Cerebrovascular Disease in the Neurocritical Care Unit

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Disclosures

• None
Topics

• Basilar Occlusion
• Peri-Operative Stroke
• Endocarditis with Recurrent Stroke
• Cerebral Venous Sinus Thrombosis with Venous Infarction
• Minor Stroke with Large Vessel Occlusion
Cerebrovascular Disease in the NICU

- Neurological conditions account for at least 10-15% of admissions to ICUs
- Neurocritical care within a healthcare system is strongly associated with reductions in mortality and improved outcomes
- Nearly 1 of 4—are in people who have had a previous stroke
- 1 out of every 20 deaths
Basilar Occlusion
Posterior Circulation Ischemic Strokes

• Posterior circulation strokes: 20-30% of all ischemic strokes
  • Basilar occlusion ~1-4 % of all strokes

• Largely overlooked, significant emphasis on carotid artery territory stroke
  • May be related, at least in part, to the greater challenges of surgical interventions for the VB system

• Nonspecific symptoms, progress more rapidly than anterior circulation, high rate of recurrent TIA and stroke
Basilar Occlusion

- Mortality rate up to and in excess of 85-90%
- Without treatment, chances for survival or good functional outcome are negligible
- Survival mainly depends on immediate recanalization and close neurologic monitoring
### Table 8.1. Prodromal symptoms and signs in 158 patients with documented basilar artery occlusion

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertigo</td>
<td>61.2%</td>
</tr>
<tr>
<td>Headache</td>
<td>49.4%</td>
</tr>
<tr>
<td>Neuro-ophthalmological signs</td>
<td>33.5%</td>
</tr>
<tr>
<td>Motor signs</td>
<td>32.9%</td>
</tr>
<tr>
<td>Abnormalities of consciousness</td>
<td>23.4%</td>
</tr>
<tr>
<td>Dysarthria &amp; dysphagia</td>
<td>22.8%</td>
</tr>
<tr>
<td>Nausea and vomiting</td>
<td>15.8%</td>
</tr>
<tr>
<td>Sensory abnormalities</td>
<td>13.9%</td>
</tr>
<tr>
<td>Auditory signs</td>
<td>7.6%</td>
</tr>
<tr>
<td>Cranial nerve signs</td>
<td>5.7%</td>
</tr>
<tr>
<td>Cerebellar signs</td>
<td>5.7%</td>
</tr>
<tr>
<td>Convulsions</td>
<td>4.4%</td>
</tr>
</tbody>
</table>


### Table 8.2. Clinical findings during the acute phase among 282 patients with documented basilar artery occlusion

<table>
<thead>
<tr>
<th>Abnormal level of consciousness</th>
<th>78.3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor signs</td>
<td>75.9%</td>
</tr>
<tr>
<td>Pupillary abnormalities</td>
<td>47.9%</td>
</tr>
<tr>
<td>Pseudobulbar manifestations</td>
<td>44.3%</td>
</tr>
<tr>
<td>Oculomotor signs</td>
<td>42.9%</td>
</tr>
<tr>
<td>Facial paralysis</td>
<td>38.7%</td>
</tr>
<tr>
<td>Abnormalities of tone</td>
<td>28.4%</td>
</tr>
<tr>
<td>Sensory abnormalities</td>
<td>23.4%</td>
</tr>
<tr>
<td>Nystagmus</td>
<td>23%</td>
</tr>
<tr>
<td>Vertigo</td>
<td>22.3%</td>
</tr>
<tr>
<td>Headache</td>
<td>20.2%</td>
</tr>
<tr>
<td>Visual abnormalities</td>
<td>15.2%</td>
</tr>
<tr>
<td>Nausea and vomiting</td>
<td>15.2%</td>
</tr>
<tr>
<td>Cerebellar signs</td>
<td>14.2%</td>
</tr>
<tr>
<td>Abnormalities of lower cranial nerves</td>
<td>10.3%</td>
</tr>
<tr>
<td>&quot;Convulsions&quot;</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

Collateral Pathways in Basilar Occlusion
Mechanism 1: Embolism

- Distal basilar occlusions
- 20% cardioembolic
- 20% thromboembolism from proximal occlusive lesions
Mechanism 2: Intracranial Atherosclerotic Disease (ICAD)

- Vertebrobasilar atherosclerotic disease -> 30% of posterior circulation strokes
- Recurrent stroke - 4-20%
- Low flow increases risk 5x
Hemodynamic impairment as an important indicator of risk for stroke (well-established in anterior circulation)

- Hypoperfusion, thrombus formation, decreased washout of emboli
What did they do

- Hypothesis - patients with low distal blood flow (imaging) are at higher risk of subsequent posterior circulation stroke
- Patients with ---
- Recent posterior circulation TIA or stroke
- 50% or more atherosclerotic stenosis of extra/intracranial VB arteries, or occlusion
- Angiogram or CTA
Distal flow status in the posterior circulation is a strong indicator of recurrent VB stroke risk in patients. Notably absent, severity of stenosis.

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>HR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low distal flow status</td>
<td>11.55 (1.88-71.00)</td>
<td>.008</td>
</tr>
<tr>
<td>Age</td>
<td>0.80 (0.70-0.91)</td>
<td>.001</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>10.47 (1.54-71.34)</td>
<td>.02</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>9.63 (1.66-55.76)</td>
<td>.01</td>
</tr>
<tr>
<td>Physical activity</td>
<td>0.06 (0.005-0.64)</td>
<td>.02</td>
</tr>
</tbody>
</table>

Table 3. Risk-Adjusted Multivariate Model of Predictors of Subsequent Stroke

No. at risk

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6</td>
<td>18</td>
<td>54</td>
</tr>
<tr>
<td>6-12</td>
<td>16</td>
<td>51</td>
</tr>
<tr>
<td>12-18</td>
<td>13</td>
<td>46</td>
</tr>
<tr>
<td>18-24</td>
<td>9</td>
<td>39</td>
</tr>
<tr>
<td>24+</td>
<td>7</td>
<td>23</td>
</tr>
</tbody>
</table>

Abbreviation: HR, hazard ratio.
IV-tPA & Posterior Circulation Ischemic Strokes

- <23% of people arrive in < 3 hours
- 12-19% of all IV-tPA strokes
- 5% of the PCIS patients in the NINDS study and 0% in the ECASS I and II trials
- NIHSS doesn’t account for posterior circulation symptoms
IV-tPA & Posterior Circulation Ischemic Strokes

- Why are the rates of symptomatic ICH lower with increased time to IV-tPA?
  - Small lesion volume in infratentorial strokes?
  - Better collateral circulation in comparison with MCA?
  - Brainstem heavily supplied by small end arteries
IV-tPA & Posterior Circulation Ischemic Strokes

• Can we extend the tPA time window for posterior circulation strokes?
• Difficult to study given CT not helpful, need MRI pre-tPA
• EXTEND (9 hour tpa window) and WAKE-UP (MRI and wake up stroke) trials included both anterior and posterior circulation strokes but did not analyze separately
Recanalization of Basilar Artery Occlusion with IV-tPA

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>n</th>
<th>Modified Rankin Scale</th>
<th>Mortality (%)</th>
<th>Time of follow-up</th>
<th>SICH (%)</th>
<th>Recanalization rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0–2 (%)</td>
<td>0–3 (%)</td>
<td>4–5 (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lindsberg</td>
<td>2004</td>
<td>50</td>
<td>22</td>
<td>32</td>
<td>28</td>
<td>40</td>
<td>3 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>30</td>
<td>34</td>
<td>20</td>
<td>46</td>
<td>1 year</td>
</tr>
<tr>
<td>Lindsberg, Mattie*</td>
<td>2006</td>
<td>76</td>
<td>22</td>
<td>N/A</td>
<td>N/A</td>
<td>50</td>
<td>Varies</td>
</tr>
<tr>
<td>BASICS—MtM</td>
<td>2009</td>
<td>49</td>
<td>53</td>
<td>63</td>
<td>20</td>
<td>16</td>
<td>1 month</td>
</tr>
<tr>
<td>BASICS—S</td>
<td>2009</td>
<td>72</td>
<td>21</td>
<td>26</td>
<td>28</td>
<td>46</td>
<td>1 month</td>
</tr>
<tr>
<td>Sairanen</td>
<td>2011</td>
<td>116</td>
<td>26</td>
<td>36</td>
<td>22</td>
<td>41</td>
<td>3 months</td>
</tr>
<tr>
<td>Miyagi#</td>
<td>2012</td>
<td>25</td>
<td>48</td>
<td>N/A</td>
<td>N/A</td>
<td>4</td>
<td>3 months</td>
</tr>
</tbody>
</table>

BASICS, Basilar Artery International Cooperation Study; MtM, mild to moderate deficit; n, number; S, severe deficit; SICH, symptomatic intracranial hemorrhage.

*Systematic review of literature up to 2005.

#Patients treated with low-dose alteplase (0.6 mg/kg).
Landmark Years in Stroke: 2015, 2017

- MR CLEAN
- REVASCAT
- ESCAPE
- SWIFT-PRIME
- EXTEND-IA
- DAWN

Efficacy of endovascular thrombectomy over standard medical care in patients with proximal ANTERIOR circulation large vessel occlusions -> up to 24 hours
Despite advances, >60% of the patients with acute BAO die or remain severely disabled.

- No time window for endovascular treatment in basilar occlusions
- Perfusion limitations
- MRI first, reversible DWI
February 2020

Endovascular treatment within 24 hours

Significant improvement in functional outcomes at 3 months and a lower rate of mortality despite an increase in symptomatic intracerebral hemorrhage (7.1% vs 0.5%)

Past trials - not great
  - BASICS, 2009
    - Addition of IA tPA, old technology
  - BEST, 2019
    - Poorly designed, no difference in outcomes
WEAVE Trial 2019

- Symptomatic intracranial atherosclerotic stenosis of 70% - 99%
- Good baseline functional status
- ≥2 strokes in the vascular territory of the stenotic lesion with at least 1 stroke while on medical therapy
- Extracranial vertebral artery stenosis lower risk
Peri-Operative Stroke
Perioperative stroke

• 5% of 800,000 strokes a year in US → 40,000 perioperative strokes
• No proven therapies to reduce risk of stroke in high-risk patients or procedures
### Table 1. Incidence of Stroke after Various Surgical Procedures.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Risk of Stroke (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General surgery(^2)</td>
<td>0.08–0.7</td>
</tr>
<tr>
<td>Peripheral vascular surgery(^3)</td>
<td>0.8–3.0</td>
</tr>
<tr>
<td>Resection of head and neck tumors(^4)</td>
<td>4.8</td>
</tr>
<tr>
<td>Carotid endarterectomy(^5)</td>
<td>5.5–6.1</td>
</tr>
<tr>
<td>Isolated CABG(^1,7)</td>
<td>1.4–3.8</td>
</tr>
<tr>
<td>Combined CABG and valve surgery(^1,7)</td>
<td>7.4</td>
</tr>
<tr>
<td>Isolated valve surgery(^1)</td>
<td>4.8–8.8</td>
</tr>
<tr>
<td>Double- or triple-valve surgery(^1)</td>
<td>9.7</td>
</tr>
<tr>
<td>Aortic repair(^7)</td>
<td>8.7</td>
</tr>
</tbody>
</table>

### Table 1. Common Cardiac Interventions and Reported Stroke Risk

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Stroke Rate, %</th>
<th>Number of Procedures in the United States in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descending thoracic aorta and thoracoabdominal aorta repair(^8,11,12)</td>
<td>1.4–8.7 (spinal infarct in 3.8–23.0)</td>
<td>10000</td>
</tr>
<tr>
<td>Ascending aortic and arch repair(^13–15)</td>
<td>3.5–5.0</td>
<td>2000</td>
</tr>
<tr>
<td>Isolated CABG(^16)</td>
<td>1.3</td>
<td>157704</td>
</tr>
<tr>
<td>AVR(^16)</td>
<td>1.0</td>
<td>25274</td>
</tr>
<tr>
<td>AVR+CABG(^16)</td>
<td>2.3</td>
<td>15855</td>
</tr>
<tr>
<td>MVR(^16)</td>
<td>1.8</td>
<td>10669</td>
</tr>
<tr>
<td>MVR+CABG(^16)</td>
<td>3.4</td>
<td>3509</td>
</tr>
<tr>
<td>Mitral valve repair(^16)</td>
<td>1.0</td>
<td>12424</td>
</tr>
<tr>
<td>Mitral valve repair+CABG(^16)</td>
<td>2.2</td>
<td>4093</td>
</tr>
</tbody>
</table>

AVR indicates aortic valve replacement; CABG, coronary artery bypass grafting; and MVR, mitral valve replacement.
Perioperative Stroke

- **6-8x increase** in 30 day mortality
- **3x greater risk** of death during 10-year follow-up
- Increased median LOS from 6 --> 13 days
- Doubles cost of hospitalization
- Increased rates of disability and discharge to long-term care facilities

Timing of when strokes occur in the postoperative period (n=563). Postoperative day 0 includes time in the intensive care unit on the day of surgery.

McKhann et al., Stroke, 2006
In-hospital stroke VS. Community-onset stroke

- significantly longer waiting times from symptom recognition to neuroimaging
- lower use of TPA
- longer time from stroke recognition to administration of thrombolysis
- longer median LOS
- more likely to be dead or disabled at discharge

Saltman et al., *JAMA Neurology*, 2015.
Patient Risk factors for Perioperative Stroke

- Age
- Hypertension
- Hyperlipidemia
- Diabetes mellitus
- Smoking
- Heart failure
- Renal disease
- Atrial fibrillation
- Prior stroke or transient ischemic attack
Mechanism

- Predominantly *ischemic* and *embolic*
- Postop coma, stroke, and encephalopathy -> continuum of conditions with a similar underlying mechanism: *showers of embolic material to the brain and decreased washout*

### Table 2. Comparison of Intraoperative and Postoperative Stroke

<table>
<thead>
<tr>
<th></th>
<th>Intraoperative Stroke</th>
<th>Postoperative Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing</strong></td>
<td>During surgery or before awakening from anesthesia</td>
<td>Early: Within first 7 d of surgery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delayed: &gt;7 d and up to 30 d after surgery</td>
</tr>
<tr>
<td><strong>Incidence</strong></td>
<td>0.98% (CI, 0.79%–1.23%)</td>
<td>0.93% (CI, 0.77%–1.11%)</td>
</tr>
<tr>
<td><strong>Risk factors</strong></td>
<td>Intraoperative factors including aortic manipulation during cannulation, cross-clamping, and proximal anastomosis of a conduit; Intraoperative hypotension</td>
<td>Previous stroke; Age; Hypertension; Diabetes mellitus; Hypercholesterolemia; Peripheral vascular disease; Atrial fibrillation</td>
</tr>
<tr>
<td><strong>Pathogenesis</strong></td>
<td>Embolic: macroembolism from atherosclerotic aorta; cardiac chambers; air embolism; Cerebral hypoperfusion: intraoperative hypoperfusion; carotid stenosis; intracranial atherosclerosis</td>
<td>Early: Atrial fibrillation: new-onset postoperative or preexisting chronic; Low cardiac output syndrome; Bleeding; Delayed: Thromboembolic: atherosclerotic emboli; Atrial fibrillation; Repeal: revascularization procedures</td>
</tr>
<tr>
<td><strong>Pattern, location</strong></td>
<td>Scattered lesions; right hemisphere slightly more common because of preferential flow in the brachiocephalic artery; Bilateral watershed strokes or infarcts in distribution of severe stenosis or occlusion if mechanism is hypoperfusion</td>
<td>Focal lesion; no specific distribution; Watershed if caused by hypoperfusion</td>
</tr>
<tr>
<td><strong>Prognosis</strong></td>
<td>Operative mortality: 28.8% (CI, 17.6%–43.3%); Late mortality: 11.7% (CI, 7.5%–18.3%)</td>
<td>Operative mortality: 17.9% (CI, 14.0%–22.7%); Late mortality: 9.4% (CI, 5.5%–14.9%)</td>
</tr>
<tr>
<td><strong>Preventive strategies</strong></td>
<td>Minimizing or eliminating aortic manipulation; Preoperative imaging of the ascending aorta and carotid arteries for assessment of calcification</td>
<td>Prophylaxis of atrial fibrillation; Anticoagulation; Left atrial appendage occlusion</td>
</tr>
</tbody>
</table>

**Figure 1. Protocol for preoperative screening.**
- CT indicates computed tomography; MRI, magnetic resonance imaging; TEE, transesophageal echocardiography; and TTE, transthoracic echocardiography.

Gaudino, Mario, et al., *Circulation*, 2020
Perioperative Hypercoagulability

- Surgical trauma/tissue injury precipitates systemic inflammation and hypercoagulability
  - Thrombogenesis
  - Plaque rupture
- Rebound hypercoagulation if taking antithrombotics preop
- General anesthesia, dehydration, bed rest, stasis in the postop period, infection
Activation of the hemostatic system and reduced fibrinolysis immediately after surgery and up to 14 to 21 days postop.
Elective surgery

• Cerebrovascular autoregulation is dysfunctional post stroke
  • Can affect perioperative hemodynamics
• Guidelines -> Avoid elective surgery within 6-9 months of TIA and stroke
• After 9 months, the associated risk appears stable yet still increased compared with patients with no stroke (Jorgenson et al., JAMA, 2014)
• Carotid disease: Consider revascularization if bilateral asymptomatic carotid stenosis ≥ 70%, unilateral carotid stenosis ≥ 70% with contralateral occlusion
Intraoperative Neuromonitoring Techniques

- EEG
- Evoked potentials
- TCDs- many of the microemboli detected may not have clear neurologic consequences, what’s the usefulness?
- NIRS
- Epiaortic ultrasound
- Laser speckle flowgraphy of ophthalmic artery
- Electrical impedance tomography
- Lower jugular bulb oxygen saturation (SjvO(2))
- Neuroprotective agents?
Risk Modification - Blood Pressure

• Matching intraoperative and early post-op blood pressure to the patient’s preoperative range
  • Prolonged changes of ≥20 mm Hg or ≥20% in relation to preop levels can result in periop complications

• Cardiac surgery - aim for higher intra-op MAP goal (>80)
  • The relative increase of stroke for every 10 minutes that the MAP during CPB is <64 mm Hg is 16%

• In noncardiac surgery, Perioperative Quality Initiative recommends MAP 60-70 mm Hg

Gaudino, Mario, et al., Circulation, 2020
McDonagh et al., Lancet Neurology, 2014
HOME OF SIDNEY KIMMEL MEDICAL COLLEGE
Perioperative Atrial Fibrillation

- Bridging non-vitamin-K antagonist anticoagulants is recommended with UFH
  - Mechanical valve
  - AF with moderate-severe mitral stenosis
  - AF with CHA2DS2-VASc score >4
  - Acute thrombotic event within the previous 4 weeks
- Post-op - Multiple episodes of AF or one episode > 24-48 hours, recommend the initiation of oral anticoagulant therapy (considering bleeding risks)
- Continue anticoagulation for at least 4 weeks after return to sinus rhythm, particularly if high risk for thromboembolism
Maintain High Index of Suspicion for Peri-Operative Stroke
Topics

• Basilar Occlusion
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• Endocarditis with Recurrent Stroke
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• Minor Stroke with Large Vessel Occlusion
Endocarditis with Recurrent Stroke
Neurologic Complications of Infective Endocarditis

- Ischemic strokes
- Intracerebral hemorrhage, Subarachnoid hemorrhage
- Toxic encephalopathy
- Arteritis
- Meningitis
- Seizures
- Abscess, cerebritis

- Vegetations - composed of micro-organisms, inflammatory cells, platelets, fibrin. Friable.
Infective Endocarditis & Stroke

• Untreated bacterial endocarditis - 70-90% cerebral embolic rate
• Symptomatic cerebrovascular complications ~ 35%
• Silent cerebrovascular complications ~ up to 80 %
• Decreases to 15-20% with antibiotic therapy in first 48 hours
• 75 percent of all strokes after antibiotic initiation occur within the first two weeks

“Bacterial Endocarditis and Cerebrovascular Disease.” Practical Neurology, 2016
Infective Endocarditis & Stroke

- Risk factors for cerebral embolization
  - *S. aureus* endocarditis
  - larger vegetation size
  - greater vegetation mobility
  - mitral valve involvement

- In-hospital mortality 15-22%
- Five-year mortality ~ 40%
- Independent predictors of mortality
  - older age
  - *S. aureus* infections
  - health care associated infective endocarditis
  - stroke and other embolic events

Infective Endocarditis & Hemorrhage (ICH, SAH, microbleeds)

- Mycotic aneurysm
- Pyogenic arteritis, subacute immune complex mediated arteritis
- Micro-abscesses
- Hemorrhagic transformation of previous ischemic stroke
- Inflammation of meningeal vasculature
- Embolic process in the vasa vasorum
- In one study, the presence of CMBs and ≥2, was an independent predictor for ICH
- Low platelet count
- Severe valve regurgitation
Mycotic Aneurysms

- Typically distal, often fusiform
- >1 aneurysm in 25% of cases
- Arterial wall weakening following septic embolization into the vasa vasorum
- May be missed on CTA or MRA if <5mm. Catheter angiography is the gold standard.
- Rupture normally occurs in early phase of IE but can occur later especially in streptococcal IE
- Unruptured aneurysms may resolve with antibiotic therapy alone, serial imaging
- Consider coiling >10 mm, enlarge during antibiotic therapy, or fail to resolve with antibiotic therapy
- Reserve angiogram for intracranial bleeding, suggestion of aneurysm on non-invasive imaging, or if suspicion remains high
- Society of Thoracic Surgeons Guidelines, European Society of Cardiology Guidelines
Infective Endocarditis and Anticoagulation

• Anticoagulation is not recommended for stroke prevention
• Observational data - no reduction in the risk of embolic events for patients with S. aureus prosthetic valve IE receiving oral anticoagulant agents
• Anticoagulation- independent risk factor for hemorrhagic events
• For those who require chronic anticoagulation, stop for at least 14 days if possible while on antibiotics
• Heparin first choice if anticoagulation absolutely indicated (high risk afib, mechanical valves)
Infective Endocarditis and Antiplatelet Therapy

- Does not significantly reduce risk of embolism
- Continue only if medical condition requires it i.e. coronary stent, high risk cerebrovascular history
- Don’t start aspirin or other antiplatelet agents for patients with IE who have an acute ischemic stroke or TIA
Considerations for Surgery

• Historically, early surgery reserved for heart failure, uncontrolled infection, recurrent embolic events though new advances are allowing surgery to be performed earlier for more patients

• Heparin bolus

• Size and location of stroke

• Pre-existing hemorrhage

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>1</td>
</tr>
<tr>
<td>Abnormal renal/liver function</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Stroke</td>
<td>1</td>
</tr>
<tr>
<td>Bleeding tendency</td>
<td>1</td>
</tr>
<tr>
<td>Labile INR</td>
<td>1</td>
</tr>
<tr>
<td>Age (eg. &gt;65)</td>
<td>1</td>
</tr>
<tr>
<td>Drugs (eg. concomitant aspirin, NSAIDs, etc)</td>
<td>1 or 2</td>
</tr>
<tr>
<td>or alcohol</td>
<td></td>
</tr>
<tr>
<td>Maximum score</td>
<td>9</td>
</tr>
</tbody>
</table>

Notes: A score of 0–2 indicates low risk of bleeding; a score of ≥3 indicates high risk of bleeding. Hypertension is defined as a systolic blood pressure ≥160 mmHg. 1 point is awarded for each of abnormal renal or liver function, and drugs or alcohol.
Cerebral Venous Sinus Thrombosis with Venous Infarction
• Annual incidence ranges from 0.22 to 1.57 per 100,000
• More common in women than men 3:1
Obstruction of dural sinus

Increased venous pressure

Venular and capillary pressure

Capillary perfusion

Cerebral perfusion

Cerebral blood flow

Failure of energetic metabolism

Cytotoxic edema

Venous and capillary rupture

Parenchymal haemorrhage

Vasogenic edema

Blood-brain barrier disruption

Impairment of CSF absorption

Increased intracranial pressure

Superior sagittal sinus thrombosis

T1-weighted magnetic resonance imaging discloses an isointense signal in the superior sagittal sinus (arrows), corresponding to a thrombus (A), and the corresponding absence of flow on magnetic resonance venography (B).
Signs and Symptoms

- Isolated intracranial hypertension syndrome (headache with or without vomiting, papilledema, and visual problems)
- Focal syndrome (focal deficits, seizures, or both)
- Encephalopathy (multifocal signs, mental status changes, stupor, or coma)
- Less common - cavernous sinus syndrome, subarachnoid hemorrhage, and multiple cranial nerve palsies
Signs and Symptoms

• Cerebral edema, venous infarction, and hemorrhagic venous infarction are associated with a more severe syndrome
  • More likely to be comatose or to have motor deficits, aphasia, and seizures
  • Deep cerebral venous system (ie, the straight sinus and its branches) occlusion- severe presentation, coma or other alterations in mental status, motor deficits, often bilateral
Immediate Treatment Goals

• Anticoagulation
  • Recanalize the occluded sinus/vein
  • Prevent propagation of the thrombus
  • Treat the underlying prothrombotic state

• Performing a lumbar puncture is not harmful in patients with CVT when concerned about CNS infection provided no large brain lesion
  • Study analyzed 624 patients with CVT and identified 224 who had lumbar puncture
  • Groups with and without LP did not differ on any of the outcome measures

Anticoagulation

- The presence of hemorrhagic venous infarction, ICH, SAH are not contraindications for anticoagulant treatment in CVT
- SQ LMWH is more effective than UFH and is at least as safe
  - Use UFH when patient is clinically unstable, or invasive interventions such as lumbar puncture or surgery are planned, or renal failure
Worsening or New ICH

- European study- 34 of 79 patients (43%) had an intracerebral hemorrhage at baseline
  - None of the patients randomized to heparin developed a new intracerebral hemorrhage
  - In contrast, a new intracerebral hemorrhage developed in three patients randomized to placebo
- Case series have also reported relatively low risks of intracranial hemorrhage (<5 percent) and systemic hemorrhage (<2 percent), no effect on outcomes
Mortality

- 23% of patients will have early neurologic deterioration
- 1/3 will have new lesions on imaging
  - depressed consciousness (high risk for deterioration)
  - mental status change
  - seizures
  - New or progression of a focal deficit
  - Worsening headaches
  - visual loss

- 5-15% death or dependency in the acute phase
- Herniation due to multiple lesions or to diffuse brain edema, status epilepticus, medical complications, pulmonary embolism
- Predictors of mortality at 30 days
  - Depressed consciousness
  - Altered mental status
  - Thrombosis of the deep venous system
  - Right hemisphere hemorrhage
  - Posterior fossa lesions
Endovascular Treatment

- Clinical deterioration despite anticoagulation, or with severe neurological deficits or coma (class IIb; level of evidence C)
- Unknown duration of anticoagulation therapy before declaring it to be a ‘failure’ and proceeding with endovascular therapy
- Insufficient evidence to determine which endovascular approach and device provides the optimal restoration of venous outflow in CVT
- Might need to use several techniques

- RCT (TO-TO ACT) failed to show benefit of endovascular treatment (thrombectomy + tPA) over anticoagulation in those with at least one risk factor for clinical deterioration

- 2015 systematic review, 42 studies, 185 patients with CVT treated with thrombectomy
  - pretreatment ICH present - 60%
  - stupor or coma - 47%
  - concurrent local thrombolysis - 71%
  - good outcome - 84%
  - mortality - 12%
  - new or worsened intracerebral hemorrhage affected 10%.
  - High recanalization rate (9%, 21% partial) was achieved

Minor Stroke with Large Vessel Occlusion
What is a Minor Stroke and a High Risk TIA?

• ≈ 15-25% of strokes are preceded by TIA
• Minor neurological deficits (NIHSS 0-5) ≈ 50% of all strokes
  • Up to 30% may have unfavorable outcomes at 3 months
• At risk for stuttering course and deterioration
• Examples-
  • NIHSS 3: Disoriented to both date and age, slurred speech
  • NIHSS 3: Severe expressive aphasia and following some but not all simple commands
  • NIHSS 3: Homonymous hemianopsia and loss of sensation
  • NIHSS 3: Hemiparesis and facial droop
Minor Strokes with Large Vessel Occlusion

- Large vessel occlusion ≈20% of all strokes
- At least 10% of all LVOs can occur with mild symptoms
- In specialized centers, LVOs can be detected in up to 30% in selected minor stroke patients
- At smaller centers or for patients with milder symptoms, many LVO cases may be missed prior to deterioration
  - Healthcare impact of this condition is likely considerable

<table>
<thead>
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<th>Score Name</th>
<th>Score Result</th>
<th>LAVO n/N</th>
<th>Number Needed to Screen*</th>
<th>Adjusted OR for LAVO†</th>
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<td>&gt;15</td>
<td>436/891</td>
<td>2.1</td>
<td>10.72 (8.00–14.37)</td>
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</tbody>
</table>
Minor Strokes with Large Vessel Occlusion

• Population-based study- LVO rates are likely comparable between patients with minor stroke and TIA
• tPA recanalization: ICA occlusion <10%, M1 occlusion 20-30%, M2 occlusion 30-40%
• Current guidelines only recommend MT in patients with NIHSS ≥6
• CTA is cost-effective when the probability of LVO > 0.16% in minor stroke patients

aKleindorfer D. Stroke. 2005
bWu, Xiao, et al. Radiology. 2020
Acute Intervention


• Meta-analysis - mechanical thrombectomy and medical therapy using IV-tPA leads to a better functional outcome after 3 months in minor stroke patients with a large vessel occlusion. Griessenauer CJ, et al. World Neurosurg 2018.

**FIGURE 1:** Twenty-seven-year-old woman with an acute onset of dysarthria and mild-left hemibody weakness (NIHSS 4). Symptoms were fluctuating at admission and deteriorated soon after. (a and b) MRA and 3dTOF showing an occlusion of the distal ICA. (c–e) Showing an infarction in the territory of the anterior choroidal artery (posterior limb of the caudate nucleus). ICA, internal carotid artery; MRA, magnetic resonance angiography; NIHSS, National Institutes of Health Stroke Scale.
Factors to consider:

- Is the patient fluctuating (i.e., NIHSS 14 initially, but now 4)? If so, this raises concern that the collateral status is not stable and that could be a bad sign.
- Auto-hypertension. For example, NIHSS 4, but BP 210/100 mmHg. What is going to happen when the patient can no longer support that blood pressure?
- The “stress test”. Sit the patient upright for 10-20 minutes and observe for any deterioration in the clinical exam
Triaging the minor stroke who does not undergo immediate MT

• Factors to consider:
  • Perfusion imaging (abnormal in 1/3 of TIA/minor stroke patients). If there is a big perfusion mismatch, this would make us more inclined to treat. Normal perfusion does not necessarily indicate the patient is not at risk for deterioration as the scan is just a snapshot on time in a highly dynamic process.
  • If the LVO is secondary to ICAD, may be more conservative as procedure is more complex and likely riskier.
<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Investigation</th>
<th>N</th>
<th>NIHSS score</th>
<th>Vessel criteria</th>
<th>Primary outcome</th>
<th>Study conclusion</th>
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<td>2020</td>
<td>Teoh et al.</td>
<td>EVT feasibility</td>
<td>20</td>
<td>≤5</td>
<td>Anterior and posterior M2, basilar</td>
<td>mRS ≤1</td>
<td>95% mTICI ≥2b, 95% mTIS ≤1, 0% mCSH, 0% SVD</td>
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<td>Bhogal et al.</td>
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<td>M1 only</td>
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<td>Kechter et al.</td>
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<td>20</td>
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<td>M1 only</td>
<td>mTICI ≥2b</td>
<td>97% mTICI ≥2b, 3% SCSH</td>
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<td>Dorgezani et al.</td>
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<td>138</td>
<td>≤7</td>
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<td>Piaff et al.</td>
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<td>mTICI ≥2b</td>
<td>Predictive of FV</td>
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<td>Brown et al.</td>
<td>EVT feasibility</td>
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<td>EVT is safe</td>
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<td>2014</td>
<td>Urra et al.</td>
<td>EVI vs BMM</td>
<td>78</td>
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<td>Anterior and posterior M2, A1, basilar, P1</td>
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<td>2018</td>
<td>Housen et al.</td>
<td>EVI vs BMM</td>
<td>118</td>
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<td>Anterior and posterior M2, ACA, basilar</td>
<td>NIHSS shift</td>
<td>EVT benefit (p = 0.03)</td>
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<td>2018</td>
<td>Noguera et al.</td>
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<td>NIHSS shift</td>
<td>EVT benefit (p = 0.03)</td>
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<tr>
<td>2019</td>
<td>I.G. et al.</td>
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<td>Safina et al.</td>
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<td>Wolmark et al.</td>
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<td>≤6</td>
<td>Anterior-coro</td>
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<td>Dargazani et al.</td>
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<td>Shang et al.</td>
<td>EVI vs BMM</td>
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<td>≤8</td>
<td>Anterior M2, ACA</td>
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<td>Mann et al.</td>
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<td>Kontavak et al.</td>
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<td>Helfer et al.</td>
<td>EVI vs NCT vs CM</td>
<td>185</td>
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<td>Anterior M1, ICA-T</td>
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<td>2019</td>
<td>Shang et al.</td>
<td>EVI vs NCT vs CM</td>
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<td>≤5</td>
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<td>2019</td>
<td>Goldkorn et al.</td>
<td>Levo vs high NIHSS score</td>
<td>71</td>
<td>≤5</td>
<td>Anterior M2, A2</td>
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<td>Outcomes better patients within low NIHSS score</td>
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<td>2019</td>
<td>Kemenz et al.</td>
<td>Levo vs high NIHSS score</td>
<td>193</td>
<td>≤7</td>
<td>Anterior M2, A2</td>
<td>mRS ≤2</td>
<td>Safety &amp; efficacy similar</td>
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<td>2019</td>
<td>Aslak et al.</td>
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<td>≤5</td>
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<td>Patient characteristics</td>
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</table>

*For vessel imaging criteria, the most distal artery of the parent artery is listed. For example, if M1 is listed, the study included MCA sections M1, M2, M3, and M4.

*Indicates study also conducted meta-analysis of literature.

ACAS: anterior cerebral artery; BMM: best medical management; CM: conservative management; EVT: endovascular therapy; ICA-T: internal carotid artery terminus; IVT: intravenous therapy; MCA: middle cerebral artery; mRS: modified Rankin Scale; mTICI: modified Thrombolysis in Cerebral Infarction; N: number of patients; NS: no difference in primary outcome; SCSH: symptomatic cerebral small vessel hemorrhage; SMD: symptomatic neurological deficit.
Moving Forward

- Ongoing clinical trials
- Minor strokes are often **major**
- LVOs are underdiagnosed, don’t delay vascular imaging
- Treat minor strokes and high risk TIAs **AGGRESSIVELY** and **EARLY**
  - One med does not fit all
- Very close monitoring in a neurologic unit -> **low threshold for thrombectomy**
Questions?
References

References


References

- Jovin, T. ICAD and Vertebrobasilar Disease. ISC 2020
References

References