Overview of Stroke: Etiologies, Demographics, Syndromes, and Outcomes

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Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

<table>
<thead>
<tr>
<th>Affiliation/Financial Relationship</th>
<th>Company</th>
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<tbody>
<tr>
<td>Consulting Fees/Honoraria</td>
<td>The Medicines Co.</td>
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<td></td>
<td>Silk Road Medical</td>
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Definitions

• Stroke - abrupt development of a focal neurological deficit due to a vascular cause associated with permanent neuronal injury

• Transient ischemic attack (TIA) - same clinical syndrome as a stroke but resolves completely < 24 hours
  • i.e. without permanent brain injury (old definition)
  • With modern imaging most events > several hours duration are associated with infarction.
Epidemiology - USA

- ~795,000 new or recurrent stroke per year
  - 610,000 first attacks
  - 185,000 recurrent attacks
- 2001 to 2011 relative rate of stroke death fell 35.1%
  - Actual number of stroke deaths declined 23.0%
  - In 2011 stroke caused ~1 of every 20 deaths in USA
  - On average, 1 stroke every 40 seconds in USA
    - 1 Stroke death every 4 minutes
- There are ~ 4.5-5 million Stroke survivors
- Stroke is the leading cause of adult disability in USA
  - 15-30% of all stroke leads to permanent disability


Dariush Mozaffarian et al. Circulation. 2015;131:e29-e322
Annual Age-adjusted Incidence of First-ever Stroke by Race.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Stroke progression during hospitalization</td>
<td>24%</td>
</tr>
<tr>
<td>Mortality</td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>8%-20%</td>
</tr>
<tr>
<td>1 year</td>
<td>15%-25%</td>
</tr>
<tr>
<td>5 years</td>
<td>40%-60%</td>
</tr>
<tr>
<td>Complete or partial dependence</td>
<td>27%-53%</td>
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<tr>
<td>6-month decrease in Quality of Well-Being score</td>
<td>27%</td>
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<tr>
<td>Dementia persisting at 1 year</td>
<td>34%</td>
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## Subsequent Stroke Risk After TIA or Stroke

<table>
<thead>
<tr>
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<th>After TIA(^1)</th>
<th>After Stroke(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 days</td>
<td>4-8%</td>
<td>3-10%</td>
</tr>
<tr>
<td>1 year</td>
<td>12-13%</td>
<td>5-14%</td>
</tr>
<tr>
<td>5 years</td>
<td>24-29%</td>
<td>25-40%</td>
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Stroke is Heterogeneous

- Thrombi/Emboli of varying compositions
Embolic

- Atrial fibrillation - most common embolic cause
  - Second most common cause of ischemic stroke
    - 36% of strokes in patients >80 years old
    - With better EKG tele (implantable) 20-30% of cryptogenic stroke likely due to AF

- Aortic atherosclerosis cause of 30% of “cryptogenic” stroke

- Acute anterior wall myocardial infarction

- Rare- Endocarditis, PFO, myxoma, hypercoagulable, air, fat,
Large Vessel Thrombotic

- Carotid atherosclerosis - most common cause in USA
  - Usually in the presence of >70% stenosis but <50% stenosis can be symptomatic

- Intracranial atherosclerosis in 7-10%
  - African/Asian > Caucasian, Women > Men, DM > Non-DM

- Hypercoagulable states

- Dissection
Large Vessel Strokes
Small Vessel Thrombotic

- Lipohyalinosis - small penetrating arteries (<2-400μm diameter)
  - MCA/BA Perforators -> disorganization and disruption of vessel lumen (hyaline material) -> occlusion -> ischemia -> necrosis -> “lacune”

- Hypertension most important risk factor

- Embolic origin <20%

- Increased incidence in African-Americans

- Single most common cause of stroke
Typical Lacunar Strokes on MRI

- Medial Medullary Stroke
- Pontine Stroke
- Posterior Limb IC/Putaminal Stroke
Intracerebral Hemorrhage

- Hemorrhage into the substance of Brain
  - Cerebral hemispheres (20%), basal ganglia (40%), thalamus (20%), pons (10%) or cerebellum (10%)

- Etiology
  - Hypertension (most common cause)
  - Anticoagulant therapy
  - Amyloid angiopathy - associated with dementia and increasing age
  - Vascular malformations (arteriovenous malformation), cavernous angioma, capillary, telangiectasia
  - Venous sinus thrombosis
  - Cerebral metastases
  - Trauma
Subarachnoid Hemorrhage

• Rupture of a Saccular aneurysm
  • Risk of hemorrhage dependent on aneurysm size and location
    • <10mm lowest risk 0.05%/year, cumulative
    • >10mm <25mm moderate risk 1%/year, cumulative
    • >25mm highest risk 6%/year, cumulative
  • Basilar tip location has highest risk of rupture (RR=13.8)

• Trauma

• Arteriovenous malformation

• Mycotic aneurysm- post endocarditis ischemic stroke
Typical Subarachnoid Hemorrhage and Saccular Aneurysm
Differential Diagnosis: Stroke Imitators

- Mass lesion - Primary brain carcinoma, metastases, meningioma, abscess
- Subdural hematoma
- Somatization
- Migraine
- Seizure
- Hyper/hypoglycemia
- Cerebritis - lupus
- Demyelination - Multiple sclerosis, acute disseminated encephalomyelitis
- Fever/infection in elderly with prior brain injury (especially urinary tract infections)
- Transient global amnesia
- Encephalitis - Herpes simplex type I
- Inherited metabolic derangements - Mitochondrial encephalopathies
CLINICAL PRESENTATION

- Symptom onset
  - Large vessel ischemia
    - Embolic -> sudden/maximal at onset
    - Thrombotic -> symptoms maximal at onset or stuttering over minutes/hours
  - Small vessel ischemia -> progression over minutes or stuttering over hours/days
  - Intracranial hemorrhage
    - Intracerebral hemorrhage -> steadily progressive over minutes/hours -> nausea/vomiting -> headache
    - Subarachnoid hemorrhage -> headache instantaneous and maximal at onset- “thunderclap”
Symptoms & Physical Findings

- Symptoms variable in type/intensity depending on vessel/brain region involved
  - Weakness, paralysis, or incoordination- Large Vessel or Small Vessel
  - Numbness or tingling- Large Vessel or Small Vessel
  - Visual loss (monocular- amaurosis fugax, binocular- hemianopsia)- Large Vessel
  - Cognitive dysfunction
    - Aphasia (dominant hemisphere, a disorder of language not articulation [dysarthria])- Large Vessel
    - Neglect (nondominant hemisphere)- Large Vessel
  - Ataxia, gait instability or vertigo- Large Vessel or Small Vessel
Symptoms & Physical Findings -continued-

- Decreased level of consciousness - Large Vessel
- Sudden headache with nausea and vomiting - Hemorrhage
- Double vision - Large Vessel or Small Vessel
- Agitation or confusion - Large Vessel
- Memory loss - Large Vessel
- Transient loss of consciousness (very rare without other neurological signs) - Large Vessel, usually vertebrobasilar
  - The term vertebrobasilar insufficiency is over used
  - 95% of transient episodes of loss of consciousness are due to a cardiovascular rather than neurovascular cause
Clinical Syndromes

- Lacunar
  - Pure Motor or sensory
  - Sensory-motor
  - Ataxic-hemiparesis

- Large Vessel
  - Cortical Dysfunction
    - Aphasia
    - Neglect
  - Hemiparesis/anesthesia
  - Hemianopsia

- Vertebrobasilar
  - Ataxia
  - Dizziness
  - Crossed sensory-motor
    - Wallenberg’s
    - Weber’s
  - Bulbar
  - Oculomotor
  - Hemianopsia
  - Early decrease consciousness
Variability of Clinical Manifestations Dependent On

- Location of Occlusion/Thrombus
- Collateral Blood Flow
  - Cerebrovascular Reserve
- Size of Embolism
- Severity of Hypoperfusion
- Duration of Ischemia
- Underlying Brain Substrate
  - Neuronal Reserve
- Age
- Medical Co-morbidities
  - Hyper/Hypoglycemia
  - Hyperthermia
Stroke Mechanisms

- Embolism
  - Most common
  - MCA >> ACA
- Thrombosis
- Hypoperfusion
- Combination
  - “Impaired Washout of Emboli”
National Institutes of Health Stroke Scale - NIHSS

- 12 Item scale
- Points are given for deficits
  - 0 = normal
  - 42 = No neurological function
- Strict guidelines for interpreting and scoring
- Requires (minimal) training
  - Video
- Can be completed in 4-5 minutes by experienced examiner
NIHSS

- 1- Alertness, Commands, Response
- 2- Horizontal Gaze
- 3- Visual Fields
- 4- Facial Movement
- 5- Arm Movement
- 6- Leg Movement
- 7- Ataxia
- 8- Sensation
- 9- Language
- 10- Speech Quality
- 11- Neglect
- 12- Hand Strength
Modified Rankin Scale (mRS)
Neurological Disability Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>No symptoms at all.</td>
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<tr>
<td>1</td>
<td>No significant disability despite symptoms: able to carry out all usual duties and activities.</td>
</tr>
<tr>
<td>2</td>
<td>Slight disability: unable to carry out all previous activities but able to look after own affairs without assistance.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate disability: requiring some help, but able to walk without assistance.</td>
</tr>
<tr>
<td>4</td>
<td>Moderate to severe disability: unable to walk without assistance, and unable to attend to own bodily needs without assistance.</td>
</tr>
<tr>
<td>5</td>
<td>Severe disability: bedridden, incontinent, and requiring constant nursing care and attention.</td>
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<tr>
<td>6</td>
<td>Death</td>
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