Carotid Stenosis:
The Manifestations and Clinical Spectrum of Ocular Findings

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Course Objectives

1. Understand and describe the appearance of retinal emboli

2. Describe the process of arteriosclerosis and its relation to carotid disease

3. Understand the diagnostic tools available and when to order

4. Describe the anterior and posterior segment findings of carotid stenosis

5. Appreciate the surgical options available for surgically significant carotid stenosis
Case 1

- 62–year–old white male presented to clinic in March 2011 for a routine exam.
- CC: New rx requested due scratched lenses
- PMH: lumbago, Type 2 Diabetes Mellitus x 10 years, hypertension, and hyperlipidemia.
- POH: Type 2 Diabetes Mellitus without retinopathy, incipient cataracts, mild dermatochalasis and CHA.
- Family history was unremarkable.
- Sys Meds: fluticasone 50 mcg nasal spray, gemfibrozil 600 mg, glipizide 20 mg, hydrochlorothiazide 12.5 mg, lisinopril 80 mg, metformin hcl 2000mg, naproxen 1000 mg, pioglitazone 30 mg, and tramadol hcl 30 mg.
- Recent hemoglobin A1C was 6.8%.
Case 1

- BCVA 20/20 OD, OS
- Extra ocular motility was full and unrestricted in both eyes.
- Confrontation fields was unremarkable OD, Small scotoma noted inferior to fixation OS.
- Amsler grid OS confirms small scotoma inferior to fixation
- Pupils: PERRLA (−) APD OU
- SLE remarkable for mild dermatochalasis and trace nuclear sclerotic lenticular opacities in both eyes.
- IOP 17 mm HG OD, 15 mm HG OS with tonopen
- DFE OD: 0.15 C/D and resolving retinal microinfarct along the supero–temporal arcade. OS: see photo
Calcific Emboli:
- Nonscintillating, white in appearance, and typically present in the central retinal artery due to the large size.
- May remain in retinal vasculature permanently because they do not dissolve.
- Associated with calcification of heart valves or aorta.
- Transesophageal echocardiogram is recommended for systemic diagnosis.

Fibrinoplatelet Emboli:
- Dull white in appearance and typically present as long, smooth emboli simulating a plug in the retinal arteriole.
- They are most commonly associated with carotid thrombosis.

Cholesterol Emboli/Hollenhorst Plaque:
- Highly refractile, crystal-like emboli typically seen at arteriole bifurcations.
- Often visually asymptomatic as they do not typically obstruct the retinal arteriole.
Hollenhorst first described cholesterol emboli in the retinal arterioles in 1958.

Formed from cholesterol deposition, most commonly originating from the ipsilateral carotid artery.

Patients are largely asymptomatic due to the malleability of the plaque and persistent vascular perfusion around the emboli.
  - May be an incidental finding during fundoscopy.
Hollenhorst Plaques

- Patients *may* experience amaurosis fugax if the plaque becomes lodged in a retinal arteriole for a transient period.

- Frequently, the plaques dislodge and may not be noted on subsequent examinations.

- Determine if symptomatic for:
  - Sudden dizziness, visual disturbances, slurred speech, hemiparesis, or Hx of CVA
Hollenhorst Plaque Workup

- Lipid Panel

- Carotid Auscultation

- Carotid Duplex
  - Consider duplex imaging for patients over the age of 60 with comorbid systemic vascular conditions and evidence of pertinent retinal findings.
Lipid Panel – 04/01/2011

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Ref Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cholesterol</td>
<td>135 mg/dL</td>
<td>0–200</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>184 mg/dL</td>
<td>0–150</td>
</tr>
<tr>
<td>HDL</td>
<td>24 mg/dL</td>
<td>&gt; 40</td>
</tr>
<tr>
<td>LDL</td>
<td>74 mg/dL</td>
<td>0–99</td>
</tr>
</tbody>
</table>

• Despite good recent lipid control, a review of patient previous cholesterol panels shows total cholesterol levels upwards of 200 mg/dL, Trigs 379 mg/dL.
Carotid Duplex

• Right Side:
  – No significant stenosis in the right carotid artery system

• Left Side
  – Peak systolic velocity (PSV) of 247 cm/sec
  – End diastolic velocity (EDV) of 81 cm/sec
  – Greater than 70% stenosis.

• Carotid Endarterectomy performed in April 2011 without perioperative complications.
Pathophysiology of Atherosclerosis
Pathophysiology of Atherosclerosis

Emerging Evidence
Atherosclerosis: An Inflammatory Process

LDL
Monocyte
Cell adhesion and migration
RBC
Platelet

Proteolytic enzymes
Cell recruitment

Pathological lesions in atherosclerosis.
WOULD YOU BE A DEAR AND HOLD MY KITTY WHILE THE DOCTOR EXAMINES MY EYES?
52–year–old African American female presented to clinic in September 2010 for an examination.

CC: Eye pain in right eye with redness x 1–2 weeks. Also notes significantly decreased vision in the right eye that was consistent with the onset of pain. Denies ocular trauma.

POH:
- 1 week prior Diagnosed with acute angle closure glaucoma
- H/o retinal tear OD–treated with pneumatic retinopexy
- s/p PRP OD
Case 2

- **PMH:**
  - Hypertension, Depression, 2 CVA affecting left side in past year
  - Known Carotid Stenosis 100% right blockage / 70% left Blockage

- Family history unremarkable.

- **Ocular Meds:** Omnipred Q 2–3H OD
  - Pilocaprine 1% Q2–3H OD

- **Sys Meds:** Buprion 75mg BID, Omeprazole 20mg
Case 2

- **BCVA:** CF Temporally OD, 20/20 OS

- **EOM:** full and unrestricted OU

- **CF:** near 360 constriction OD FTFC OS

- **Pupils:** mid-dilated OD c tr reaction
  - 2+ APD OD by reverse testing

- **SLE:** Conj: 2+ limbal flush OD
  - AC: 1+ cell, 2+ flare OD
  - rare cell, no flare OS
  - Iris: NVI at 3–10 o’c OD

- **GAT 31/16**

- **Gonio:**
  - OD: closed angle 350 degrees with remaining SS at 6 o’c.
  - (+) Peripheral NVI OD
  - OS: open to CB 360 c flat iris approach, 2+TM pigmentation.
  - (-) NVI/NVA

**DFE OD:** see photo
**OS:** Unremarkable
1. Ocular Ischemic Syndrome OD
2. Branch Retinal Artery Occlusion OD
3. Neovascular Glaucoma OD
Ocular Ischemic Syndrome

- Widespread ischemia to the eye may result when the carotid artery is occluded at least 90%.

- **Symptoms:**
  - Decreased vision
  - Peri-orbital eye pain
  - Headache
  - Amaurosis fugax
  - Extended visual recovery after photostress.
Ocular Ischemic Syndrome

- **Posterior segment findings:**
  - Arteriolar narrowing
  - Venous dilation without tortuosity
  - Midperipheral retinal hemorrhages
  - Microinfarcts
  - Spontaneous arterial pulse
    - Diastolic < IOP
    - 5% of OIS patients
  - Optic disc/retinal neovascularization.

- Since many of these findings are noted in other ocular conditions, clinicians should especially consider OIS when ocular findings are asymmetrical.
Ocular Ischemic Syndrome

- **Anterior Segment findings:**
  - Uveitis
  - Cataract
  - Iris neovascularization
  - Episcleral injection
  - Corneal edema
  - Corneal folds
Iris Neovascularization

- Usually secondary to widespread retinal hypoxia
  - DM, Venous Occlusive Disease, Carotid Artery Disease, Sickle Cell
  - Vascular Endothelial Growth Factors (VEGF) is released by *dying* (ischemic) retinal tissue.

- Healthy endothelial cells of viable capillaries stimulate the formation of a neovascularization membrane
  - If few viable capillaries remain, VEGF may diffuse forward to the nearest area of viable capillaries at the posterior iris.
Neovascular Glaucoma

- Occurs when iris neovascularization grows over the chamber angle and closes from peripheral anterior synechia (PAS) formation

- Although neovascular glaucoma should initially be treated with topical medical therapy, surgical intervention may be necessary if the intraocular pressure is not reduced to an appropriate level.

- Surgical intervention may include trabeculectomy or tube shunt.
  ◦ Good procedures but less successful outcome compared to other forms of glaucoma
Ocular Ischemic Syndrome

- Intraocular Pressure
  - IOP can range from low to high depending on the state and duration of OIS.
    - A unilateral low eye pressure is indicative of hypoperfusion to the ipsilateral ciliary body.
    - Significantly elevated intraocular pressures may be due to neovascular glaucoma from widespread ocular ischemia.
Diagnostic Testing

- Carotid Auscultation
- Fluorescein Angiography
- Ophthalmodynamometry/Oculoplethysmography
- Carotid Duplex
- Computed Tomography Angiography (CTA)
Carotid Auscultation

Using Bell Mode
- For low-frequency sounds
  - Heart Murmur/Carotid Bruit
  - Rest the bell *lightly* on the patient. When the diaphragm membrane is suspended, the membrane resonates low-frequency sounds.

Using Diaphragm Mode
- For high-frequency sounds
  - Lungs/Normal Heart
  - Use *firm* pressure on the head. This blocks low-frequency sounds and allows you to hear higher frequency sounds.
Carotid Auscultation

- Have patient move head to opposite direction on the carotid being evaluated (if examining right carotid turn head left)

Internal Carotid Artery
Move the bell up to the angle of the jaw for the level of the

Common Carotid Artery
Position Bell of Stethoscope approximately 1 inch above clavicle
Fluorescein Angiography

<table>
<thead>
<tr>
<th>Sign</th>
<th>Percentage of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged arteriovenous transit time</td>
<td>95%</td>
</tr>
<tr>
<td>Retinal vascular staining</td>
<td>85%</td>
</tr>
<tr>
<td>Delayed choroidal filling</td>
<td>60%</td>
</tr>
<tr>
<td>Macular edema</td>
<td>17%</td>
</tr>
</tbody>
</table>

- Normal Transit time is approximately 12-15 sec in the elderly

Ophthalmodynamometry and Oculoplethysmography

- The central retinal artery is observed at the slit lamp while force is gradually applied until pulsations of the central retinal artery are observed.
  - 1st Reading: pulsation of CRA = diastole
  - 2nd Reading: collapse of CRA = systole
    - Always measure contralateral eye for comparison!

- The normal ophthalmic artery systolic pressure is 100 mmHg and diastolic pressure is 60 mmHg.

- Limited usefulness as screening tool.
Carotid Duplex Imaging

- Utilizes B-mode and Doppler ultrasonography to evaluate the common carotid, internal carotid and external carotid arteries.

- Duplex imaging rapidly alternates between the two methods, providing the imager with an accurate determination of blood flow velocity and the extent of arterial plaque.
Evaluation of the carotids provides information about:

- Peak Systolic Velocity (PSV)
- End Diastolic Velocity (EDV)
- Diameter reduction
- Plaque size and morphology
- Spectral characteristics
- Direction of vertebral flow

Significant internal carotid artery stenosis is characterized by a vessel diameter reduction of 80-99%, PSV > 125 cm/sec, EDV > 140 cm/sec and extensive spectral broadening.

It is typical to note an increased PSV with a larger degree of stenosis. As the vessel lumen decreases, blood is forced through at a higher velocity.
### Table 9-3. Consensus Panel Table of Ultrasound and Doppler Criteria for Diagnosis of Internal Carotid Artery Stenosis

<table>
<thead>
<tr>
<th>Degree of Stenosis</th>
<th>ICA PSV</th>
<th>Plaque Estimate*</th>
<th>ICA/CCA PSV Ratio</th>
<th>ICA EDV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt;125 cm/sec</td>
<td>None</td>
<td>&lt;2.0</td>
<td>&lt;40 cm/sec</td>
</tr>
<tr>
<td>&lt;50%</td>
<td>&lt;125 cm/sec</td>
<td>&lt;50% diameter reduction</td>
<td>&lt;2.0</td>
<td>&lt;40 cm/sec</td>
</tr>
<tr>
<td>50%–69%</td>
<td>125–230 cm/sec</td>
<td>≥50% diameter reduction</td>
<td>2.0–4.0</td>
<td>40–100 cm/sec</td>
</tr>
<tr>
<td>≥70 but less than near occlusion</td>
<td>≥230 cm/sec</td>
<td>≥50% diameter reduction</td>
<td>&gt;4.0</td>
<td>&gt;100 cm/sec</td>
</tr>
<tr>
<td>Near occlusion</td>
<td>High, low, or undetectable</td>
<td>Visible</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>Total occlusion</td>
<td>Undetectable</td>
<td>Visible, no detectable lumen</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>
Computed Tomography Angiography

- Performed to accurately determine the degree of carotid stenosis prior to surgical intervention.
  - The procedure uses an intravenous contrast which allows for clear imaging of the arterial lumen

- CTA has a sensitivity of 85% and specificity of 93% when performed on patients with stenosis percentages between 70% and 99%.\textsuperscript{12}

- CTA is especially beneficial when duplex results are suggestive of total occlusion, as there may be mild patency of the artery allowing for surgical intervention.
Local ocular treatment is targeted at retinal and iris neovascularization.

Panretinal photocoagulation (PRP) has produced mixed results when used to treat OIS.
- PRP has been shown to successfully reduce ocular neovascularization
  - The results are only mild in comparison to those of diabetics and retinal venous occlusions.
  - Vision does not typically improve after PRP.

Anti–vascular endothelial growth factor intravitreal injections have also been found to be effective in reducing retinal, iris and angle neovascular glaucoma secondary to OIS.
OIS: Carotid Surgical Treatment

- The treatment of OIS is targeted at fixing the underlying etiology of the carotid artery or other atherosclerotic sites.

- Surgical procedures include carotid endarterectomy (CEA) and carotid artery stenting (CAS)
  - Small scale studies have shown resolution of neovascularization within several days of carotid endarterectomy.
  - Other case reports have also shown that OIS retinopathy without neovascularization can improve following CEA.

- It is important to note though that surgical intervention has never been shown to reverse chronic neovascular glaucoma.
Would it be okay if I put some drops in your eyes?

Would it be okay if I gave you a paper cut and poured lemon juice on it?
Carotid Endarterectomy (CEA)

- Surgical procedure to remove fatty plaque from neck arteries to prevent the adverse sequelae of carotid artery stenosis secondary to atherosclerotic disease.

**General Consensus:**
- Perform CEA with 70% or greater stenosis in symptomatic patients
- Asymptomatic studies only recommend CEA intervention when the risk of perioperative stroke, myocardial infarction or death is low.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Indication</th>
<th>Perioperative CVA/Death</th>
<th>Risk Reduction</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASCET</td>
<td>Sx: ≥70%</td>
<td>5.8%</td>
<td>16.5%/2 yr</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Sx: 50%-69%</td>
<td>6.7%</td>
<td>10.1%/5 yr</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>ECST</td>
<td>Sx: 70%-99%</td>
<td>7.5%</td>
<td>9.6%/3 yr</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>ACAS</td>
<td>Asx: ≥60%</td>
<td>2.3%</td>
<td>5.9%/5 yr</td>
<td>.004</td>
</tr>
<tr>
<td>ACST</td>
<td>Asx: &gt;60%</td>
<td>3.1%</td>
<td>5.4%/5 yr</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

ACAS, Asymptomatic Carotid Atherosclerosis Study; ACST, Asymptomatic Carotid Surgery Trial; Asx, asymptomatic; CVA, cardiovascular accident; ECST, European Carotid Surgery Trialists; NASCET, North American Symptomatic Carotid Endarterectomy Trial; Sx, symptomatic. Data from references 9-12, 15, 16.
Carotid Endarterectomy
Carotid Artery Stenting (CAS)

- Arteriogram of the carotid artery followed by placement of a filter, known as a cerebral protective device (CPD), to prevent debris and emboli from traveling to the ipsilateral cerebral hemisphere.

- Balloon is then inserted to dilate the artery (angioplasty) and a stent is inserted to recanalicularize the blood flow.
Carotid Artery Stenting

CAROTID STENTING & ENDARTERECTOMY
Is CEA or CAS Better?

- Carotid Revascularization Endarterectomy vs. Stenting Trial (CREST)
  - CEA and CAS were both found to be safe and effective through 4 years of follow up
    - CEA: increased risk of myocardial infarction (MI)
    - CAS: increased risk of cerebrovascular accident (CVA)

- Stenting and Angioplasty with Protection in Patients at High-Risk for Endarterectomy (SAPPHIRE)
  - Patients enrolled if high risk for CEA and 50% symptomatic stenosis or 80% asymptomatic stenosis
  - CAS good option for those unable to undergo CEA
Medical Treatment

- Medical
  - Antiplatelet therapy
  - Manage Diabetes, Cholesterol, Hypertension
  - Smoking Cessation
  - Regular Aerobic Exercise

- Subgroup analysis in the Stroke Prevention by Aggressive Reduction in Cholesterol Levels Trial (SPARCL)
  - Demonstrated that intense lipid reduction with atorvastatin reduced the risk of both cerebrovascular and cardiovascular events in patients with carotid stenosis.
Pt went on to develop a mature cataract within 1.5 years, Tractional RD, and near phthisical eye with IOP of ~3 mmHg.

Surgery not performed due to poor visual prognosis from widespread retinal ischemia

Why was carotid surgery not performed?
Difficult to open a chronically occluded ICA

- Management of a chronic ICA occlusion mainly includes strategies to reduce the risk of future strokes and other cardiovascular events.
- Carotid endarterectomy is usually ineffective for total (100%) carotid occlusion because of the high incidence of postoperative carotid thrombosis. In these cases, extracranial-to-intracranial (EC–IC) may be considered.

Extracranial–intracranial arterial bypass surgery

- Little long-term visual benefit from EC–IC bypass procedures.
If cholesterol emboli are seen, determine if the patient is symptomatic for sudden dizziness, visual disturbances, amaurosis, slurred speech, hemiparesis, or Hx of CVA

Idiopathic anterior uveitis is relatively rare in elderly patients. Suspect OIS in elderly patients presenting with an anterior uveitis.

Consider carotid duplex imaging for patients over the age of 60 with comorbid systemic vascular conditions and evidence of pertinent retinal findings.

Ocular ischemic syndrome occurs with internal carotid stenosis > 90%.

Consider ocular ischemic syndrome when ocular findings are asymmetric


References


References

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