Advances in Endovascular Treatment of Large Vessel Occlusion

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Diagnosis and endovascular treatment of cerebrovascular disease
- Ischemic and hemorrhagic stroke
- Cerebral aneurysms
- Intra and extracranial steno-occlusive disease
- Brain AVMs and dural fistulas
- Spinal vascular malformations

Minimally invasive treatment of diseases of the head, neck, and spine
- Vertebral augmentation
- MMA embolization
- Preoperative tumor embolization
- Pulsatile tinnitus
- Epistaxis

Medical Societies:
- American Society of Neuroradiology
- Society of Neurointerventional Surgery
- Southeastern Neuroradiological Society
- American College of Radiology
Financial Disclosure

• No pertinent disclosures
Objectives

• Identify recent advances in the care and treatment of vascular disease.

• Recognize opportunities for APPs in interventional and vascular surgery

• Determine when it is appropriate to refer patients to vascular surgery
Stroke – Clinical Context

• Stroke is a clinical syndrome
  • Ischemic
  • Hemorrhagic
  • “Stroke mimickers”

• 80% of acute strokes are ischemic.

• Majority of mortality results from large vessel occlusions and cardio-embolic sources.
Acute Ischemic Stroke

- Fifth leading cause of death and leading cause of adult disability in the US.
- 795,000 new strokes per year, resulting in 128,000 deaths.
- One stroke every 40 seconds and one stroke death every 4 minutes.
- $34 billion in US health care dollars per year.
Emergent Large Vessel Occlusion

- ELVO
- Higher stroke severity
- Higher mortality
- ICA, MCA, basilar
• This subset of ischemic stroke comprises blockages in the:
  – Internal Carotid Artery (ICA)
  – Middle Cerebral Artery (MCA)
  – Vertebral / Basilar Artery

• 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
Appropriate Vascular Surgery Involvement in Acute Stroke

• Acute ischemic stroke usually does not require vascular surgery involvement

• Increasing role for neurointervention in acute stroke for treatment of intracranial occlusions, as well as tandem cervical vascular disease
Terminology

- NIH Stroke Scale
- Modified Rankin Score
- Thrombolysis in Cerebral Infarction (TICI) scale
### NIH Stroke Scale

#### 15 item scale
0 - 42

<table>
<thead>
<tr>
<th>Score</th>
<th>Stroke Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Stroke Symptoms</td>
</tr>
<tr>
<td>1-4</td>
<td>Minor</td>
</tr>
<tr>
<td>5-15</td>
<td>Moderate</td>
</tr>
<tr>
<td>16-20</td>
<td>Moderate to Severe</td>
</tr>
<tr>
<td>21-42</td>
<td>Severe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Score/Description</th>
<th>Date/Time Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Level of Consciousness</td>
<td>0 = Alert, 1 = Drowsy, 2 = Stuporous, 3 = Coma</td>
<td></td>
</tr>
<tr>
<td>1b. LOC Questions</td>
<td>0 = Answers both correctly, 1 = Answers one correctly, 2 = Incorrect</td>
<td></td>
</tr>
<tr>
<td>1c. LOC Commands</td>
<td>0 = Observe both correctly, 1 = Observe one correctly, 2 = Incorrect</td>
<td></td>
</tr>
<tr>
<td>2. Best Gaze</td>
<td>0 = Normal, 1 = Partial gaze palsy, 2 = Forced deviation</td>
<td></td>
</tr>
<tr>
<td>3. Visual Fields</td>
<td>0 = No visual loss, 1 = Partial Hemianopia, 2 = Complete Hemianopia, 3 = Bilateral Hemianopia (Blind)</td>
<td></td>
</tr>
<tr>
<td>4. Facial Paresis</td>
<td>0 = Normal, 1 = Minor, 2 = Partial, 3 = Complete</td>
<td></td>
</tr>
<tr>
<td>5a. Motor Arm - Left</td>
<td>0 = No drift, 1 = DIF, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement, X = Unstable (Joint fusion or limb amputation)</td>
<td>Left</td>
</tr>
<tr>
<td>5b. Motor Arm - Right</td>
<td>0 = No drift, 1 = DIF, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement, X = Unstable (Joint fusion or limb amputation)</td>
<td>Right</td>
</tr>
<tr>
<td>6a. Motor Leg - Left</td>
<td>0 = No drift, 1 = DIF, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement, X = Unstable (Joint fusion or limb amputation)</td>
<td>Left</td>
</tr>
<tr>
<td>6b. Motor Leg - Right</td>
<td>0 = No drift, 1 = DIF, 2 = Can't resist gravity, 3 = No effort against gravity, 4 = No movement, X = Unstable (Joint fusion or limb amputation)</td>
<td>Right</td>
</tr>
<tr>
<td>7. Limb Ataxia</td>
<td>0 = No ataxia, 1 = Present in one limb, 2 = Present in two limbs</td>
<td></td>
</tr>
<tr>
<td>8. Sensory</td>
<td>0 = Normal, 1 = Partial loss, 2 = Severe loss</td>
<td></td>
</tr>
<tr>
<td>9. Best Language</td>
<td>0 = No aphasia, 1 = Mild to moderate aphasia, 2 = Severe aphasia, 3 = Mute</td>
<td></td>
</tr>
<tr>
<td>10. Dysarthria</td>
<td>0 = Normal articulation, 1 = Mild to moderate slurring of words, 2 = Severe to unintelligible or worse, X = Intubated or other physical barrier</td>
<td></td>
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<tr>
<td>11. Extinction and Inattention</td>
<td>0 = No neglect, 1 = Partial neglect, 2 = Complete neglect</td>
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**TOTAL SCORE**
NIH Stroke Scale

• Stroke severity scale
• 0 - 42
• < 6 strong predictor of good outcome
• > 16 strong predictor of death
• Each point increase equals 17% reduction in good outcome
• Five strongest predictors: Gaze, visual fields, language, arm motor, leg motor
Modified Rankin Scale

• 0 - No symptoms.
• 1 - No significant disability. Able to carry out all usual activities, despite some symptoms.
• 2 - Slight disability. Able to look after own affairs without assistance, but unable to carry out all previous activities.
• 3 - Moderate disability. Requires some help, but able to walk unassisted.
• 4 - Moderately severe disability. Unable to attend to own bodily needs without assistance, and unable to walk unassisted.
• 5 - Severe disability. Requires constant nursing care and attention, bedridden, incontinent.
• 6 - Dead.
mRS

- Functional outcome
- Usually measured at 90 days
Thrombolysis in Cerebral Infarction (TICI)

1 – contrast past site of occlusion but minimal filling of normal territory
2a – partial reperfusion, less than 50% of expected territory
2b – partial reperfusion, 50-99%
2c – complete perfusion but delayed run off
3 – normal
Mechanical Thrombectomy
MODERN work-up of an acute stroke patient
Ischemic Stroke Devices
Thrombectomy History

- 2004: Merci
- 2008: Penumbra
- 2012: IMS III, MR RESCUE
- 2013: MR CLEAN, SWIFT PRIME, EXTEND IA, ESCAPE, REVASCAT
- 2015: DAWN, DEFUSE 3

Select 2

BAOCHÉ, ATTENTION, ANGEL ASPECTS,

Penumbra 3D

Sofia, Jet, AXS, Zoom
Aspiration
- ACE/JET (Penumbra)
- CAT 6 (Stryker)
- Sofia Plus (Microvention)
- React (Medtronic)
- LBC (Cerenovus)
- Zoom (Imperative Care)

Pumps
- ENGINE (Penumbra)
- AXS Universal (Stryker)
- Riptide (Medtronic)

Stent retrieval
- Solitaire (Medtronic)
- Trevo (Stryker)
- 3D (Penumbra)
- Embotrap (Cerenovus)

Balloon Guide
- FlowGate (Stryker)
- Cello (Medtronic)
- Walrus (Q’Apel)
Clinical evidence for stroke treatment up to 24 hours

**NINDS Trial: IV tPA**
- 0 - 3 hours

**ECASS III: IV tPA**
- 3 – 4.5 hours

**5 RCTS: stent retriever**
- 0 - 6 hours

**DAWN Trial: stent retriever**
- 6 - 24 hours

**DEFUSE 3: thrombectomy**
- 6-16 hours
NUMBER NEEDED TO TREAT

MR CLEAN

ESCAPE

EXTEND-IA

SWIFT PRIME

Primary PCI vs. thrombolysis for STEMI: Prevention of MI/Stroke/Death
SELECT2

• Randomized Controlled Trial to Optimize Patient’s Selection for Endovascular Treatment in Acute Ischemic Stroke
• Prospective RCT (US, Canada, Europe, Australia, and New Zealand)
• ICA, M1
• 24h
• ASPECTS 3-5
• Core infarct >50 cc (RAPID)
• Randomization 1:1 (stopped early)
  – 178 patients thrombectomy group
  – 174 patients medical-care group
ASPECTS

- Alberta Stroke Program Early CT score (ASPECTS) is a 10-point quantitative topographic CT scan score

- ASPECTS was developed to offer the reliability and utility of a standard CT examination with a reproducible grading system to assess early ischemic changes on pretreatment CT studies in patients with acute ischemic stroke of the anterior circulation

- ASPECTS CT score is simple and reliable
How to compute ASPECTS

• Two regions of the MCA territory:
  – Basal ganglia
  – Supraganglionic level (corona radiata and centrum semiovale)

• The abnormality should be visible on at least two consecutive cuts

• One point for each normal segment

• Normal = 10

• Entire MCA infarct = 0
ASPECTS

Ganglionic Level

Supraganglionic Level
Outcomes

• mRS 5 and 6 merged
• Primary outcome was ordinal score on mRS
• mRS 0-2 secondary outcome at 90 days
• mRS 0-3 secondary outcome at 90 days
• Etc...
• Predefined subgroups
Outcomes

• mRS measured at 24h, 5-7d, 30d, 90d

• Primary outcome
  – mRS 4 for thrombectomy
  – mRS 5 for medical

• Secondary outcome
  – mRS 0-2 20% for thrombectomy
  – mRS 0-2 7% for medical
Other outcomes

- Early neurologic worsening
  - 44 patients (24.7%) in the thrombectomy group
  - 27 patients (15.5%) in the medical-care group

- sICH
  - One patient (0.6%) in the thrombectomy group
  - Two patients (1.1%) in the medical-care group

- Procedural complications occurred in 33 patients (18.5%) in the thrombectomy group.
  - Arterial access site included occlusion (in 3 patients [1.7%]) hematoma (in 1 patient [0.6%]), and infection (in 1 patient [0.6%]).
  - 10 patients (5.6%) had vascular dissections
  - 7 (3.9%) had arterial perforation
  - 11 (6.2%) had intraprocedural vasospasm
RESCUE Japan LIMIT

• Recovery by Endo-vascular Salvage for Cerebral Ultra-acute Embolism Japan Large IscheMIc core Trial (RESCUE Japan LIMIT)
• RCT 202 patients
• 90-day mRS 0–2 was twice as high in the MT compared with the medical management (MM) group (14% vs 7.8%, respectively)
• MRS 0–3 (that is, ambulatory) in the MT group was 31% compared with 12.7% in the MM group.
• MT yielded higher lifetime benefits (2.20 QALYs vs 1.41 QALYs) despite marginally higher lifetime healthcare costs per patient ($285 861 vs $272 954). The difference of 0.79 QALYs equated to 288 additional days of healthy life per patient.
ANGEL-ASPECT

- Endovascular Therapy in Acute Anterior Circulation Large Vessel Occlusion Patients with a Large Infarct Core (ANGEL-ASPECT) trial
- RCT 456 patients from 46 centers in China with large infarct core
  - including those with ASPECTS 0–2
  - including core volume of 70–100mL
  - ELVO within 24 hours.
- Terminated early due to efficacy
  - mRS 0–2 of 30% for EVT
  - mRS 0-2 11.6% for MM
  - shift in distribution of mRS scores towards better outcomes with thrombectomy
- sICH was higher in the MT group (6.1% vs 2.7%)
- MT reduced the number of mRS 5 patients by nearly half
Expanding the Treatable Stroke Pool
SELECT-2 Trial

Case Presentation
ED Triage Evaluation

<table>
<thead>
<tr>
<th>Date and Time Last seen Normal</th>
<th>4/21 0200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date, Time, and Name of MD Notified</td>
<td>4/21 0427- upon arrival to ED.</td>
</tr>
</tbody>
</table>

**BEFAST**

<table>
<thead>
<tr>
<th>Balance</th>
<th>Trouble Walking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes</td>
<td>Trouble seeing in one or both eyes.</td>
</tr>
<tr>
<td>Face</td>
<td>Facial Droop/numbness</td>
</tr>
<tr>
<td>Arm &amp; Leg</td>
<td>Difficulty walking</td>
</tr>
<tr>
<td>Speech</td>
<td>Slurred</td>
</tr>
<tr>
<td>Time</td>
<td>Date and Time of Onset of Symptoms 0235</td>
</tr>
<tr>
<td>Glucose</td>
<td>EMS 127</td>
</tr>
<tr>
<td></td>
<td>POC 149</td>
</tr>
</tbody>
</table>

Get MD quick evaluation within 10-minutes of arrival

Per family arriving at hospital, family member saw patient watching TV, acting his normal self around 0200. Pt heard “coughing” and maybe a thump around 0235. Pt found slumped half way out of chair at time of EMS call. Pt arrived in ED at 0427.
SUBJECTIVE:
Time of Stroke Alert Notification: 0430  Time of Initial Neurology Response: 0432
Hospital Setting: Emergency Department

Reason for Stroke Alert: 66 year old male with A fib (on plavix) presents with acute onset R MCA syndrome
Last Seen Normal Date: 04/21/23
Last Seen Well Time: 0245

OBJECTIVE:
BP 177/98  Temp 96.3 °F (35.7 °C)  Resp 16  Wt 93.3 kg (205 lb 11 oz)  SpO2 95%

Exam Info:
Television Exam Performed? Yes
Time of Television Connection: 0445

NIH Stroke Scale
1a. Level of Consciousness: 0-->Alert, keenly responsive
1b. LOC Questions: 0-->Answers both questions correctly
1c. LOC Commands: 0-->Performs both tasks correctly
2. Best Gaze: 2-->Forced deviation, or total gaze paresis not overcome by the oculocephalic maneuver
3. Visual: 2-->Complete hemianopia
4. Facial Palsy: 2-->Partial paralysis (total or near-total paralysis of lower face)
5a. Motor Arm, Left: 4-->No movement
5b. Motor Arm, Right: 0-->No drift, limb holds 90 (or 45) degrees for full 10 secs
6a. Motor Leg, Left: 4-->No movement
6b. Motor Leg, Right: 0-->No drift, leg holds 30 degree position for full 5 secs
7. Limb Ataxia: 0-->Absent
8. Sensory: 2-->Severe to total sensory loss, patient is not aware of being touched in the face, arm, and leg
9. Best Language: 0-->No aphasis, normal
10. Dysarthria: 2-->Severe dysarthria, patients speech is so slurred as to be unintelligible in the absence of or out of proportion to any dysphasias, or is mute/anarthric
11. Extinction and Inattention (formerly Neglect): 2-->Profound hemi-inattention/extinction more than 1 modality
Total (NIH Stroke Scale): 20

Glucose Value: 124 mg/dL
Pre-treatment BP: 177/98

Head CT Findings: Dense right MCA sign
Initial Non-Contrast Head CT
Initial Non-Contrast Head CT
Initial Non-Contrast Head CT
Selected CTA Source Images
Selected CTA Source Images
Suspected LVO

Records informational purposes only. Not for diagnostic use.
CT Perfusion Data

Hypoperfusion Index: 0.7
CBV Index: 0.5
Neurointerventional Surgery Consultation Note

Consult Date: 4/21/2023, 5:55 AM

PCP: None

Chief Complaint: Stroke

History of Present Illness: 66 y.o. male with known past medical history of atrial fibrillation and hypertension who presents with abrupt onset of left-sided weakness, facial droop, and neglect. The patient has a reported medication list that includes antiplatelet monotherapy with Plavix 75 mg daily. There is no documentation of oral anticoagulation use. Last known well at 2:45 AM. CT and CTA imaging demonstrates a large core right MCA infarct with a right M1 occlusion. The patient received intravenous thrombolysis with emergent transfer via air ambulance to SMJH for endovascular treatment.
Pre-Thrombectomy RMCA Superior Division (M2)
Post-Thrombectomy RMCA Superior Division
Post Thrombectomy Dyna-CT
Neurology Consult Post-Thrombectomy

Neurological Examination:

Mental Status:
Attention: Awake and alert. Attentive to examiner.
Appropriately oriented.
Language: Fluent, coherent speech. Follows commands. Able to repeat.
Neglect: Left visual neglect and tactile extinction noted.
Mood: Euthymic.

Cranial Nerves:
II: Visual fields full to confrontation. PERRL.
III, IV, VI: Conjugate primary gaze. Right gaze preference. Able to overcome. Otherwise EOMI.
V: Facial sensation symmetric.
VI: Decreased left facial activation.
VIII: Hearing at baseline bilaterally.
IX, X: Mild dysarthria.
XI: Shoulder shrug weak on left.
XII: Tongue midline.

Motor: Strength 5/5 in right arm and leg.
Strength 4-5 in left arm and leg.
Left arm and left drifts to bed. Decreased left fine manual dexterity.
No tremor or adventitious movements.
Sensory: Decreased sensation to pinprick on left arm and leg.
Coordination: No dysmetria on FNF. Slowed left rapid alternating movements.
Gait: Deferred.

NIH Stroke Scale:
1) Level of Consciousness:
0 - Alert and keenly responsive.
2) Month and age:
0 - Answers both questions correctly.
3) Commands:
0 - Performs both task correctly.
4) Gaze:
1 - Partial gaze palsy in one or both eyes. No forced deviation or total paresis.
5) Visual fields:
0 - No visual loss.
6) Facial paresis:
2 - Partial/lower unilateral facial paralysis.
7) RUE Strength:
0 - No arm drift over 10 seconds.
8) LUE Strength:
0 - Some effort against gravity. Arm drifts to bed.
9) RLE Strength:
0 - No leg drift over 5 seconds.
10) LLE Strength:
0 - Some effort against gravity. Leg drifts to bed.
11) Ataxia:
0 - No ataxia.
12) Pin Sensation:
1 - Mild/moderate sensory loss. Can sense sharp touch.
13) Language:
0 - No aphasias.
14) Dysarthria:
0 - No dysphasic speech.
15) Neglect:
2 - Severe neglect or extinction to >1 modality.

Total NIHSS: 11
DWI MRI Day 1 Post-Thrombectomy
Neurology Follow-up Day 2 Post Thrombectomy

Mental Status:
Attention: Awake and alert. Attentive to examiner. Appropriately oriented.
Language: Fluent, coherent speech. Follows commands. Able to repeat.
Neglect: No visual or tactile neglect noted.
Mood: Euthymic.

Cranial Nerves:
II: Visual fields full to confrontation. PERRL.
III, IV, VI: Conjugate primary gaze.
V: Facial sensation symmetric.
VII: Decreased left facial activation.
VIII: Hearing at baseline bilaterally.
IX, X: Mild dysarthria.
XI: Shoulder shrug weak on left.
XII: Tongue midline.

Motor:
Strength 5/5 in right arm and leg.
Strength 4/5 in left arm. 5/5 in left leg.
Left arm drifts but not to bed. No drift in left leg. Decreased left fine manual dexterity.
No tremor or adventitious movements.

Sensory:
Decreased sensation to pinprick on left arm and leg.
Coordination: No dysmetria on FNF. Slowed left rapid alternating movements.
Gait: Deferred.

NIH Stroke Scale:
1. Level of Consciousness:
0: Alert and keenly responsive.
2. Month and age:
0: Answers both questions correctly.
3. Commands:
0: Performs both task correctly.
4. Gaze:
1: Partial gaze palsy in one or both eyes. No forced deviation or total paresis.
5. Visual fields:
0: No visual loss.
6. Facial paresis:
2: Partial/total unilateral facial paralysis.
7. RUE Strength:
0: No arm drift over 10 seconds.
8. LUE Strength:
1: Arm drifts but not to bed over 10 seconds.
9. RLE Strength:
0: No leg drift over 5 seconds.
10. LLE Strength:
0: No leg drift over 5 seconds.
11. Ataxia:
0: No ataxia.
12. Pin Sensation:
1: Mild/moderate sensory loss. Can sense sharp touch.
13. Language:
0: No aphasia.
14. Dysarthria:
1: Mild/moderate dysarthria. Slurred but intelligible.
15. Neglect:
0: No neglect or extinction.
Total NIHSS: 6
Head CT Day 3 Post-Thrombectomy
Head CT Day 3 Post-Thrombectomy
Head CT Day 3 Post-Thrombectomy
Conclusions

• Faster reperfusion leads to better outcome
• Appropriate patient selection leads to increased good outcomes and decreased bad outcomes/complications
  • LVO
  • Salvageable tissue
  • Early treatment
• Mechanical thrombectomy is the standard of care for this subset of stroke patients (up to 24 h)
• LVO scales help improve speed of diagnosis and treatment
Questions?