Carotid Artery Stenosis

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Carotid Artery Stenosis

- Carotid Artery Stenosis (Divided)
  - Asymptomatic
  - Symptomatic
Asymptomatic Carotid Artery Stenosis

- Defines any stenosis that occurs without TIA or Stroke
- Goal of treatment is to prevent stroke
Symptomatic Carotid Artery Stenosis

- **Stroke** - a focal neurological deficit related to neuronal cell death with signs and symptoms lasting *greater than* 24 hours

- **Transient Ischemic Attack (TIA)** - a focal neurological deficit with signs and symptoms lasting *less than* 24 hours
Stroke

- #1 cause of long term disability and loss of independence
  - ~500,000 new strokes/yr
  - Over $50 Billion lost wages
- Third most common cause of death in U.S.
  - ~200,000 deaths/year
- Major public Health Issue

MRI of an acute stroke
- **Risk Factors**
  - Hypertension
  - Increasing age
  - Cardiovascular disease
    - Especially *atrial fibrillation*
  - Cigarette Smoking
  - Carotid Artery Stenosis
Peripheral Vascular Disease

Stroke

- Etiology of strokes
  - Hemorrhage
    - ~20% of strokes
      - Aneurysms
      - Trauma
      - Anticoagulation related
      - Congenital anomalies
  - Ischemia
    - ~80% of strokes
- Extracranial vascular anatomy
  - Aortic Arch
  - Brachiocephalic vessels
    - Innominate
    - Left common carotid
    - Left subclavian
  - Branches
    - Internal/External carotids
    - Vertebrals
### Intracranial vascular anatomy

- **Internal carotid branches**
  - Middle cerebral
  - Anterior cerebral
Stroke

Anterior cerebral artery (lateral projection)
How does vascular disease cause stroke?

- Low flow/occlusion
- The vast majority of arterial related strokes occur secondary to embolization
Pathophysiology

- Lacunar infarcts: 15-25%
- Atherothrombotic Stroke
  - Carotid Disease
  - Vertebrobasilar disease
  - Watershed/hypotension
  - Idiopathic
  - Iatrogenic
Carotid Artery Stenosis

- **Anatomy**
  - Disease of the carotid bulb
  - Rich source of emboli
  - Embolic risk related to plaque burden
Carotid Artery Stenosis

- **Anatomy**
  - Predominantly atherosclerotic
  - Other causes
    - Fibromuscular Dysplasia
    - Arteritis
      - Takayasu’s
      - Giant Cell Arteritis
    - Dissections
Carotid Artery Stenosis

- Epidemiology- (associated factors)
  - Hypertension
  - Cardiovascular disease
  - Other peripheral vascular disease conditions
  - Hyperlipidemia
Presentation

- Physical exam finding - bruit
  - Poor sensitivity and specificity
- Found on evaluation of other problem
- Screening
  - Most common mode of presentation
Carotid Artery Stenosis

- **Presentation**
  - TIA
  - Amaurosis fugax
  - Completed Stroke
  - Asymptomatic
Carotid Artery Stenosis

- **Transient Ischemic Attack (TIA)** - a focal neurological deficit with signs and symptoms lasting less than 24 hours
  - Contralateral paresis
  - Contralateral numbness
  - Aphasia (if left hemispheric)
Amaurosis fugax

- Temporary ipsilateral monocular visual loss due to embolization of retinal artery or branches
  - Visual field defect
  - ‘Like a black shade’
  - Not scotomas or ‘floaters’
  - May see Hollenhorst plaques on fundoscopic exam
Carotid Artery Stenosis

- **Diagnosis**
  - **Carotid duplex**
    - Non-invasive
    - Safe
  - CTA arteriography
  - MR Arteriography
  - Digital subtraction angiography
Carotid Duplex and Angiography

90% stenosis ulcerated plaque.

RICA PRX
Angiographic Stenosis Compared to Carotid Duplex Velocities

Grant et al. Radiology 2000: 214 p 247 -252
## Categories of Internal Carotid Artery Stenosis by Duplex Ultrasound

<table>
<thead>
<tr>
<th>Percent Stenosis</th>
<th>PSV</th>
<th>EDV</th>
<th>Spectral Broadening</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19%</td>
<td>&lt;105</td>
<td>…</td>
<td>Absent</td>
</tr>
<tr>
<td>20-39%</td>
<td>&lt;105</td>
<td>…</td>
<td>Present</td>
</tr>
<tr>
<td>40-59%</td>
<td>105-169</td>
<td>…</td>
<td>Present</td>
</tr>
<tr>
<td>60-79%</td>
<td>170-240</td>
<td>…</td>
<td>Present</td>
</tr>
<tr>
<td>80-99%</td>
<td>&gt;240</td>
<td>≥135</td>
<td>Present</td>
</tr>
<tr>
<td>Occluded</td>
<td>No DS</td>
<td>No DS</td>
<td>No DS</td>
</tr>
</tbody>
</table>
## Recommendations for Repeat Carotid Duplex Scanning

<table>
<thead>
<tr>
<th>ICA Stenosis</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19%</td>
<td>Only repeat if new clinical indications are present</td>
</tr>
<tr>
<td>20-39%</td>
<td>Repeat every year</td>
</tr>
<tr>
<td>40-59%</td>
<td>Repeat every year</td>
</tr>
<tr>
<td>60-79%</td>
<td>Repeat every 6 months</td>
</tr>
<tr>
<td>80-99%</td>
<td>Refer for carotid endarterectomy or stent</td>
</tr>
<tr>
<td>Occlusion</td>
<td>Repeat every year</td>
</tr>
<tr>
<td>Occlusion on one side and 60-79% on contralateral side</td>
<td>Refer to a vascular specialist</td>
</tr>
<tr>
<td>Post carotid endarterectomy</td>
<td>Repeat in 6 months and then yearly. If the contralateral side is 80-99%, repeat one week after CE</td>
</tr>
<tr>
<td>Post carotid stent</td>
<td>Repeat at 24 hours, 6 months and yearly</td>
</tr>
</tbody>
</table>
Natural History

- Depends on presentation
  - Asymptomatic
    - 5 year stroke risk ~11% (60% or greater stenosis)
      - ACAS trial data
      - Risk increases with increasing lesion severity
    - Lesion progression common
  - Symptomatic
    - 2 year stroke risk ~15-30% (50% or greater stenosis)
      - NASCET trial data
Carotid Artery Stenosis

- Treatment
  - Medical Therapy
  - Carotid Endarterectomy
  - Carotid Artery Stenting
Carotid Artery Stenosis

- Treatment - Medical
  - Secondary Prevention/ Medical Management
    - Hypertension Management
    - Smoking Cessation
    - Lipid Management
      - Statins
    - Diabetes Management
    - Antiplatelet agents
      - Aspirin, Clopidogrel
      - Dipyridamole, Ticlopidine
Carotid Artery Stenosis

- Treatment - Surgical Options
  - Carotid endarterectomy
    - Excellent Durability
    - Excellent stroke protection
    - 60-70% risk reduction
    - Safe
Carotid Artery Stenosis
Carotid Artery Stenosis
American Heart Association Guidelines

- Asymptomatic Patients
  - For treatment of 60% or greater stenosis
    - Perioperative stroke/death must be less than 3%
- Symptomatic Patients
  - For treatment of 50% or greater stenosis
    - Perioperative stroke/death must be less than 6%
- No proven indications beyond these thresholds

Biller et al, Circulation 1998
Carotid Artery Stenosis

- Treatment - Surgical
  - Options
    - Carotid stenting
      - Unproven Durability
      - Excellent stroke protection
    - Higher perioperative stroke rates
  - Indications
    - Prior Neck XRT
    - Prior Neck Surgery
    - Recurrent Disease
Carotid Artery Stenosis
Rationale for CAS in lieu of CEA

- Less invasive
- ? Lower risk of adverse outcomes
  - Stroke
  - Death
  - Procedural morbidity
- ? Less Cost
CREST RESULTS
<table>
<thead>
<tr>
<th></th>
<th>CAS (n=1262)</th>
<th>CEA (n=1240)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td><strong>Female - %</strong></td>
<td>36</td>
<td>34</td>
</tr>
<tr>
<td><strong>Asymptomatic - %</strong></td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td><strong>Hypertension - %</strong></td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td><strong>Diabetes - %</strong></td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>Dyslipidemia - %</strong></td>
<td>82</td>
<td>85</td>
</tr>
<tr>
<td><strong>Current smoker - %</strong></td>
<td>26</td>
<td>26</td>
</tr>
</tbody>
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### Carotid Artery Stenosis

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<th>CAS (n=1262)</th>
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<tbody>
<tr>
<td>Cardiovascular disease - %</td>
<td>41</td>
<td>43</td>
</tr>
<tr>
<td>Systolic BP, mean mmHg</td>
<td>142</td>
<td>141</td>
</tr>
<tr>
<td>% stenosis ≥ 70%</td>
<td>85</td>
<td>87</td>
</tr>
<tr>
<td>Days from randomization to treatment</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>
Primary Endpoint $\leq$ 4 years
(any stroke, MI, or death within peri-procedural period plus ipsilateral stroke thereafter)

<table>
<thead>
<tr>
<th>CAS vs. CEA</th>
<th>Hazard Ratio, 95% CI</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2 vs. 6.8%</td>
<td>HR = 1.11; 95% CI: 0.81-1.51</td>
<td>0.51</td>
</tr>
</tbody>
</table>
Primary Endpoint

ITT analysis

% Event Free

Follow-up Time (years)

Assignment  
CAS  CEA
Carotid Artery Stenosis

- No effect detected for symptomatic status or sex
- Interaction suggested for age
Primary outcome – 4 year

\[ P_{interaction} = 0.020 \]

Hazard Ratio

Age (Years)

CEA Superior

CAS Superior
Primary Endpoint: peri-procedural components
(any death, stroke, or MI within peri-procedural period)

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<th>CAS vs. CEA</th>
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<tbody>
<tr>
<td><strong>5.2 vs. 4.5%</strong></td>
<td>HR = 1.18; 95% CI: 0.82-1.68</td>
<td>0.38</td>
</tr>
</tbody>
</table>
## Peri-procedural Stroke and MI

<table>
<thead>
<tr>
<th>Comparison</th>
<th>CAS vs. CEA</th>
<th>Hazard Ratio 95% CI</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>4.1 vs. 2.3%</td>
<td>HR = 1.79; 95% CI: 1.14-2.82</td>
<td>0.01</td>
</tr>
<tr>
<td>MI</td>
<td>1.1 vs. 2.3%</td>
<td>HR = 0.50; 95% CI: 0.26-0.94</td>
<td>0.03</td>
</tr>
</tbody>
</table>
# Peri-procedural Stroke

<table>
<thead>
<tr>
<th>CAS vs. CEA</th>
<th>Hazard Ratio 95% CI</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Stroke</strong></td>
<td>4.1 vs. 2.3%</td>
<td>HR = 1.79; 95% CI: 1.14-2.82</td>
</tr>
<tr>
<td><strong>Major Stroke</strong></td>
<td>0.9 vs. 0.6%</td>
<td>HR = 1.35; 95% CI: 0.54-3.36</td>
</tr>
</tbody>
</table>
### Cranial Nerve Palsies

**Peri-procedural**

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<th>CAS vs. CEA</th>
<th>Hazard Ratio, 95% CI</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 vs. 4.7%</td>
<td>HR = 0.07; 95% CI: 0.02-0.18</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>CAS vs. CEA</td>
<td>Hazard Ratio, 95% CI</td>
<td>P-Value</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>2.0 vs. 2.4%</td>
<td>HR = 0.94; 95% CI: 0.50-1.76</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Carotid Artery Stenosis

- Similarity in the Primary Endpoint driven by differences in perioperative stroke and MI
  - More MIs after CEA
  - More strokes after CAS
Carotid Artery Stenosis

- **Recent CREST data**
  - **Rates of Stroke/Death**
    - Age less than 60: 1.7%
    - Ages 60-69: 1.3%
    - Ages 70-79: 5.3%
    - Ages 80-89: 12.1%

- **Recent CREST Advisory**
  - Age>80
  - Extreme tortuosity
  - Severe calcification
  - Limited cerebral reserve

Carotid Artery Stenosis

Treatment- Surgical

- Based upon symptoms and degree of stenosis
  - Strong Recommendations + High Quality Evidence:
    - a) We recommend optimal medical therapy without revascularization in symptomatic patients with <50% stenosis.
    - b) We recommend optimal medical therapy without revascularization in asymptomatic patients with <60% stenosis.
    - c) We recommend carotid endarterectomy plus optimal medical therapy in symptomatic patients with 50-99% carotid stenosis.
    - d) We recommend carotid endarterectomy plus optimal medical management in asymptomatic patients with 60-99% stenosis and low perioperative risk.

Society for Vascular Surgery Consensus Practice Guidelines
Surveillance

- For restenosis and adverse events
  - One month
  - Six month intervals for two years
  - Yearly thereafter
Recurrence (time)

- 0-2 years = Intimal Hyperplasia
- > 2 years = Atherosclerosis
Questions

• ?