</td>
<td>43/1600 (2.7)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>31-60</td>
<td>192/4841 (4.0)</td>
<td>1.34 (0.96-1.86)</td>
</tr>
<tr>
<td>61-90</td>
<td>146/3013 (4.9)</td>
<td>1.41 (0.96-2.06)</td>
</tr>
<tr>
<td>&gt;90</td>
<td>430/5176 (8.3)</td>
<td>1.86 (1.36-2.54)</td>
</tr>
</tbody>
</table>

(Wang, JAMA. 2011;305(24):2540-2547)
Optimizing Processes for Transfer

- Drip and Ship vs Mothership
  - ASPECTS >7  50% vs 76%
  - mRS 0-2  29% vs 51%
- Every minute delay in transfer decreased IAT eligibility by 1%
- Suggestions for optimizing transfer
  - Contact CSC early on (referring ED vs neurology)
  - Arrange transfer before CT based on severity
  - Transfer based on NCCT and NIHSS vs CTA
  - Straight to NIR is short transfer (vs ED / CT)

Optimizing Processes for Transfer

• The nuts and bolt - Plan ahead!
  – Know who, how and when
  – Train on post-tPA protocol
    • Blood pressure & bleeding precautions
    • Angioedema
    • Follow the neuro exam
    • Ensure communication en route
  – Know where to go when you get there
  – Like EMS, provide feedback
Optimizing Processes for EVT

Acute Stroke: Door to Intra-Arterial Therapy

Future Accreditation for Performance

• AHA / ASA accreditation program
• Partner with certification organizations
  – AHA Guideline based – science focused
  – Expand expectations to be patient-centered and less infrastructure based
  – Use certification partners to work with hospitals
  – Use GWTG to monitor performance
  – Eventually public reporting of dashboards
An Example from South Carolina
Stroke Systems of Care Act

Ratified 6/08/2011
Vetoed by the Governor 6/14/2011
Veto overridden by Senate 6/21/2011
Veto overridden by House 6/21/2011
Ed’s happy dance 6/22/2011
An Example from South Carolina Stroke Systems of Care Act

• Victory was sweet but brief – bill defunded
• It took 5 years to finally get funding
  – New director of health took on stroke with a passion
  – Hired FTE in Dept of Health
  – Created SC Stroke Advisory Committee
    • All stakeholders
    • Create guidance for Director
    • Created triage algorithm
    • Funding for state-wide stroke registry of all hospitals
Adult Stroke Patient Destination
Determination by Stroke Center Capability

STROKE SCREEN POSITIVE

Determine and Document Time
Last Known Well

Perform and Document RACE Score

Race Score = 4

YES → Last Known Time Well ≥ 7 Hours

Transport Time to CSC ≤ 30 minutes

YES → Transport to Comprehensive Stroke Center

NO → Transport to closest ASCH, PSC, or CSC Per Local Protocol

COMPREHENSIVE STROKE CENTER
- Physician / Nursing Staff trained in neurologic care on-site 24 hours a day
- Organized Emergency Department with written pathway for rapid identification and management of acute stroke patients
- CT of the head with technician on-site 24 hours a day
- Clinical Laboratory Services
- 24/7 Stroke Call and capabilities for IV IPIA therapy for eligible patients
- 24/7 Endovascular Call and capabilities for endovascular therapy for eligible patients
- 24/7 Neurosurgery Call
- Neuro-Intensive Care Unit and neurointensivists
- Stroke Registry and Quality Improvement Process
- Accredited Comprehensive Stroke Center (CSC)

PRIMARY STROKE CENTER
- Physician / Nursing Staff trained in neurologic care on-site 24 hours a day
- Organized Emergency Department with written pathway for rapid identification and management of acute stroke patients
- CT of the head with technician on-site 24 hours a day
- Clinical Laboratory Services
- 24/7 Stroke Call and capabilities for IV IPIA therapy for eligible patients
- Stroke Registry and Quality Improvement Process
- Accredited Primary Stroke Center (PSC)

ACUTE STROKE CAPABLE CENTER
- Emergency Department 24 hours a day with Physician or physician extender and nursing staff trained in neurological care on-site 24 hours a day
- CT of the head with technician on-site 24 hours a day
- Clinical Laboratory Services
- Telestroke – Video Conferencing Capabilities
- 24/7 with Capabilities for IV IPIA therapy for eligible patients
- Transfer agreement established in advance to ensure orderly transition from Level II Stroke Hospital to specialized stroke care facility
- Stroke Registry and Quality Improvement Process
- Accredited Acute Stroke Capable Hospital (ASCH)

Non-Stroke Hospitals
- No organized treatment for acute stroke
South Carolina Telestroke Alliance Map
## SC Primary Stroke Centers

<table>
<thead>
<tr>
<th>Hospital Name</th>
<th>City</th>
<th>State</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>AnMed Health</td>
<td>Anderson</td>
<td>SC</td>
<td>3/20/13</td>
</tr>
<tr>
<td>Medical University of South Carolina Medical Center</td>
<td>Charleston</td>
<td>SC</td>
<td>11/8/13</td>
</tr>
<tr>
<td>Roper Hospital, Inc.</td>
<td>Charleston</td>
<td>SC</td>
<td>3/6/13</td>
</tr>
<tr>
<td>Bon Secours St. Francis Xavier Hospital, Inc.</td>
<td>Charleston</td>
<td>SC</td>
<td>4/26/14</td>
</tr>
<tr>
<td>Trident Medical Center LLC</td>
<td>Charleston</td>
<td>SC</td>
<td>3/8/13</td>
</tr>
<tr>
<td>Palmetto Health Richland</td>
<td>Columbia</td>
<td>SC</td>
<td>4/26/13</td>
</tr>
<tr>
<td>McLeod Regional Medical Center of the Pee Dee, Inc.</td>
<td>Florence</td>
<td>SC</td>
<td>6/27/14</td>
</tr>
<tr>
<td>Georgetown Memorial Hospital</td>
<td>Georgetown</td>
<td>SC</td>
<td>7/8/14</td>
</tr>
<tr>
<td>Greenville Health System</td>
<td>Greenville</td>
<td>SC</td>
<td>9/24/13</td>
</tr>
<tr>
<td>Coastal Carolina Medical Center Inc.</td>
<td>Hardeeville</td>
<td>SC</td>
<td>11/22/14</td>
</tr>
<tr>
<td>East Cooper Medical Center</td>
<td>Mount Pleasant</td>
<td>SC</td>
<td>4/4/13</td>
</tr>
<tr>
<td>Waccamaw Community Hospital</td>
<td>Murrells Inlet</td>
<td>SC</td>
<td>7/8/14</td>
</tr>
<tr>
<td>Grand Strand Medical Center, LLC</td>
<td>Myrtle Beach</td>
<td>SC</td>
<td>3/14/13</td>
</tr>
<tr>
<td>Regional Medical Center of Orangeburg &amp; Calhoun Counties</td>
<td>Orangeburg</td>
<td>SC</td>
<td>12/10/14</td>
</tr>
<tr>
<td>Piedmont Medical Center</td>
<td>Rock Hill</td>
<td>SC</td>
<td>12/17/14</td>
</tr>
<tr>
<td>Mary Black Health System, LLC</td>
<td>Spartanburg</td>
<td>SC</td>
<td>1/26/14</td>
</tr>
</tbody>
</table>
MUSC Telestroke Consults

![Graph showing the increase in MUSC Telestroke Consults from 2008 to 2016. The number of consults increases significantly from 87 in 2008 to 2641 in 2016.](image-url)
Recommendations for Alteplase
MUSC Telestroke Transfer Volume

% Transfers - MUSC
% Transfers - Other
What Would Triage Look Like Here?

15 Minute Drive Time

30 Minute Drive Time
Final Thoughts
The True Secret Sauce

Your physician and nurse stroke champions make the difference and must be supported and worshiped. Without them the system fails.
Pay Attention to Detail

• Never forget your inpatients!
  – 10-20% of all strokes
  – Call a BAT just like a MET
    • Less likely discharged home (OR 0.37)
    • Less likely ambulatory at DC (OR 0.42)
    • In-hospital mortality higher (OR 2.72)

• Send somebody big to champion the stroke patient in the ED and push them through the system.
The Importance of Feedback
In-Patient Stroke

• Review of inpatient stroke cases from 2006 to 2012 in GWTG-Stroke

• After adjustment and in comparison to community-onset ischemic stroke, inpatient strokes were:
  – Less likely discharged home (OR 0.37)
  – Less likely ambulatory at discharge (OR 0.42)
  – In-hospital mortality also higher (OR 2.72)

(Cumbler, Stroke, 2014)
How Will You Be Judged?

• Moving forward is will not be so much on what you have but what you do!

• Centers of Excellence
  – Action based metrics (DTN, DTG, DIDO)
  – Outcomes based (mRS 90 days)
  – Systems based (do you play well with others)
  – Volumes (no more once a year)
Conclusion

• No matter where you practice you will see stroke
• Acute treatments’ *efficacies* are nearly asymptotic
• Now the goal is to maximize their *effectiveness*
  – Build a resourced and supported *team*
  – Apply best practices to each location in system
  – Measure success on outcomes not check boxes
• Recognize importance of sustained public education, secondary prevention and rehabilitation
## Future Stroke Dashboards

<table>
<thead>
<tr>
<th>Measure</th>
<th>Hospital A</th>
<th>Hospital B</th>
<th>Hospital C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics / Volume</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certification</td>
<td>ASRH</td>
<td>PSC</td>
<td>CSC</td>
</tr>
<tr>
<td>CY ischemic stroke admissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY intracerebral hemorrhage admissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY subarachnoid hemorrhage admissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY tPA administration (#)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY EVT administration (#)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY SAH aneurysms coilings (#)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DTN (mins – median, mean)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DTN (% under 45 mins)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DTG (min – median, mean)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sICH rate (PH1, PH2) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 day modified Rankin Score (median, mean)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periprocedural complications</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>