Acute Stroke: Chicago Workflow

Rush Center for Neuroendovascular surgery

Disclosures:

Pipeline & Onyx proctor
Advisory Board: Intreped, Premier, Shield project
Principal Investigator: PUFS, Intreped, Swift Prime, Premier, Barrel, Aspire
National PI: Shield trial
Research collaboration: Pipeline Shield Technology Project

Stroke Burden is Immense

- #5 cause of death among adults in the U.S.
- on average EVERY 4 MINUTES someone dies of stroke
- about 795,000 Americans each year suffer a new or recurrent stroke
- every 40 seconds someone has a stroke
- 80% can be prevented
- kills 128,000 people a year. That’s about one out of every 19 deaths.

Statistics from the American Heart Association/American Stroke Association. All rights reserved. Unauthorized translation © 2016. PDF Data
Stroke still is …

#1 Cause of adult disability in the USA

Treatment Effect

In order to have one additional stroke patient be independent at 90 days

- MR Clean
- Escape
- Extend-IA
- Swift Prime

Treatment effect used to justify STEMI treatment approach

Our Stroke Program

- Primary Stroke Center since 2005
- A stroke unit, a 28-bed neurosciences-ICU, 24/7 stroke, interventional and CV coverage
- Designated Comprehensive Stroke Center in 2013
  - High level of standards of care set by JCAHO
Rush approach:

- Quality Initiative (QI): project to address the issue of inconsistent treatment and outcomes of IA patients
- Termed: Stroke 60 Code Alert
- Stroke 60: Initiated May 1, 2012

Changing Workflow of First Responders

Primary Stroke Center
- Medical teams first and only responders
  - ED physicians & neurologists

Comprehensive Stroke Center
- Neuroendovascular, neurosurgery and neurocritical care need to be included

Initial Steps

- Created structured workflow of Stroke 60 process
- Defined roles and responsibilities of all team members
- Established goals (based on current studies/guidelines) for IA treatment and communicated this with all team members
- Provided education to other departments providing care on the Stroke 60 workflow and goals for patient care
- Created feedback loop to all team members on details of Stroke 60 code, achievement of goals, kudos and issues to improve
Stroke 60 Team

- Neurointerventionalists: Neurosurgeons and interventional neurologists
- Neurology Stroke Attending
- Neurointerventional and Neurology Stroke Fellow
- Acute Care Nurse Practitioner
- Neuroendovascular Registered Nurse
- Neuroendovascular Technologist
- Stroke Research Coordinator
- Anesthesia
- Radiology Technologist
- Rush Transfer Center
- EMS Crew
- RUSH ER and NSICU RN’s

STROKE 60 – Team roles during code

Stroke 60 Team Member Roles During Stroke 60 Admission

Neurointerventional Attending
- Conference Call with NY Research Coordinator or Call for trial consent if patient meets criteria. Can be determined by Research Coordinator on call.
- Obtain patient baseline MRI and complete MRI questionnaire during consent phone call.
- Await confirmation from all team members they have received page. Follow, NY RN, NY RT, NY/Research Coordinator or Call.
- Confirm with follow that they have notified anesthesia.
- Sign in time of arrival on Arrival Log.
- Communicate patient information and plan to team members.
- Meet patient in CT and/or MRI.
- At anesthesiologist’s request to anesthesia team during transfer.

Anesthesia
- Make a team room for patient arrival.
- Discuss with NPI standing of type of anesthesia, blood pressure goals and other parameters for the patient.
- Meet patient in ER. Following criteria: patient intubated, posterior circulation stroke, concern for acute compression, or requiring continuous drugs/PF needs for hemodynamic management, at request of NPI team.

Stroke 60 Code Activation:

- ✔ If Stroke Patient is a candidate for IA = Stroke 60 Code is activated

- ✔ Transfer center links:
  Stroke neurology + Endovascular attending

- No patient denied even if hospital full
- Improved team communication (App)
- Rapid imaging protocol/automated process
- Endovascular intervention protocol
Criteria for Mechanical Thrombectomy

- CT head negative for hemorrhage
- Clinical syndrome suggestive of large vessel occlusion (LVO) such as M1 or carotid T
- Able to treat with IA therapy within 6 hours of onset/LKW
- NIHSS ≥ 8
- CT ASPECTS ≥ 6 or other imaging showing small core and mismatch on perfusion
- Pre-mRS ≤ 2
- Any new trials criteria – Wake up stroke

Source: MR CLEAN; ESCAPE; EXTEND-IA; SWIFT PRIME, 2015

Consider all the possibilities a stroke code can be activated:

1) Drip & Ship Direct phone line to Neuro critical care MD - 942 Brain
2) EMS – Pre notification
3) Walk in – ER calls Stroke Code
4) In house – Anybody can activate Stroke Code Page

Stroke 60 Workflow for Drip and Ship Patient
Patient Transfer Type on Swift Prime

Mothership vs. drip and ship

Key Results

- Onset to ED time was significantly longer for Drip and Ship than Mothership patients
- Once pt reaches study hospital, workflow is faster in Drip and Ship patients

Workflow Quality Improvement Program

1. Form was filled out by study sites after each patient enrollment.
2. Immediately routed to Workflow & Imaging PI for review:
   - Imaging PI and site PI
   - Opportunity to learn local best practices from sites with excellent workflow
   - Feedback given to sites with delayed workflow
   - Sites with continued poor performance risked becoming disqualified.
3. Feedback loop:
   - Monthly newsletter highlighted sites with excellent workflow
   - Regular maintenance & discussion of site workflow records

RUSH is involved on Swift Prime, Therapy and Dawn RCTs
Rush Drip and Ship Participating Sites

- Rush University Medical Center
- Franciscan St. Anthony Health
- MetroSouth
- Ingalls
- Swedish Covenant Hospital
- Mount Sinai Hospital Medical Center
- St. Anthony Medical Center
- Copley Memorial Hospital
- Holy Cross Hospital
- Swedish Covenant Hospital
- Metro South Medical Center
- St. Margaret Mercy Healthcare
- Vista Medical Center - East
- St. Mary Medical Center Inc.
- St. Margaret Mercy Healthcare-South
- St. Catherine Hospital
- Vista Medical Center - East
- St. Margaret Mercy Healthcare-North
- Vista Medical Center - East

Patient presents to the nearest hospital. Stroke alert protocols are initiated. Rush Vascular Neurologist provides a neurologist consultation as indicated within stroke protocols. TPA implemented and administered if appropriate. Patient is treated at the most appropriate facility. 

<table>
<thead>
<tr>
<th>Spoke Hospital</th>
<th>City</th>
<th>State</th>
<th>Annual Stroke Admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Hospital</td>
<td>Munster</td>
<td>IN</td>
<td>1,364</td>
</tr>
<tr>
<td>Methodist Northlake</td>
<td>Gary</td>
<td>IN</td>
<td>1,072</td>
</tr>
<tr>
<td>Ingalls Memorial Hospital</td>
<td>Harvey</td>
<td>IL</td>
<td>832</td>
</tr>
<tr>
<td>St. Anthony Medical Center</td>
<td>Crown Point</td>
<td>IN</td>
<td>652</td>
</tr>
<tr>
<td>St. Mary Medical Center Inc.</td>
<td>Hobart</td>
<td>IN</td>
<td>652</td>
</tr>
<tr>
<td>Swedish Covenant Hospital</td>
<td>Chicago</td>
<td>IL</td>
<td>610</td>
</tr>
<tr>
<td>Vista Medical Center - East</td>
<td>Washington</td>
<td>IL</td>
<td>566</td>
</tr>
<tr>
<td>St. Margaret Mercy Healthcare-South</td>
<td>Dyer</td>
<td>IN</td>
<td>576</td>
</tr>
<tr>
<td>Metro South Medical Center</td>
<td>Blue Island</td>
<td>IL</td>
<td>564</td>
</tr>
<tr>
<td>St. Margaret Mercy Healthcare-North</td>
<td>Hammond</td>
<td>IN</td>
<td>553</td>
</tr>
<tr>
<td>Copley Memorial Hospital</td>
<td>Aurora</td>
<td>IL</td>
<td>432</td>
</tr>
<tr>
<td>Holy Cross Hospital</td>
<td>Chicago</td>
<td>IL</td>
<td>400</td>
</tr>
<tr>
<td>St. Catherine Hospital</td>
<td>East Chicago</td>
<td>IN</td>
<td>376</td>
</tr>
<tr>
<td>Mount Sinai Hospital Medical Center</td>
<td>Chicago</td>
<td>IL</td>
<td>316</td>
</tr>
<tr>
<td>Riverside Medical Center</td>
<td>Joliet</td>
<td>IL</td>
<td>645</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>9,734</strong></td>
</tr>
</tbody>
</table>

TeleStroke Model

- Patient presents to the nearest hospital.
- Stroke alert protocols are initiated.
- Rush Vascular Neurologist provides a consultation as indicated.
- TPA administered and appropriate treatment is followed.
- Patient is treated at the most appropriate facility.

- Transferred to RUMC or other facility
- Emphasis is placed on clinical needs
This includes:

- Audio-visual dialogue through a mobile cart placed in the ED
- CT scan viewing and interpretation
- Provide the clinical support for the diagnosis and treatment of the patient

Rush TeleStroke History

Time to Treatment Goals in 2015

- Door to Puncture: less than 60 minutes
- Door to CT complete: less than 25 min
- Door to MRI complete: less than 45 min
- Door to Recanalization: less than 90 minutes
- Recanalization of: TICI 2b or TICI 3
### Time To Treatment Goals in 2016

#### CT Pathway
- Door to CT complete: less than 10 min
- Door to Puncture: less than 30 minutes
- Door to Recanalization: less than 45 minutes

#### MRI Pathway:
- Door to MRI complete: less than 35 minutes
- Door to Puncture: less than 45 minutes
- Door to Recanalization: 60 minutes
- Recanalization of: TICI 2b or TICI 3

#### Imaging – moving target at this point

**ASPECTS (Alberta Stroke Program Early CT Score)**

![CT Scan Images](image)

**10 = normal**

#### CTA to confirm presence of large vessel occlusion (LVO)

![CTA Image](image)
RAPID Processing (software)

- Stroke MRI/CTP
- Auto Image Analysis:
  - motion & time correction
  - AIF & VOF selection
  - deconvolution & map generation
  - CTP or DWI and PWI lesion segmentation
  - Lesion volume calculation

CT/MR tech pushes CTP/DWI & PWI to RAPID via DICOM

Mini Computer

RAPID auto-send via DICOM

Auto Image Analysis:
- Motion & time correction
- AIF & VOF selection
- Deconvolution & map generation
- CTP or DWI and PWI lesion segmentation
- Lesion volume calculation

RAPID software report template

- Estimated core: 43 ml
- Hypoperfusion (Tmax<6s) 103 ml
- Mismatch volume: 61 ml
- Mismatch ratio: 2.4
- Estimated core < 50 ml? YES
- Mismatch volume > 15ml and ratio > 1.87: YES
- Tmax < 10s: YES

RUSH Stroke App

1) Click on app
2) Password protected access
3) Acute Stroke case registration
Unique Team interaction: NO invitation required
Two interventional MDs, Fellow, Research coordinator, Stroke neurology, Ambulance team, Techs, Nurses, NPs

Live ambulance tracking: “Uber like” feature

Stroke Team to ER only when patient is around the corner

Communication with transport team: Via chat and pictures

Important to avoid team to burn out!!!
Easy Clinical updates during transport:
• Allows prepare for anesthesia
• Cancel interventional team if patient back to baseline
• Have the right resources available

No surprises on arrival to ER!!

Indoor garage  Bypass ER admission

To CT scan in ER

Time stamps
Arrival to hospital?
Time to CT?
Time to puncture?  Time to recanalization?

Generate a report of stroke code to upload on EMR and Database
Assuming certain pre-conditions, the patient has a window of 4.5 hours (270') to go to tPA Door to Needle Site to door Symptom to EMS Not controllable

Pre set time: NO

Time site-to-door calculated by the software with GPS

Pre set time: 30 minutes (varies by location)

Calculate: time difference CSC - PSC

PSC

CSC

Controllable

Pre set time: 60 min

The eligibility for the tPA will depend on the time that has passed from the moment that symptoms got started, plus the time that an ambulance will take to take to a Stroke Center, and the time that such Stroke Center takes from to door to apply the tPA.

Asking the use or anticoagulant and the age

IS THE PATIENT ON ANTICOAGULANT / BLOOD THINNERS?

YES

NO

HOW OLD IS THE PATIENT?

OLDER THAN 60 YEARS OLD

80 YEARS OLD OR YOUNGER

AGE IS UNKNOWN

Asking time of symptom start. If it is unknown, ask the time patient last seen well.

DID ANYONE SEE WHEN THE SYMPTOMS STARTED?

YES, ENTER TIME

NO

WHAT TIME WAS THE PATIENT LAST SEEN WELL?

YES, ENTER TIME

UNKNOWN
The answer: Best choice of level of care the patient needs

FAST ED SCORE = 4
Large Vessel Occlusion Probability = 40%
The assessment indicates that the patient should be taken to the closest Comprehensive Stroke Center (CSC).
Critical. Please consider helicopter transport.

FAST ED SCORE = 5
Large Vessel Occlusion Probability = 100%
The assessment indicates that the patient should be taken to the closest stroke center.

Go to Comprehensive Stroke Center
The algorithm calculating the ideal Stroke Centers to be taken, in order of time distance.

“Every minute, 1.9 M neurons are lost”
The stroke workflow

Today

| 00 min | Arrive at hospital |
| 30 min | CT |
| 45 min | MRI |
| 75 min | MRI |
| 105 min | MRI |

The One-stop-shop vision

| 00 min | ER |
| 30 min | Angio suite, treatment |
| 45 min | MRI, DWI, PWI |
| 45 min | Anatomical Imaging (native DynaCT, DynaCTA, MRI) |
| 45 min | Physiological Imaging (PBV, PBF, MTT) |
| 1h saved | |

Chicago MSU
Operations: Communities Served

Hospitals within 5 miles of Rush Oak Park Hospital

Legend
- Rush Oak Park Hospital
- Advanced Primary Stroke Center
- Organization without Stroke Designation

<table>
<thead>
<tr>
<th>#</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>West Suburban Medical Center</td>
</tr>
<tr>
<td>2</td>
<td>Community First Healthcare of IL</td>
</tr>
<tr>
<td>3</td>
<td>Loretto Hospital</td>
</tr>
<tr>
<td>4</td>
<td>MacNeal Hospital</td>
</tr>
<tr>
<td>5</td>
<td>Loyola University Medical Center</td>
</tr>
<tr>
<td>6</td>
<td>Westlake Hospital</td>
</tr>
<tr>
<td>7</td>
<td>Gottlieb Memorial Hospital</td>
</tr>
</tbody>
</table>

Operations

Hours of Operations:
- 8am – 6pm, 7 days, every week
- 2-6 runs/day (up to 42 runs per week)
- ~3 stroke pts. treated per week

Staffing:

<table>
<thead>
<tr>
<th>Staff Type</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Stroke Unit Staff</td>
<td>Rush</td>
</tr>
<tr>
<td>Vascular Neurologist (telestroke)</td>
<td></td>
</tr>
<tr>
<td>RN, Critical Care</td>
<td></td>
</tr>
<tr>
<td>Paramedic Critical Care</td>
<td></td>
</tr>
<tr>
<td>CT Tech (Driver)</td>
<td></td>
</tr>
</tbody>
</table>

Early Results

- 25 minute reduction in symptom onset to tPA treatment with MSU (Germany)
- Increase in percentage of patients receiving tPA within 60 minutes of onset from 4.9% to 31% with Mobile Stroke (UT)
- 19 minute average arrival to tPA needle time with MSU, compared to 60 minute average door to needle time in ED. (CC)
- Patient originally presenting with NIHSS 20-22 discharged with a NIHSS 1 after MSU treatment. (CC)
Mobile Stroke Unit

- Improve outcomes with rapid stroke assessment and treatment with tPA before ED transport
- Determine whether earlier treatment within critical time window is better
- Avoid hospital to hospital transfer delays for patients that need CSC
- Determine opportunities outside Ischemic Stroke

Work to do...

- Symptoms Identification – How to educate EMS services to recognize stroke symptoms RACE and FAST ED?
- Bypass strategy – In those cases where there is a suspicion of large vessel occlusions, should we systematically bypass the primary stroke center and go directly to the comprehensive stroke center?
- Door to groin puncture – Is the goal of performing this in less than 30 minutes achievable? How can we accomplish this?
- Repeat imaging – Should we perform another series of imaging if the patient is clinically stable between the primary stroke center (PSC) and the CSC?

Early stages of research:

Dr. J. Blasco (Barcelona, Spain)
- "Influence of mechanical thrombectomy (MT) on endothelial cells"
- rtPA
  - Blood-brain barrier disruption, increased endothelial permeability, brain edema or direct neurotoxic effect.
- Stent-retrievers
  - Endothelial damage
  - Study assessing the impact of gadolinium vessel enhancement (GVE) after mechanical thrombectomy (TOF and FLAIR gadolinium sequences)
  - GVE was present in more than 50% of the patients after MT.
- This presence was associated with a previous use of rtPA and the number of passes of the device. Severe BBB was present in 40% of patients and associated with ICH and poor clinical outcome.
Dr. R. Bourcier (Nantes, France)

“Detecting thrombus composition by imaging tools”

Need for a reliable and quantitative tool to predict thrombus composition

Susceptibility vessel sign (SVS):

Reliable marker to predict thrombus?

Initial findings:

Composition: Mean T2* relaxation time; a low mean relaxation time being associated with a lower number of attempts of MTH than a higher relaxation time.

The BrainPath Approach to Subcortical Brain Access

MSU – Hemorrhagic stroke