STROKE Intervention

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Interventional Radiology
Inland Imaging/Missoula
TIME is BRAIN!

• For every **MINUTE** of prolonged ischemia without treatment,
• **1.9 Million Neurons are Lost**
STROKE: OBJECTIVES

• Stroke Incidence and Impact
• Imaging Techniques and Algorithm
• Current Guidelines for Treatment
• Treatment Options – Clot Retrieval
• Case Reviews
• Transfer Process
• Answer Your Specific ?’s and Concerns
• An evolving treatment paradigm: DAWN and Defuse 3
Stroke Incidence

An estimated 795,000 Americans will suffer a new or recurrent stroke this year...

...that’s one every 40 seconds

Stroke is a Leading Cause of Death

Stroke accounts for 1 of every 18 deaths in the United States, that’s 1 death every 4 minutes

Physiological Impact of Stroke

Estimated Pace of Neural Circuitry Lost in a Typical Large Vessel Acute Ischemic Stroke

<table>
<thead>
<tr>
<th>Time</th>
<th>Neurons Lost</th>
<th>Synapses Lost</th>
<th>Myelinated Fibers Lost</th>
<th>Accelerated Aging</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 second</td>
<td>32,000</td>
<td>230 million</td>
<td>218 yards</td>
<td>8.7 hours</td>
</tr>
<tr>
<td>1 minute</td>
<td>1.9 million</td>
<td>14 billion</td>
<td>7.5 miles</td>
<td>3.1 weeks</td>
</tr>
<tr>
<td>1 hour</td>
<td>120 million</td>
<td>830 billion</td>
<td>447 miles</td>
<td>3.6 years</td>
</tr>
<tr>
<td>Avg. stroke</td>
<td>1.2 billion</td>
<td>8.3 trillion</td>
<td>4470 miles</td>
<td>36 years</td>
</tr>
</tbody>
</table>
There are Over 7 Million Stroke Survivors...

...2/3's of which are living with Moderate to Severe disability

19% had aphasia

35% had depressive symptoms

50% had some hemiparesis

26% were dependent in activities of daily living

30% were unable to walk without assistance

26% were institutionalized in a nursing home

The total estimated cost of stroke is $48 Billion.

- Lost productivity due to mortality and morbidity: $15 Billion
- Hospitalization Costs: $16 Billion
- Rehabilitation: $4.5 Billion
- Physician Costs: $4 Billion
- Medications & Other Costs: $3.5 Billion
- The lifetime cost of stroke to a single patient is more than $140,000
Two Types of Stroke

**Ischemic Stroke**

*Ischemic = type of condition in which oxygen is deficient*

Often caused by a blood clot or plaque buildup that blocks blood flow

**Hemorrhagic Stroke**

*Hemorrhage = bleeding*

Occurs when a blood vessel ruptures, causing blood to leak into the surrounding tissue
Two Types of Stroke

87% of strokes are ischemic; only 1% of these patients get intervention.

13% of strokes are hemorrhagic:
- 10% intracerebral
- 3% subarachnoid

4 out of every 5 families will be affected by stroke.
35-40% of Ischemic Strokes are Considered “Large Vessel”

• This subset of ischemic stroke comprises blockages in the:
  • Internal Carotid Artery (ICA)
  • Middle Cerebral Artery (MCA)
  • Vertebral / Basilar Artery

• If left untreated, patient prognosis with these types of stroke is poor

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA</td>
<td>53%(^1)</td>
</tr>
<tr>
<td>MCA</td>
<td>27%(^2)</td>
</tr>
<tr>
<td>Basilar Artery</td>
<td>89-90%(^3)</td>
</tr>
</tbody>
</table>

2. Furlan A, et al. PROACT II Trial
TIME is BRAIN!

- For every 30 minutes of prolonged ischemia without treatment,
- 10% Decrease in Chance for a Good Outcome
Timing Is Critical – IMS I & II

Cases with angiographic reperfusion

Each 30 minutes = 10% loss!

Cases without reperfusion

Time from symptom onset to angiographic reperfusion (minutes)

(Khatri. Neurology, 2009)
Patients With Suspected Stroke Should be Triaged with the Same Priority as Patients with Myocardial Infarctions

Heart Attack

• Care for myocardial infarction revolutionized over the past 20 years

• Estimated annual incidence of MI is 610,000 new attacks and 325,000 recurrent attacks

“Brain Attack”

• Care of ischemic stroke will be revolutionized over the next 20 years

• Acute ischemic disease that is #1 cause if disability and #4 cause of death in the USA

• 795,000 of acute stroke cases per year in the USA

• 35-40% of ischemic strokes are large vessel (~300,000)

Options for Patients Experiencing an Ischemic Stroke

IV tPA
Gold-standard in ischemic stroke care. Drug is designed to break apart the clot.

Medical Management
Monitor vitals and provide secondary stroke prevention.

Bridging Therapy

Endovascular Clot Removal
Mechanical disruption or removal of the clot using standard endovascular approaches
IV tPA Reperfusion Limitations

- Location
  - Vessel occlusion location prognostic of response:
    - Distal ICA 4.4%
    - M1-MCA 32.3%
    - M2-MCA 30.8%
    - Basilar 4.0%
  - Reperfusion most predictive of outcome (RR 2.7)

- Clot size (<8mm)**
  - Reperfusion remains strongly predictive
    - Mean discharge mRS
      - Reperfused 1.9
      - No reperfusion 4.4

*Bhatia Stroke. 2010;41:2254-2258, **Riedel, Stroke. 2011;42:1775-1777
Impact of Clot Burden on Success Rate of IV tPA

Successful Recanalization

~40% recanalization

Persistent Occlusion

% Reperfusion after TPA if Clot >8mm long

- 0%
Meta-analysis Shows a Strong Correlation Between Revascularization and Good Patient Outcomes

- Good Outcome (mRS 0-2):
  - Revascularized: 58.1%
  - Non-revascularized: 24.8%

- 90-Day Mortality:
  - Revascularized: 14.4%
  - Non-revascularized: 41.6%

- SICH *
  - Revascularized: 13.7%
  - Non-revascularized: 12.5%

*Differences in SICH were not statistically significant between the revascularized and non-revascularized groups.*

“Well, there it goes again. ... And here we sit without opposable thumbs.”
Technological advances

- Stent-retriever technology for safe, reliable performance
- Significant improvement in revascularization and patient outcomes vs older technology, proven in randomized clinical trials*

Neurovascular Anatomy

**Anterior Anatomy**
- Anterior Cerebral Artery (ACA)
- Middle Cerebral Artery (MCA)
- Internal Carotid Artery (ICA)
- Common Carotid Artery (CCA)

**Posterior Anatomy**
- Posterior Cerebral Artery (PCA)
- Basilar Artery
- Vertebral Artery

Arch
Distal ICA
Middle Cerebral Artery: M1, M2, M3
Modified Rankin Scale - mRS

- commonly used scale for measuring the degree of disability or dependence in the daily activities of people who have suffered a stroke or other causes of neurological disability. It has become the most widely used primary clinical outcome measure for stroke clinical trials.

- 0 – 6 Scale, Lower the better: Asymptomatic (0) to Death (6)
- 0 Asymptomatic
- 1 No Significant Disability, Can Do all.
- 2 Slight Disability but No assistance needed
- Dichotomized: 0-2 vs >2
- 0-2 considered Functionally Independent
- 3 Moderate Disability, Needs some help, but walks unassisted
- 4 Moderately Severe Disability, Need help to walk and for bodily needs
- 5 Severe Disability – Bedridden, Need constant Care
- 6 Death
Modified Rankin Scale Score

A Overall

Control (N=147)

- 0: 7
- 1: 10
- 2: 12
- 3: 15
- 4: 24
- 5: 12
- 6: 19

Intervention (N=164)

- 0: 15
- 1: 21
- 2: 18
- 3: 16
- 4: 13
- 5: 7
- 6: 10

Patients (%)
Previous Stroke Trials Failed to Show Benefit in Endovascular

- Past trials of IAT + tPA versus tPA alone were neutral
  - IMS 3, MR RESCUE, SYNTHESIS-Expansion
- Key learnings to improve IA Stroke trial results:
  - Imaging to confirm large vessel occlusion
  - Imaging to exclude patients with a large infarct core
  - Improve time to treatment
  - Use newest devices to improve recanalization rates
Endovascular Therapy after Intravenous t-PA versus t-PA Alone for Stroke

CONCLUSIONS
The trial showed similar safety outcomes and no significant difference in functional independence with endovascular therapy after intravenous t-PA, as compared with intravenous t-PA alone. (Funded by the National Institutes of Health and others; ClinicalTrials.gov number, NCT00359424.)

Broderick, NEJM, 2013
Clinical Equipoise in Stroke Therapy

IMS III
SYNTHESIS
MR RESCUE

IV Therapy

2013

SWIFT
TREVO

IA Therapy
Clinical Equipoise in Stroke Therapy

IMS III SYNTHESIS MR RESCUE

IV Therapy

MR CLEAN

IA Therapy

JANUARY 2015
Clinical Equipoise in Stroke Therapy

IMS III
SYNTHESIS
MR RESCUE

MR CLEAN

IV Therapy

IA Therapy

JANUARY 2015
CONCLUSIONS

In patients with acute ischemic stroke caused by a proximal intracranial occlusion of the anterior circulation, intraarterial treatment administered within 6 hours after stroke onset was effective and safe. (Funded by the Dutch Heart Foundation and others; MR CLEAN Netherlands Trial Registry number, NTR1804, and Current Controlled Trials number, ISRCTN10888758.)

Berkhemer, NEJM, January 2015
Clinical Equipoise in Stroke Therapy

IMS III
SYNTHESIS
MR RESCUE

ESCAPE
EXTEND IA
MR CLEAN

IV Therapy

IA Therapy

MARCH
2015
<table>
<thead>
<tr>
<th>Clinical Trial</th>
<th>Country</th>
<th>Planned Sample Size</th>
<th>First Patient Enrolled</th>
<th>Number of Enrolled</th>
<th>Status October 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASICS</td>
<td>EU</td>
<td>200</td>
<td>April 2011</td>
<td>80</td>
<td>Enrolling</td>
</tr>
<tr>
<td>ESCAPE</td>
<td>Canada/USA/EU/S. Korea</td>
<td>500</td>
<td>February 2013</td>
<td>238</td>
<td>Halted</td>
</tr>
<tr>
<td>EXTEND-IA</td>
<td>Australia/New Zealand</td>
<td>100</td>
<td>August 2012</td>
<td>70</td>
<td>Halted</td>
</tr>
<tr>
<td>MR CLEAN</td>
<td>Netherlands</td>
<td>500</td>
<td>December 2010</td>
<td>445</td>
<td>Completed</td>
</tr>
<tr>
<td>PISTE</td>
<td>UK/Norway</td>
<td>450</td>
<td>April 2013</td>
<td>65</td>
<td>Halted</td>
</tr>
<tr>
<td>RESILENT</td>
<td>Brazil</td>
<td>690</td>
<td>N/A</td>
<td>0</td>
<td>Enrolling March 2015</td>
</tr>
<tr>
<td>REVASCAT</td>
<td>Spain</td>
<td>690</td>
<td>November 2012</td>
<td>150</td>
<td>Halted</td>
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<tr>
<td>SWIFT-PRIME</td>
<td>USA/EU</td>
<td>833</td>
<td>January 2013</td>
<td>196</td>
<td>Halted</td>
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<tr>
<td>THERAPY</td>
<td>USA/EU</td>
<td>692</td>
<td>March 2012</td>
<td>108</td>
<td>Halted</td>
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<tr>
<td>THRACE</td>
<td>France</td>
<td>480</td>
<td>June 2010</td>
<td>394</td>
<td>Halted</td>
</tr>
<tr>
<td>Trial</td>
<td>Device(s) Used in Intervention Arm</td>
<td>TOTAL PTS:</td>
<td>STENT RETRIEVER:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR CLEAN (N = 500)</td>
<td>97% stent retriever (~66% Trevo® Retriever), 2% other mechanical</td>
<td>1229</td>
<td>&gt;95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESCAPE (N = 316)</td>
<td>86% stent retriever (~23% Trevo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*SWIFT PRIME (N = 196)</td>
<td>100% Solitaire stent retriever</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTEND-JA (N = 70)</td>
<td>100% Solitaire stent retriever</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVASCAT (N = 206)</td>
<td>100% Solitaire stent retriever</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial</td>
<td>Intervention Arm</td>
<td>Control Arm</td>
<td>Adjusted Odds Ratio (95% CI)</td>
<td></td>
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<tr>
<td>---------------</td>
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<td>----------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR CLEAN</td>
<td>33% (n=233)</td>
<td>19% (n=267)</td>
<td>2.16 (1.39-3.38)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESCAPE</td>
<td>53% (n=164)</td>
<td>29.3% (n=147)</td>
<td>1.8 (1.4-2.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*SWIFT PRIME</td>
<td>60.2% (n=98)</td>
<td>35.5% (n=93)</td>
<td>2.75 (1.53, 4.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTEND-IA</td>
<td>71% (n=35)</td>
<td>40% (n=35)</td>
<td>4.2 (1.4-12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVASCAT</td>
<td>43.7% (n=206)</td>
<td>28.2% (n=206)</td>
<td>2.1 (1.1, 4.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SIGNIFICANT CLINICAL BENEFIT OVER IV TPA ALONE (OR: 1.8-4.2)**
<table>
<thead>
<tr>
<th>Trial</th>
<th>sICH*(intervention; control)</th>
<th>Mortality at 90 days (intervention; control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR CLEAN (N = 500)</td>
<td>7.7%; 6.4%</td>
<td>18.9%; 18.4% (within 30 days)</td>
</tr>
<tr>
<td>ESCAPE (N = 316)</td>
<td>3.6%; 2.7%</td>
<td>10.4%; 19%</td>
</tr>
<tr>
<td>*SWIFT PRIME (N = 196)</td>
<td>0%; 3% (at 27hrs)</td>
<td>9%; 12%</td>
</tr>
<tr>
<td>EXTEND-IA (N = 70)</td>
<td>0%; 6%</td>
<td>9%; 20%</td>
</tr>
<tr>
<td>REVASCAT (N = 206)</td>
<td>1.9%; 1.9% (p=1.00)</td>
<td>18.4%; 15.5% (p=0.50)</td>
</tr>
</tbody>
</table>

NO HIGHER SICH (lower?) + TREND TOWARD ↓ MORTALITY
2015 AHA/ASA Focused Update of the 2013 Guidelines for the Early Management of Patients With Acute Ischemic Stroke Regarding Endovascular Treatment
Endovascular RX with a **stent retriever** if they meet *all* the following criteria:

(a) prestroke mRS score 0 to 1
(b) acute ischemic stroke receiving intravenous r-tPA within 4.5 hours
(c) occlusion of the internal carotid artery or proximal MCA (M1)
(d) age ≥18 years
(e) NIHSS score of ≥6
(f) ASPECTS of ≥6
(g) treatment can be initiated *(groin puncture)* within 6 hours of symptom onset

*(Class I; Level of Evidence A). (New recommendation)*
Non-Stent Retrievers...

The use of mechanical thrombectomy devices other than stent retrievers maybe reasonable in some circumstances.

(Class IIb, Level B-NR). (New recommendation)
BGC and Optimal Techniques...

The use of proximal balloon guide catheter or a large bore distal access catheter rather than a cervical guide catheter alone in conjunction with stent retrievers may be beneficial

(Class IIa; Level of Evidence C).
Conclusions

• IA therapy with mechanical thrombectomy is no longer rescue treatment
• Imaging improves patient selection
• IA Treatment beneficial if initiated within 6 hours
NASA Registry (JNIS 2014)

- BCG: faster procedures and better outcomes – Stroke 2014
- Local anesthesia: improved outcomes – Stroke 2014
- Age is a predictor of bad outcome – Stroke 2014
- Age, NIHSS, diabetes, use of rescue therapy are predictors of bad outcome despite successful recanalization – JNIS 2015
- Failure to recanalize, symptomatic hemorrhage, proximal occlusion, NIHSS >17, rescue therapy are predictors of mortality – Stroke 2015
# Inclusion / Exclusion Characteristics of Patients with Ischemic Stroke Who Could be Treated with rtPA

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria (0 – 3 hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Diagnosis of ischemic stroke causing measurable neurologic deficit</td>
<td></td>
</tr>
<tr>
<td>• Onset of symptoms &lt;3 hours before beginning treatment</td>
<td></td>
</tr>
<tr>
<td>• Age &gt; 18 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Head trauma, intracranial or intraspinal surgery or prior stroke in previous 3 months</td>
</tr>
<tr>
<td></td>
<td>• Symptoms suggest subarachnoid hemorrhage</td>
</tr>
<tr>
<td></td>
<td>• Arterial puncture at non-compressible site in previous 7 days</td>
</tr>
<tr>
<td></td>
<td>• Evidence of intracranial hemorrhage</td>
</tr>
<tr>
<td></td>
<td>• Uncontrolled hypertension at time of treatment (systolic &gt;185 mm Hg or diastolic &gt;110 mm Hg)</td>
</tr>
<tr>
<td></td>
<td>• Evidence of active internal bleeding on examination</td>
</tr>
<tr>
<td></td>
<td>• Blood glucose concentration &lt;50 mg/dL (2.7 mmol/L)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion Criteria (3 – 4.5 hrs)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Age &gt; 80 years</td>
<td></td>
</tr>
<tr>
<td>• NIHSS &gt; 25</td>
<td></td>
</tr>
<tr>
<td>• Taking oral anticoagulant regardless of INR</td>
<td></td>
</tr>
<tr>
<td>• History of both diabetes and prior stroke</td>
<td></td>
</tr>
<tr>
<td>Intracranial neoplasm, AVM or aneurysm</td>
<td></td>
</tr>
<tr>
<td>Seizure at the onset of stroke</td>
<td></td>
</tr>
<tr>
<td>Acute bleeding diathesis, including but not limited to:</td>
<td></td>
</tr>
<tr>
<td>• Platelet count &lt;100 000/mm3</td>
<td></td>
</tr>
<tr>
<td>• Heparin received within 48 hours, resulting in a PTT &gt; upper limit of normal</td>
<td></td>
</tr>
<tr>
<td>• Current use of anticoagulant with INR &gt; 1.7 or PT &gt; 15 seconds</td>
<td></td>
</tr>
<tr>
<td>CT demonstrates multilobar infarction (hypodensity &gt;1/3 cerebral hemisphere</td>
<td></td>
</tr>
</tbody>
</table>

Acute Ischemic Stroke Imaging Algorithm

**Med Team / Stroke Assessment**
Establish last seen well

Notify Primary Care and follow algorithm for Acute Stroke Triage-Inpatient

**ED Triage / Stroke Assessment**
Establish last seen well

Last seen well < 5 hours

Activate ED Stroke Team
- CT
- ED MD, RN
- House Supervisor

- Pharmacist
- ECG
- Neurologist

Verify LSW, complete Lab, IV, NIHSS (LSW and NIHSS score to CT tech)

- CT to alert ED they received page
- CT to have table ready in 15 mins.
- CT to go to patient bedside when table ready.

**0 – 4.5 hour window**

NIHSS < 6 (tPA candidate)
CT Head w/o contrast

- CT -
  - YES
  - Consider tPA exclusion
  - Initiate tPA immediately; goal < 60 min
  - Document reasons for any delay

- CT +
  - YES
  - Consider neurosurgery consult

NIHSS ≥ 6 (tPA & TREVO candidate)

*CT Head w/o contrast
AND CTA Head/Neck
AND CTP Brain w/ contrast

1. Consider tPA exclusion
2. Initiate tPA immediately; goal < 60 min
3. Document reasons for any delay
4. To IR for large vessel occlusion

**Contraindication to IV-tPA or 4.5 - 6 hours onset and NIHSS > 6 (TREVO candidate)**

*CT Head w/o contrast
AND CTA Head/Neck
AND CTP Brain w/ contrast

* Order all images. CTA/CTP may be cancelled after initial study per MD-MD discussion.
** Suspect posterior circulation stroke? Window for endovascular treatment extends up to 24 hours.

Revised 11/30/2016

- Sudden change in level of consciousness.
- Sudden numbness, weakness, or paralysis of face, arm, or leg; especially if unilateral.
- Difficulty swallowing, speaking, or understanding simple statements.
- Dizziness, loss of balance, or coordination.
- Pronounced visual changes.
ACLS, NINDS and AHA Recommended Guidelines for Ischemic Stroke Patients Upon Arrival to ED

0 min
Patient arrives to ED

<10 min
General Assessment & Stabilization

<15 min
Alert Stroke Team

25 min
Neurological Assessment by Stroke Team & CT Scan

45 min
Interpret CT Scan & Treatment Decision by Specialist

60 min
Treatment

# Neurological Assessment by Stroke Team & CT Scan

<table>
<thead>
<tr>
<th>Actions*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the patient’s history, including medical history.</td>
</tr>
<tr>
<td>Perform physical exam.</td>
</tr>
<tr>
<td>Establish time zero, if not already done.</td>
</tr>
<tr>
<td>Perform neurological exam to assess patient’s status using the NIHSS or Canadian Neurological Scale (CNS).</td>
</tr>
<tr>
<td>Manage hypertension if patient is a potential candidate for acute reperfusion therapy with fibrinolytics (&lt;185 mm Hg systolic and &lt;110 mm Hg diastolic)</td>
</tr>
<tr>
<td>• Labetalol 10–20 mg IV over 1–2 minutes, may repeat 1, or</td>
</tr>
<tr>
<td>• Nicardipine IV 5 mg/hr, titrate up by 2.5 mg/hr every 5–15 minutes, maximum 15 mg/hr; when desired blood pressure reached, lower to 3mg/hr, or</td>
</tr>
<tr>
<td>• Other agents (hydralazine, enalapril, etc) may be considered when appropriate</td>
</tr>
</tbody>
</table>

CT scan should be completed with 25 minutes from the patient’s arrival in the ED and should be read within 45 minutes.

**Note:** Advanced imaging (CTA, CTP, MRI, DWI) can also be done but should not delay administration of IV tPA, if the patient is a candidate, AND Vice Versa

*These are recommended guidelines. Always reference established suspected stroke protocol at your facility.


# Title Responses & Scores

<table>
<thead>
<tr>
<th>#</th>
<th>Title</th>
<th>responses &amp; scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Level of Consciousness</td>
<td>0 – Alert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Drowsy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Obtunded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – Coma/Unresponsive</td>
</tr>
<tr>
<td>1B</td>
<td>Orientation Questions (2)</td>
<td>0 – Answers both correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Answers 1 correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Answers neither correctly</td>
</tr>
<tr>
<td>1C</td>
<td>Response to Commands (2)</td>
<td>0 – Performs both tasks correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Performs one task correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Performs neither</td>
</tr>
<tr>
<td>2</td>
<td>Gaze</td>
<td>0 – Normal horizontal movements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Partial gaze palsy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Complete gaze palsy</td>
</tr>
<tr>
<td>3</td>
<td>Visual Fields</td>
<td>0 – No visual field defect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Partial hemianopia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Complete hemianopia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – Bilateral hemianopia</td>
</tr>
<tr>
<td>4</td>
<td>Facial Movements</td>
<td>0 – Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Minor facial weakness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Partial facial weakness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – Complete unilateral palsy</td>
</tr>
<tr>
<td>5</td>
<td>Motor Function (arm)</td>
<td>0 – No drift</td>
</tr>
<tr>
<td></td>
<td>a. Left</td>
<td>1 – Drift before 5 seconds</td>
</tr>
<tr>
<td></td>
<td>b. Right</td>
<td>2 – Falls before 10 seconds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – No effort against gravity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 – No movement</td>
</tr>
<tr>
<td>6</td>
<td>Motor Function (leg)</td>
<td>0 – Alert</td>
</tr>
<tr>
<td></td>
<td>a. Left</td>
<td>1 – Drowsy</td>
</tr>
<tr>
<td></td>
<td>b. Right</td>
<td>2 – Obtunded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – Coma/Unresponsive</td>
</tr>
<tr>
<td>7</td>
<td>Limb Ataxia</td>
<td>0 – No ataxia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Ataxia in 1 limb</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Ataxia in 2 limbs</td>
</tr>
<tr>
<td>8</td>
<td>Sensory</td>
<td>0 – No sensory loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Mild sensory loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Severe sensory loss</td>
</tr>
<tr>
<td>9</td>
<td>Language</td>
<td>0 – Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Mild aphasia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Severe aphasia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – Mute or global aphasia</td>
</tr>
<tr>
<td>10</td>
<td>Articulation</td>
<td>0 – Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Mild dysarthria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Severe dysarthria</td>
</tr>
<tr>
<td>11</td>
<td>Extinction or inattention</td>
<td>0 – Absent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – Mild (loss 1 sensory modality)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – Severe (loss 2 modalities)</td>
</tr>
</tbody>
</table>

**NIH Stroke Scale**

- Most commonly used stroke scale
- Rating of **0-42**, with 42 being the worst score
- Strong predictor of clinical outcome\(^1\)
  - A score of >10 is highly correlated with large artery occlusions that may require treatment beyond IV tPA

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<td>432 (64%)</td>
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<td>144 (65%)</td>
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- Lewandowski et. Al. examined stroke severity and occlusion location\(^2\)
  - NIHSS 5-9: 36% Positive Predictive Large Vessel Occlusion
  - NIHSS 10-15: 44% Positive Predictive Large Vessel Occlusion
  - NIHSS >15: 100% Positive Predictive Large Vessel Occlusion

---


NIH Stroke Scale

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---


IMAGING

- **CT (Unenhanced Head CT)** - include for rtPA
  - Bleed, extent of stroke, ASPECTS scoring, surprises
- **CTA (CT Angiogram Head & Neck)** - Clot Retrieval
  - Include for Clot Retrieval
  - LVO clot, Anterior vs Posterior, extent of clot, Carotid stenosis/occlusion, Anatomy, Arch, Circle of Willis, Collaterals, RAPID analysis, surprises
- **CTP (CT Perfusion)** – Exclude from Clot Retrieval
  - Completed Core Infarct vs At Risk Recoverable Penumbra
IMAGING

• CT  - rtPA
• CTA  - Clot Retrieval
• CTP - Exclude from Clot Retrieval
Important Considerations

• The decisions to give rtPA and perform Clot Retrieval are nearly independent decisions (unless there is very rapid improvement after rtPA is given)

• Obtaining the CTA (and CTP) should not significantly delay the administration of the rtPA. They can (potentially) occur simultaneously (give rtPA with the pt in the CT scanner for the CTA/CTP)
ASPECTS

10-point quantitative topographic NonCon Head CT scan score used in patients with middle cerebral artery (MCA) stroke. Segmental assessment of the MCA vascular territory is made and 1 point is deducted from the initial score of 10 for every region involved.

An ASPECTS score ≤ 7 predicts worse functional outcome at 3 months as well as symptomatic hemorrhage.

Complicated by prior infarcts.

Our NeuroRads don’t routinely use it. No Retrieval if > 1/3 vascular distribution.
CT Perfusion

• **important adjunct**, along with CT Angiography (CTA), to conventional unenhanced CT brain imaging:

• **CT-CTA-CTP** (non-con head CT, CT Angiography Head and Neck and CT Perfusion studies)

• **differentiates** salvageable ischemic brain tissue (**Penumbra**) from irrevocably damaged infarcted brain (**infarct core**). This is useful when assessing a patient for potential treatment with clot retrieval:** Patient Selection** for Intervention

• **MRI Diffusion Weighted Imaging (DWI)** is *more sensitive* in detecting early ischemic change – but timely access makes it **impractical**

• Additional small contrast injection and repeat brief CT, select arterial and venous points, use software and interpret.
CT Perfusion Measures

- CBF – Cerebral Blood Flow
- CBV – Cerebral Blood Volume
- MMT – Mean Transit Time
- Or TTP – Time To Peak

Brain is mapped using a color coded scale with the Red end of the scale higher values and the Blue end of the scale Lower values with yellow and green in between.
CT Perfusion

• The **infarct core** is the part of the ischemic brain which has already infarcted or is destined to infarct regardless of therapy.

• It is defined as an area with prolonged MTT or Tmax, markedly decreased CBF and markedly reduced CBV.

• The **Ischemic Penumbra**, which in most cases surrounds the infarct core, also has prolonged MTT or Tmax but in contrast has only moderately reduced CBF and, importantly, near normal or even increased CBV (due to autoregulatory vasodilatation).
CT Perfusion Normal
CT Perfusion INFARCT
Matched Defect CBV and MTT
CT Perfusion  PENUMBRA
Mismatched Defect CBV and MTT
CT Perfusion: Infarct vs Penumbra

- **Core infarct**
- **Ischemic penumbra**

- **CBF**
- **CBV**
- **MTT / TTP**
CT Perfusion Pitfalls

• Poor Cardiac Output
• A Fib
• Severe Proximal arterial stenosis
• Poor placement of the arterial and venous density regions of interest
• the decreased blood flow can lead to inaccurate perfusion maps and specifically to overestimated MTT (i.e. erroneous diagnosis of extensive ischemia or global hypoperfusion) and underestimated CBF.
• Small infarcts (e.g. lacunar infarcts) are poorly visualized on perfusion maps due to their low resolution
• In cases of seizures, the ictal region shows hyperperfusion, which may lead to an interpretation of hypoperfusion in the contralateral hemisphere mimicking infarct.
CT Perfusion

• Routine Use is currently Controversial, In and Out of Favor, Evolving
• **One View:** if meet criteria and in Time Window <6 Hours, Don’t do perfusion, go right to Retrieval
• **Other View:** Do on everyone so get good at it (tech’s doing it and Docs interpreting them), and will exclude some patients with completed infarct and no Penumbra to save – **US!!** (currently)
• Essential in Patient Selection when marginal time frame (unsure or pushing the 6 hours)
• Will do on all Transfers with significant time lag on arrival at SPH
• DAWN Trial results (with potential treatment extended out to the 6-24 Hour window) will make CTP critical in patent selection
• Software specific to Stroke
• St Patrick Hospital is purchasing this fall – server based, will need to do the perfusion Imaging at SPH. Wont be done at the transferring Hospital.
• Analyzes CT Perfusion or MRI DWI data
• Will use in conjunction with TeleStroke neurologists, will send email to Treating Provider (IR, Neurologist) with in 5 minutes from receipt,
• Game Changer for fast decision making, particularly for stroke patients that are on the edge of the treatment window.
• Will Not necessarily help with decision to transfer unless the sending hospital has the software.
CT Perfusion
RAPID

Collaterals
Treatment

### Actions*

<table>
<thead>
<tr>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>If patient is a candidate for IV tPA, review the risks/benefits with the patient’s family and give tPA.†</td>
</tr>
<tr>
<td>Repeat neurological exam</td>
</tr>
<tr>
<td>If appropriate, perform additional imaging (CTA, CTP, etc.) to help identify large vessel stroke.</td>
</tr>
<tr>
<td>Initiate stroke pathway and triage patient to the angio suite if they are a candidate for mechanical clot removal.</td>
</tr>
</tbody>
</table>

† NOTE: Do not give anticoagulants or antiplatelet treatment for 24 hours after tPA until a follow-up CT scan at 24 hrs does not show intracranial hemorrhage.

*These are recommended guidelines. Always reference established suspected stroke protocol at your facility.


Evolution of Stroke Treatment

- IV t-PA
  - Approved 1996
- ECASS-3
  - IV t-PA 4.5 Hours 2008
  - IMS III 2013

1995 NINDS PROACT
2004 Merci
2007 Penumbra
2012 Stentriever

Pharmacological Thrombolysis
Mechanical Thrombectomy
Devices we started with...

- Microcatheter and wire
- Microcatheter and IA tpa
- Alligator
- Snare
EVOLUTION OF TOOLS FOR AIS...
EVOLUTION OF TOOLS FOR AIS...

IV TPA ➔ MERCI/MULTI ➔ PENUMBRA ➔ STENT RETRIEVERS
Acute Ischemic Stroke Treatment: Standard of Care: Mechanical Thrombectomy
Large Vessel Occlusion: Clot removal Devices

- **Stent retrievers** – “**Stent on a Stick**”
  - (MERCI - 2004)
  - TREVO - 2012
  - Solitaire
- **Aspiration** Thrombectomy Catheter – “**Vacuum**”
  - PENUMBRA (FAST and ADAPT techniques)
- **MERCI** – “Corkscrew with Fishing Line” - Outdated
Acute Ischemic Stroke Treatment:
Standard of Care: Mechanical Thrombectomy

- Stent Retrievers (Trevo & Solitaire) vs Non-Stent Retriever (Penumbra & Merci)
- *Journal of Neurosurgery, April 2017/ Vol. 126/ No. 4: pg 1123-1130*
- Jefferson Hospital for Neuroscience, 166 pts, 2008-2014
- **Stent Retrievers**: Lower 90 day NIHSS, Better 90 day mRS Scores(<2)(62% vs 22.%), Higher TICI 2b-3 Recanalization rates (97% vs 79%), Higher % of parenchyma salvaged, and higher discharge rates to home. Lower, incidence of ICH(13% vs 40%) and Trend toward lower 90 day mortality
- **Aspiration (Penumbra)**: Device and results are improving
- Future: Combined Devices?
  - “Solumbra”: Solitaire (or TREVO) + Penumbra
  - “Switching Strategy”: change from one device to the other
Merci Retriever
Rapid evolution FDA cleared devices.

2004-MERCI DEVICE
2012-“STENT ON A STICK”

Stryker Neurovascular Trevo™ Retriever

EV3 Solitaire™
Stent Retrievers:
Idea from Cardiology + Neurosurgery
Stent assisted Aneurysm Coiling
Stent Retrievers: Removed
Best of both worlds

• Don’t have to aggressively AntiPlatelet/Anticoagulate as in Cardiology
  • Don’t want to anticoagulate, antiplatelet Rx in acute LVO stroke
• Don’t have to leave in place as in Aneurysm Coiling Stent
• Just like camping:
  • Pack it in/Pack it out:
  • Both the Clot and the Stent Retriever removed
Stent Retrievers

TREVO

Solitaire
TREVO: Stent Retriever for Clot Removal

• https://youtu.be/PxcERzyI67I
TREVO – Sheath/Catheter/Trevo Set Up
TREVO: Stent Retriever – Set Up
TREVO - Latest, greatest
TREVO: Stent Retriever for Clot Removal
TREVO: Stent Retriever for Clot Removal
PENUMBRA

• CLOT ASPIRATION SYSTEM
• Reperfusion Catheter
• Hi-Flow Aspiration Tubing
• Pump Max Vacuum
Penumbra Technique
PENUMBRA: Aspiration Thrombectomy

• https://youtu.be/ajcgsAr6K2A
“Solumbra”

• simultaneously uses both the stent retriever and the large-bore aspiration catheter at once to enhance the efficacy of recanalization.

• localized aspiration at the site of the thrombus may promote entrapment of the thrombus within the stent.

• Also, flow control induced by aspiration may reduce the incidence of thrombus fragmentation and distal embolization.

• a number of case series and clinical studies are associated with good results of the Solumbra technique. However, it is still an area of controversy

• Common approach: Trevo (3 passes/device, 6 passes/vessel). If unsuccessful after 2-3 passes, switch to or add Aspiration
Cases
69 yo male new onset facial droop, right sided weakness and decreased responsiveness

- H/O afib, cardioversion SPH ER 5 days prior, on Pradaxa
- NIHSS=10
- Head CT: wnl. No IVtPA since on Pradaxa
- CTA: Left Distal M1 embolus
- CTP: Large penumbra Left MCA distribution
- Angio: Clot had migrated more distally in MCA
- TREVO: complete clot retrieval with one pass
- Onset 1700, ER 1800, Angio 1930, Retrieval 2015 (3 hours 15 minutes)
- NIHSS post retrieval = 5, on Discharge to home 3 days later = 1
- OutPt f/u with Speech Therapy for mild residual aphasia
69 yo Male  
Aphasia, right weakness  
CTA: Prox M2
69 yo Male    Aphasia, right weakness.    CTP

CBF

CBV
69 yo Male    Aphasia, right weakness.  CTP

MTT

TTDD
69 yo Male  Aphasia, right weakness.  CTP

Large Penumbra Left MCA with minimal completed core infarct.

Perfect candidate for Clot Retrieval
69 yo Male    Aphasia, right weakness

Left Distal MCA    TREVO 3.0
69 yo Male   Aphasia, right weakness

Left Distal MCA   TREVO 3.0
69 yo Male  Aphasia, right weakness

MRI DWI  day 1 Post  At Risk
69 yo Male  Aphasia, right weakness. 
Head Ct 1 week later as an OutPt

NIHSS from 10 to 1 
Mild Aphasia 
Discharged to home day #3
37 yo Healthy Male

• Feeling normal talking to his wife who is visiting him at his office.
• All of sudden he becomes unresponsive and collapses and has a seizure, right in front of his wife.
• Taken to the emergency room and is comatose. (‘Locked In’)
• CAT scan of head obtained.
37 yo male, Acutely Obtunded
Head CT, no contrast

Hyperdense Basilar Artery
37 yo male, Acutely Obtunded
Head CTA Contrast, Basilar artery thrombus
37 yo male, Acutely Obtunded
Head CTA Contrast, Basilar artery thrombus
37 yo Male, **Basilar Thrombosis**, Comatose
Right Vertebral Arteriogram

Where’s the Basilar?
37 yo Male, **Basilar Thrombosis**, Comatose
Merci Catheter through Basilar into Post. Cerebral Aa
37 yo Male, **Basilar Thrombosis**, Comatose
Merci Catheter pulled down through Basilar thrombus
Merci Clot Retrieval
37 yo Male, **Basilar Thrombosis**, Comatose
Right Vertebral Arteriogram, Post Merci retrieval
Pre Merci
37 yo Male, **Basilar Thrombosis**, Comatose
Right Vertebral Arteriogram, Post Merci retrieval
37 yo Male, **Basilar Thrombosis**, Comatose

- **RESULT**
- Without intervention, certain death. Previously no good options.
- Puncture to Clot retrieval = 28 Minutes
- Pt woke up. Small pontine infarct. No significant residual neurologic deficit.
- Then and 6 years later - near NORMAL. (sl. swallowing issue, sl. Memory difficulty, mild blurred vision when turns head to right)
- ? Source.
83 yo Female, assisted living, Acute onset severe left Hemiparesis, Left neglect, right gaze preference

- Normal at 1500, Left hemiparesis at 1530
- ER 1620, CT no bleed with Hyperdense Right MCA
- NIHSS= 14, tPA given with 50 minutes (1705)
- CTA: Right MCA, M2 thrombus
- MultiPhase CT: Pial Collateral score = 4
- Angio: Posterior Division Right MCA
- TREVO: 2 passes required
- Post CT: small amount of SAH
- Discharged on Day 4 to SNF, NIHSS 0-1
83 yo Female, assisted living, Acute onset severe left Hemiparesis: Hyperdense MCA
83 yo Female, assisted living, Acute onset severe left Hemiparesis:

CTA

Multiphase CT

Pial Collateral Score of 4 (delayed 1 Phase)
83 yo Female, assisted living, Acute onset severe left Hemiparesis:

Distal Right MCA Embolus

TREVO
83 yo Female, assisted living, Acute onset severe left Hemiparesis

Post TREVO – 2 Passes

Post Head – no change in 2 days, Blood
20 yo student at UM, collapsed in class, Congenital Heart Disease – prior surgeries

- 6 years ago, timing documentation less complete
- no NIHSS in notes (GCS=10)
- Severe Right hemiparesis and aphasia
- Did emergent EEG first (?), Then Head CT
- Beyond tPA window (4 hours post event)
- CTA – Left MCA M1 occlusive embolus
- Angio: Merci clot retrieval
20 yo Student: Left M1 Occlusion
20 yo Student: Left M1 Occlusion

Angio: AP

Angio: Lateral
20 yo Student: Left M1 Occlusion: MERCI, plus tPA 1 mg beyond the clot
20 yo Student: Left M1 Occlusion
Post TREVO

Angio: AP

Angio: Lateral
20 yo Student: Left M1 Occlusion
Post TREVO

• Markedly improved, Hemiparesis nearly resolved, mild residual speech, did not require rehab stay
• Possible endocarditis, transferred to University of Washington due to congenital heart disease
• Don’t have post imaging available, has pacemaker
• Recurrent stroke symptoms December 2015, treated with tPA with near complete resolution of symptoms. CTA/P at that time showed penumbra without occlusive clot. Probable distal emboli. Resolved for the most part.
56 yo Male Ischemic Cardiomyopathy, Extended Lead Explant procedure

• Difficult prolonged lead explant under general anesthesia for several hours
• Required cardioversion twice during that procedure
• Out of anesthesia noted to have right sided weakness, aphasia, fixed gaze with eye deviation and decreased LOC
• Head CT: Hyperdense Basilar artery, probable cerebellar infarct
• CTA: thrombosed Basilar artery and ? Of clot in the left vertebral artery, posterior cerebral and superior cerebellar arteries
• CTP: Posterior right cerebellar hemisphere completed infarct with moderately large penumbra in the remainder of the right cerebellar hemisphere, and the pons and left basal ganglia
56 yo: Basilar Thrombosis: CTA

Basilar Thrombus
Left Vertebral - partial
? Left post cerebral
? Left sup Cerebellar
Bilateral Pulmonary Emboli
56 yo: Basilar Thrombosis: CTP

Right Cerebellar Infarct

Moderately large Penumbra cerebellum, pons, left basal ganglia
56 yo: Basilar Thrombosis: Trevo

Pre Angio

TREVO
56 yo: Basilar Thrombosis: Trevo
56 yo Male Ischemic Cardiomyopathy, Extended Lead Explant procedure

• Initial mild Neurologic Improvement
• Neurologist “He is going to have progressive edema, herniate and possibly need surgical decompression. ”
• Neurosurgery considered but ultimately did not decompress.
• Progressive edema with no room to swell given bony posterior fossa.
• Did herniate with progressive neurologic decompensation and death.
Progressive Posterior Fossa Edema with Herniation and Neurologic Decompensation
62 yo Healthy female with Collapse

- Very healthy and active 62 yo without significant medical history
- Episode of arm numbness and tingling 3 days prior – very stressful week with depositions etc
- Syncopal episode and hit her head.
- Awoke with right hemiparesis and facial droop and aphasia. CMC ER
- CT/CTA, no CTP, thrombosed left MCA. Fetal origin Lt PCA.
- Received tPA in CMC ER within 1.5 Hours of symptom onset
- Quickly transferred to SPH – directly to angio, starting within 2.5 hours of onset of sxs
62 yo Healthy female with Collapse

**CT:** Hyperdense MCA

**CTA:** Left MCA M1 Thrombosis
62 yo female with Left MCA thrombosis
62 yo female with Left MCA thrombosis
62 yo female with Left MCA thrombosis

Microcatheter: Distal MCA

TREVO
62 yo female with Left MCA thrombosis
Post TREVO: 3 passes required
62 yo Healthy female: Left MCA TREVO

- Post TREVO NIHSS=18, No Change from initial but then progressisvely deteriorated
- Head CT shows massive infarct in Left MCA and PCA distributions with Ventricular decompensation and shift and herniation
- Surgical decompression considered but comfort care chosen by family due to large extent of the infarct in multiple distributions.
- Progressive neurologic decompensation and death
- Fetal Origin of left Posterior Cerebral artery disadvantage in this case since it was also effected by the embolus that took out the MCA
- Would have perfusion shown a large completed infarct with little penumbra despite early tPA and referral. Every Pt is unique, some with completed fatal stroke in 1 hour, others with sig penumbra at 6. Collaterals
- Balloon Occlusion Sheath balloon rupture. ??
- Source of embolus/thrombus not known
43 yo Female with MS, Chronic LUE and Bilat. LE weakness with acute onset of new right hemiplegia and aphasia

- NIHSS 25 – confounded by baseline deficits from MS – severe stroke on top of baseline deficits devastating so wanted aggressive Tx
- Received tPA at SPH
- CTA: Proximal Left ICA thrombus(Cervical) plus Left MCA thrombus
- CTP: Significant Penumbra without significant completed infarct
- Tx to Sacred Heart Spokane – No Penumbra device at SPH at that time and if associated carotid dissection might need carotid stenting
- Cervical ICA clot aspirated and MCA clot removed with Trevo
- Improved right sided weakness and aphasia with NIHSS from 25 to 11
- MRI with progression of MS, new small scattered infarcts left basal ganglia, periventricular white matter and left frontal lobe
- Challenging case from all perspectives – intervention very helpful, could now probably handle at SPH
MS
MS
Left Internal Carotid Artery Thrombotic Occlusion
Left MCA Embolic Occlusion – Lateral View
ICA patent post Penumbra Aspiration
Left MCA – M2 embolus
Post TREVO – Single Pass, 4 x 30 mm
Left MCA: TREVO – Single Pass, 4 x 30 mm

PRE

POST
### Shift Summary: Include Pain RX

- CVA, NIH 11. Hx of MS, hypertonic BUE with hemiparesis of RUE. W/C bound at B/L. 1:1 feeder. Q2 turn/change. Q4 baclofen. Aphasia improved since last night- able to identify all but hammock on NIH test. Pills with applesauce. Bruising throughout body, large bruise under pannis. Pt denies pain, PICC RUE.

<table>
<thead>
<tr>
<th>Neuro</th>
<th>A+O x4</th>
</tr>
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<tbody>
<tr>
<td>NIH Stroke Scale Total Score</td>
<td>Total (NIH Stroke Scale): 11 (07/08/17 0005)</td>
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</table>
Patient Transfer for Clot Retrieval
Acute Ischemic Stroke Requiring Immediate Intervention
Process for referral to Providence St. Patrick Hospital

Clot Retrieval Window
Anterior Circulation: 6 hours from last known well
Posterior Circulation: up to 12 hours from last known well

Referring Physician calls St. Patrick Hospital Referral Line at 1-888-878-7287

1. RLC asks following questions prior to contacting the Interventional Radiologist or Neurologist:
   - When was the last time the patient was seen normal? ________
   - Is the patient <80 years old? □ Yes □ No
   - What time did patient arrive in the ED? ________
   - Has TPA been given? □ No
     - If yes: □ 3 hour window □ 4.5 hour window
   - Is patient on any anticoagulants?
     - If yes, what medication? ________
     - If Coumadin, what is the INR? ________
   - Has a CTA been done? □ No (advise sending that IR will request)
     - If yes, before or after t-PA (if t-PA given)?
       - □ Before □ After □ NA
   - Does CTA reveal carotid terminus occlusion, M1 occlusion or vertebral/basilar occlusion (complete carotid occlusion not candidate)?
     - □ No □ Yes (location): ________
   - NIH stroke scale between 10 and 30? □ Yes □ No □ Score: ________
   - Vital signs: ________
   - Have images been pushed to St. Patrick Hospital? □ If no, please send.

2. If answer is YES to all Underlined questions, contact IR.

- Referral Line Coordinator (RLC)* will connect the referring physician to the Interventional Radiologist on call using his/her cell phone**;
- If the transferring physician is a neurologist, connect with IR physician.
- If the transferring provider is NOT a neurologist, go to step 3.

3. RLC connects the referring physician to Neurologist.
   - □ Does patient have any significant co-morbidities that require urgent monitoring?

4. RLC contacts patient supervisor regarding patient admission;
5. RLC contacts referring facility to confirm transfer details;
Acute Ischemic Stroke Requiring Immediate Intervention
Process for referral to Providence St. Patrick Hospital

6. The referring facility will arrange transportation. If assistance is needed with arranging transportation the referring facility will advise the RLC who will step in.

*The RLC is available 7 days a week, including holidays and weekends, between the hours of 8am and 8pm. After hours the phone will transfer to the ED Charge Nurse to coordinate with house supervisor. Neurologists are on call 24 hours/day by calling the number above. Hospitalists are available at all times and can be reached by calling number above. Interventional Radiologists are on call 24 hours/day and available by calling number above.

**Time is of the essence for these transfers and RLC/ED CN should not page neurologist on call but use the cell phone number available on daily on-call list.
Referring Physician calls St. Patrick Hospital Referral Line at 1-888-878-7287

1. RLC asks following questions prior to contacting the Interventional Radiologist or Neurologist:
   - When was the last time the patient was seen normal? ________________
   - Is the patient <80 years old? ❑ Yes ❑ No
   - What time did patient arrive in the ED? ________________
   - Has TPA been given? ❑ No
     - If yes: ❑ 3 hour window ❑ 4.5 hour window
   - Is patient on any anticoagulants?
     - If yes, what medication? ________________
     - If Coumadin, what is the INR? ________________
   - Has a CTA been done? ❑ No (advise sending that IR will request)
     - If yes, before or after t-PA (if t-PA given)?
       - ❑ Before ❑ After ❑ NA
     - Does CTA reveal carotid terminus occlusion, M1 occlusion or vertebral/basilar occlusion (complete carotid occlusion not candidate)
       - ❑ No ❑ Yes (location): ________________
   - NIH stroke scale between 10 and 30? ❑ Yes ❑ No
     - Score: ________________
   - Vital signs: ________________
   - Have images been pushed to St. Patrick Hospital? If no, please send.
   - Can the patient arrive SPH within 5 hours from time last seen normal for anterior circulation stroke and within 12 hours for posterior circulation stroke? ❑ Yes ❑ No
Age Limit - ?

• >18 : It’s not that they couldn’t benefit, safely, Just no data.
• Upper Age Limit?
  • <80?, <85?
    • Pre Event Functional Status (mRS 0-2) more predictive than age
• Suggested that If Pt Age + NIHSS >100 : do poorly, but have not seen this absolutely verified with data verified
When to Transfer?

• Could depend on symptoms/NIHSS, probability of LVO, time since onset of symptoms, distant from accepting hospital, capabilities of transferring hospital.

• At first recognition of significant stroke (even before Head CT); Stabilize and Ship

• After CT with high NIHSS and administration of rtPA: Drip and Ship

• After CTA confirming retrievable clot
  • NIHSS 5-9: 36% Positive Predictive Large Vessel Occlusion
  • NIHSS 10-15: 44% Positive Predictive Large Vessel Occlusion
  • NIHSS >15: 100% Positive Predictive Large Vessel Occlusion

• CT Perfusion study not realistic at most transferring hospitals
  • If borderline time frame will likely be performed at SPH when we receive the patient, to confirm significant recoverable penumbra
When to Transfer? After CTA - WHY

• Confirms retrievable clot (Don’t need to transfer if no LVO to Retrieve)
  • NIHSS 5-9: 36% Positive Predictive Large Vessel Occlusion
  • NIHSS 10-15: 44% Positive Predictive Large Vessel Occlusion
  • NIHSS >15: 100% Positive Predictive Large Vessel Occlusion
• Determine Location of Clot (Anterior 6 hours, Posterior 24 hours)
• Specific to SPH (currently): If long segment Cervical Internal Carotid artery Occlusion need to transfer to a Center performing Carotid Stenting (ie, Chris Zylak, Sacred Heart Hospital, Spokane, WA)
• When in doubt – if the permutations are overwhelming you, get Head CT and CTA Head and Neck without delay, send images to SPH and call referral Line, while giving tpa if indicated, anticipate transfer options
TRANSFERS

• Never as smooth as hoped: plenty of room for improvement on both the transferring and receiving ends.

• Even the tertiary, high volume centers admit as much

• “Practice makes Better“ (rarely perfect)— re: efficiency of handling stroke pt’s, coordinating transfers and performing the clot retrieval.

• Best Practice: is still being established.

• Criteria and Protocols are evolving: hard to keep up.

• As a low volume center, we have no ego in this, if the pt is better served at a Tertiary High Volume Stroke Center so be it but may not be realistic with the clock ticking.
TRANSFERS

• Sensitive to the Impact of transferring Patients
• Transport is $$$
• Families of Patients are Displaced
• Loss of Patient for the Transferring Hospital
• Receiving hospital accepting patients who might not get intervention
• Therefore, only want to Transfer Patients with LVO/Retrievable Clot
• Transfers **ALWAYS** take longer than predicted
48 yo Male, Transfer from Gt Falls Beyond the Window, Rt M1 Occlusion, TREVO retrieval at 6.5 Hours at best, Significant Transport Delay of 3 hours, No CT Perfusion on arrival
48 yo Male, Transfer from Gt Falls Beyond the Window, Rt M1 Occlusion, TREVO retrieval at 6.5 Hours at best, Significant Transport Delay of 3 hours, No CT Perfusion on arrival

Immediate Post TREVO NonCon Head CT;

Primarily Contrast Staining, not blood, Breakdown of the BBB

The Patient Died.
64 yo Male Acute Onset Left hemiplegia

- Last seen normal in Breakfast line at Family Reunion in Plains
- 10 minutes later, relative hears a crash in his trailer
- Acute onset dense left hemiparesis, left facial droop, left neglect, right gaze preference, slurred speech, slightly confused, nonreactive to left stimuli
- Clark Fork Valley ER: SS=21, Head CTA – Hyperdense Rt MCA, IV-tPA
- Transfer to SPH for CTA/CT Perfusion and TREVO clot retrieval
- Good Example of efficient work-up, transfer and treatment – and still not a perfect outcome
TIMELINE

• 9:30 Last Seen Normal
• 9:40 Event heard
• 10:29 EMS to Clark Fork Valley ER, NIHSS=21
• 10:31 IV started
• 10:39 Pt to CT Head noncon – Hyperdense Right MCA
• 10:47 Pt back to ER
• 11:01 Discussed with Neurology (KRMC)
• 11:06 Alteplase (iv-tPA) bolus and infusion started
• 11:45 Slight improvement in symptoms, NIHSS ~ 18
• 11:48 Discussed with SPH Hospitalist, accepted for transfer
TIMELINE

- 12:15 Taken to Helicopter
- 12:45 Arrives SPH – Brief Eval as taken Directly to CT
- 12:53 Head CT
- 12:56 CTA Head & Neck, with Multiphase Imaging
- 13:01 CT Perfusion completed
- Taken directly from CT to Angio for TREVO, Consented as transported, Balloon Occlusion sheath and set up already being prepped (10 min)
- 13:10 Patient and all staff in room to start patient prep
- 13:22 Lidocaine in groin
- 13:25 Sheath and catheter in
TIMELINE

• 13:57- 14:02  TREVO -First Pass (4:17 from onset of sx), partial patency
• 14:19-14:24  TREVO - 2nd Pass  Fully patent Rt MCA, brisk flow
• 14:43  Perclose Suture Mediated closure of access
• 14:56  Post procedure Head CT, Transfer to hospital room
• Every step fairly efficient but still barely within treatment time window and pt still had a significant completed Stroke.
• Many Montana patients significant delay in presenting, and transfer from longer distance, taking more time.
• Could we have gone straight to Angio, skipping CTA/CTP? ~17 minutes
  • But would add time at time of angio . Plus, info critical, So - NO!
64 yo Male Acute Onset Left hemiplegia

Non Con Head CT
Hyperdense Rt MCA
Hypodense Insular Cortex, BG
64 yo Male Acute Onset Left hemiplegia
CTA
64 yo Male Acute Onset Left hemiplegia
CTA
Multiphase CTA - First Phase
Multiphase CTA - Third Phase
CT Perfusion
CT Perfusion
CT Perfusion
CT Perfusion
RED – Infarct
Not Recoverable

Yellow – Penumbra
Recoverable
CT Perfusion

• Moderate sized Completed Infarct
• Moderate sized Penumbra
• **TREVO** Clot Retrieval - ??
  • ? > 1/3 of MCA distribution
• Within Time Window
• Moderate Penumbra
• YES! Definite possible gain, low risk
TREVO Clot Retrieval
MicroCatheter and Wire Through Clot
TREVO Stent retriever – 4 mm x 30 mm
FloGate Balloon Occlusion Sheath, 8Fr BCG (Balloon Guide Catheter)
TREVO Stent retriever – 4 mm x 30 mm, First Pass
TREVO Stent retriever – 4 mm x 30 mm – 2nd Pass
TREVO Stent retriever – 4 mm x 30 mm

PRE

POST
TREVO Stent retriever – 4 mm x 30 mm
CT Head- Post TREVO:
Contrast Staining vs Hemorrhage or Both
Clinical Result

• NIHSS, the following morning (HD #2) post Trevo, down from 21 to 11. Persistent sig Left sided weakness and loss of sensation, and moderate left facial weakness

• The following morning (HD#2), pt developed AFIB with RVR - likely cause of the embolus, started on Amiodarone.

• **CT Head** at >24 hours: afternoon HD #2
  - Hemorrhagic transformation with extension into Right lateral ventricle with mass effect and some shift, but without significant change in neurologic status

• Aspiration Pneumonia

• Discharged after 12 days to CMC Inpt Rehab.
CT Head: 1 day post retrieval
MRI - Post TREVO

- Not performed before Tx to Rehab
- Final clinical outcome - IDK
Glorified Plumber
5 Interventionalists comfortable with TREVO clot retrieval in acute LVO stroke

- 4 Fellowship trained Vascular and Interventional Radiologist:
  - MARK ELLIOTT, MD
    Specialty: Diagnostic and Interventional Radiology, Vascular Imaging, Mammography
  - SARSFIELD DOUGHERTY, MD
    Specialty: Diagnostic Radiology, Interventional Radiology, Vascular Imaging
  - PAUL EIKENS, MD
    Specialty: Diagnostic Radiology, Vascular Imaging, Mammography
  - KYLE LAIRD DALE, MD
    Specialty: Diagnostic Radiology, Vascular and Interventional Radiology

- 1 Fellowship trained Neuroradiologist – does some Neurointervention:
  - RICHARD T. DAHL, MD
    Specialty: Diagnostic Radiology, Neuroradiology

- 24/7/365 - An Interventionalists is on call at SPH to do Clot Retrieval
- In Your Area (We are the only group in Montana doing this)
Realistic Transfer Territory???
Realistic Transfer Territory?? - Ideal
Realistic Transfer Territory? Currently asked to consider
Realistic Transfer Territory???

TBD
Our Experience: ST. Patrick Hospital

- 1990’s – started many days with 2 Carotid/Cerebral arteriograms
- Occasional Intracranial Arterial Thrombolysis
- MultiDetector CTA’s, IV tPA – more organized Stroke Treatment
- Carotid Stenting, Clot Retrieval: MERCI
- MultiDisciplinary Stroke Committee, Stroke Team Activation
- Low Volume: 25-30 Clot Retrieval cases between Merci and Trevo
- Committed to 24/7/365 coverage, Availability, Competence
- Asked by Other Montana Hospitals to accept transfers for Retrieval
- Programs, Protocols and Procedures are constantly Evolving
- Challenge – even for in House Strokes, Transfers – New Challenges

“Practice Makes Better”. Every case is unique + different, but protocols and algorithms set up so the process is consistent and efficient as possible
Holes in our Stroke Service

• Carotid Stenting
• Penumbra Device for Aspiration now available
• Do Not have a Dedicated Stroke Icu or NeuroIntensivist
• Shortage of Neurologists: Telestroke coming soon and will help!
• RAPID software: this Fall – speed up, simplify and standardize decision making in conjunction with the dedicated Telestroke Neurologist – who will improved quality and availability
• HOWEVER, able and willing stroke service from ER-Clot Retrieval-Post Stroke Care- Rehab, and your closest option.
TeleSTROKE

Providence Acute Telestroke Service
Improving Outcomes & Access
Acute Intraoperative Stroke

• 76 yo male with >70% Left ICA stenosis with recent TIA’s
• Left Carotid Endarterectomy: High Bifurcation – No Shunt, Clot on ulcerated plaque noted.
• Pt woke up from anesthesia with Severe stroke with Dense Right Hemiplegia and Aphasia and required reintubation
• Time from onset within 2.5 Hours.
• CTA: Left M1 MCA embolus and CTP: large completed infarct with no collaterals and no penumbra, therefore, clot retrieval not performed.
• Family said pt would not want any treatment given expected very poor outcome (likely fatal or massive deficits if he survives)
• comfort measures only and pt expired.
CT Head – Hyperdense Left MCA
CTA – Left MCA M1 occlusion
CTA – Left MCA Occlusion with No Collaterals
CT PERFUSION: No mismatch
Large MCA Completed Infarct, No Penumbra
CT PERFUSION: No mismatch
Large MCA Completed Infarct, No Penumbra
Collaterals are the Key!!

- Some pt’s have a completed infarct literally within minutes
- Others might not have a completed infarct for up to 24 hours.
- Every patient is different and a challenge
- Now investigating clot retrieval in the extended window from 6-24 hours
• Diffusion Weighted Imaging (DWI) or Computerized Tomography Perfusion (CTP) Assessment With Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention with Trevo (DAWN)

• The purpose of the study is to evaluate the hypothesis that Trevo thrombectomy plus medical management leads to superior clinical outcomes at 90 days as compared to medical management alone in appropriately selected subjects experiencing an acute ischemic stroke when treatment is initiated within 6-24 hours after last seen well.
• The current AHA and ESO guidelines define a rigid therapeutic window of six hours as level 1a evidence.

• However, this treatment paradigm disregards individual variations in compensatory mechanisms for ischemia led by, but not restricted to, collateral flow.

• Moreover, there is growing evidence to support a physiological rather than a purely time based approach where patients with clinical-core mismatch (meaning those patients with significant clinical deficits but still limited infarct size) could potentially benefit from reperfusion regardless of time to treatment.
• Wake-up stroke, stroke with unclear onset time, and witnessed late presenting stroke (>6 hours) represents a large proportion of LVOs (~40%), yet no proven treatment options exist for this population.

• Identify Patients beyond the 6 hour window who have significant clinical deficit but relatively small infarct with larger Penumbra (brain at risk): with CT Perfusion or MRI DWI.

• The much-anticipated results from the DAWN trial were finally revealed at the European Stroke Organisation Conference (ESOC; May 16-18, 2017, Prague, Czech Republic) - So positive for retrieval if there is a penumbra even if out > 6 hours-< 24 hours (anterior), they stopped enrolling after first efficiency analysis at 200 of the planned 500 patients.
RESULTS

• Mean mRS 2.1x better in the Treatment arm
• 90 Day Functional Independence (mRS 0-2): 48.6% vs 13.1%
• NNT to achieve Functional Independence= 2.8
• Treatment effect persists up to 24 hours but sooner still better, “Time is Brain” is unchanged
• For every 100 patients, 49 will have a less disabled outcome as a result of treatment, including 36 who will be functionally independent.
• Prediction: The 6 hour number will become less rigid – pt by pt basis, based on presence of penumbra. Perfusion imaging or its equivalent (multiphase CT) will be key.
• Is a low NIHSS a good predictor of a good outcome? Occlusion with SS <6 still do better with retrieval. Maybe that 6 number changes as well – Rx SS <6. ???
defuse 3

NIH prospective randomized phase III multicenter controlled trial of patients with acute ischemic anterior circulation strokes due to large artery occlusion treated between 6 and 16 hours of stroke onset with endovascular thrombectomy therapy plus standard medical therapy versus standard medical therapy, Endpoint mRs at 90 days.

Purpose: is to assess the safety and efficacy of thrombectomy in carefully selected patients in this extended time window

After interim review of the initial 182/486 patients, DEFUSE 3 was terminated in July due to the high likelihood of benefit in the mechanical thrombectomy group.

The trial results are expected to be presented in early 2018 at the International Stroke Conference (ISC; 24–26 January, Los Angeles)
Ramifications of DAWN and DEFUSE-3

• Potentially **extend** the treatment window for LVO clot retrieval in the Anterior circulation to >6 and <24 hours.

• Could significantly increase the # of patients transferred for possible clot Retrieval

• Potentially increase the # of Clot Retrievals (SHMC predicts up to 4 X )

• **CT Perfusion** imaging will be the **standard** (done well at SPH!) – since CTP wont be performed at the transferring hospital and will be done at SPH, many patients in the 6-24 hour could get transferred but CTP could show it is too late (completed infarct without penumbra) and no intervention will be performed. (transferred for nothing??)

• Providence **Dawn work group** – Algorithms will change. **TELESTROKE** service and **RAPID** software will be critical.

• **STAY TUNED!**
If Interested in an Outreach Lecture at your Hospital?

• Anna Hoppe
  Outreach Program Manager
  (o) 406.327.1625
  (c) 406.360.2575
  Anna.hoppe@providence.org
First Annual Rocky Mountain Stroke Conference

Great Falls, MT
November 3, 2017
TRANSFERS

• **WHO**
  • RULES OF 6 (SS>6, ASPECTS>6 (No big infarct evident), Arrive so can puncture groin by 6 hours (arrive at SPH by 5 hours). Basilar out to 24 hours.
  • LVO (Retrievable Clot) on CTA

• **WHEN**
  • As soon as CTA confirms LVO(retrievable clot)

• **HOW**
  • Call SPH Referral Line @ 1-888-878-7287 (If ?, call ER)
  • Direct discussion with IR or Neurologist
  • If in doubt, discuss Tx, will get CT Perfusion when arrive at SPH

• **Telestroke, Rapid, Dawn Trial – Could Change This**
  • Remember, giving tPA does not preclude TREVO, ideally give tPA while obtaining CTA – one doesn’t slow down the other: Simultaneous imaging and tPA
  • Anticipate Transfer Options sooner rather than later: Rate Limiting Step
Thank You!