5 Amaurosis Fugax and Not So Fugax—Vascular Disorders of the Eye

In no other structure of the body are the termination of an artery and the commencement of a vein presented to view and information regarding the general state of the vascular system is often to be gained from an inspection of their size, texture, and conditions of the circulation within them.

William Gowers[1]

Transient and long-lasting monocular vision loss related to arteriolar occlusive and venous occlusive disease is part of what makes looking at the retina and the disc such an immediately gratifying diagnostic tool. Nowhere else in the body can one so clearly see blood vessels to the capillary level.

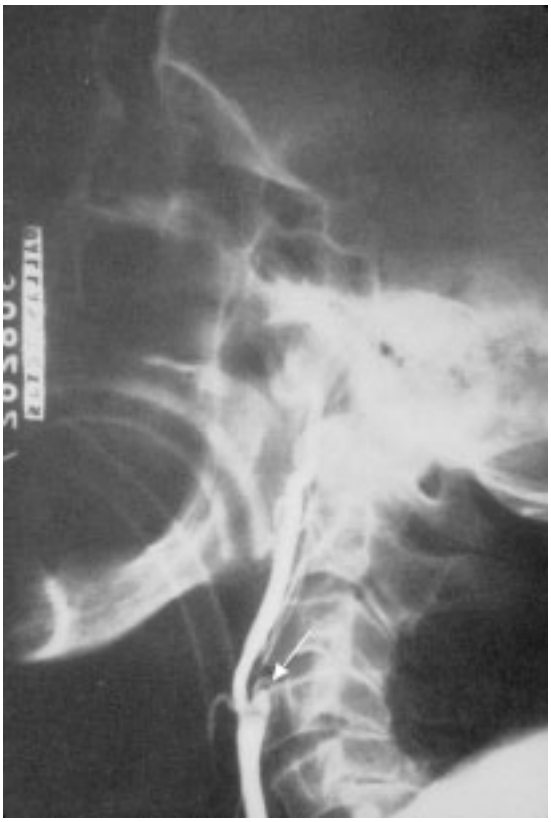
Because the eye is such a vascular structure, disorders of the blood vessels frequently affect vision. As we have seen in viewing the disc for swelling or pallor, knowing the history helps us to know what to expect when we look at the disc and retina. The historical features to consider in evaluating anyone with transient vision loss thought to be related to vascular changes include the age and general health

of the patient; family history of stroke, myocardial infarction, and migraine; and the types of drugs taken (e.g., vasoconstricting agents, cocaine use, cigarette smoking). Specific historical questions should include whether one or both eyes are affected, the sequence of loss (e.g., abrupt, slow, stepwise), the duration of loss, the mode of return of vision (if any), and associated symptoms (e.g., weakness, numbness, pain). By knowing the vascular anatomy and historical features, the examiner knows what to be looking for in the examination of the disc and ocular fundus.

Introduction to the Vascular Supply of the Eye

The blood supply to the globe derives from the ophthalmic artery which, in turn, derives from the internal carotid artery, with greater or lesser contribution from the middle meningeal artery.[2] The ophthalmic artery passes through the optic canal, inferior to the optic nerve, and branches within the orbit to form muscular, lacrimal, posterior ciliary, and central retinal artery segments. These ophthalmic artery branch vessels anastomose with the middle meningeal, supratrochlear, anterior, and posterior ethmoidal arteries, all of which derive from the external carotid system. Thus, if the internal carotid artery is occluded, the blood supply to the retina may derive exclusively from the external carotid system. Furthermore, embolic material from the stump of the occluded internal carotid artery can embolize to the retina in a retrograde fashion through the external carotid collateral vessels.

Figure 5-1. A. **Diagram of the overall blood supply to the eye; the most important source of blood is from the internal carotid artery via the ophthalmic artery and central retinal artery. However, the external carotid communications are potential collaterals to the eye. Look at the numerous opportunities for the external carotid artery branches to communicate with the globe and the internal carotid circulation. The lighter gray is from the internal carotid artery, and the darker gray is from the external carotid artery. See the corresponding color figure on the accompanying CD-Rom.** B. **Here you see a person with an occluded internal carotid artery. The person had episodic vision loss (amaurosis fugax). How could this be, with the occluded internal carotid artery? The person's amaurotic events were coming from the external carotid via collaterals. The arrow points to the occluded stump of the internal carotid artery.**



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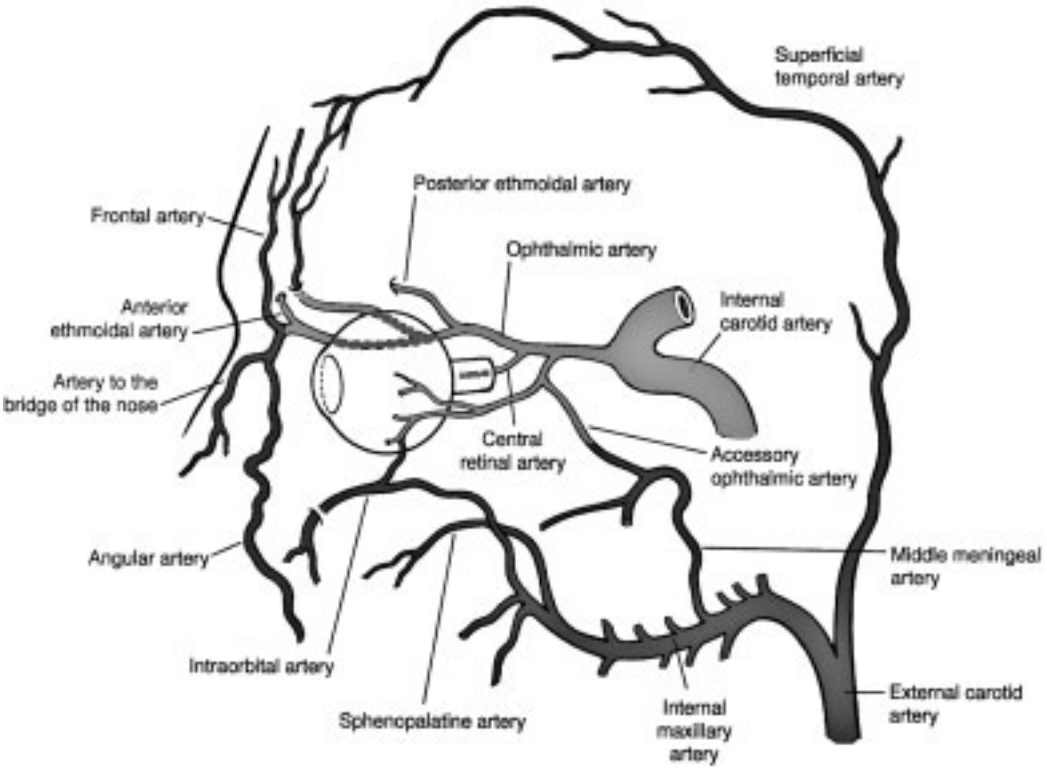

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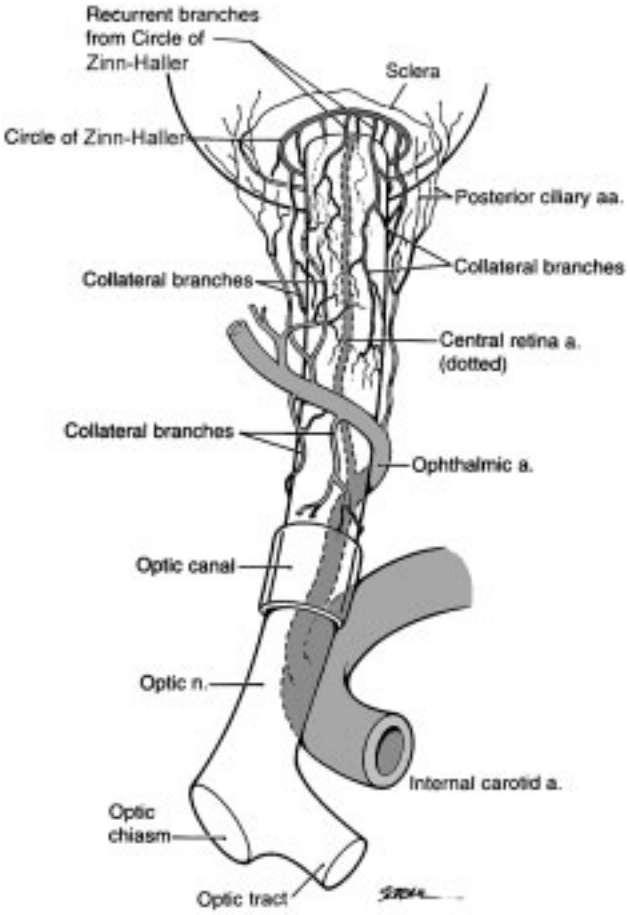

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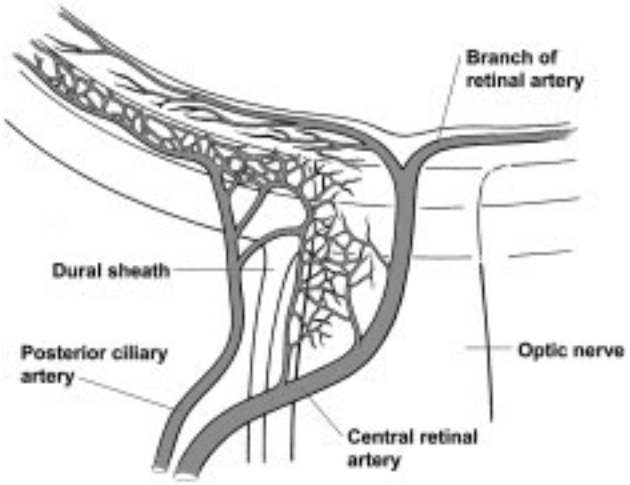

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The external carotid artery circulation has important potential collaterals that connect the external and internal carotid artery blood supply. The external carotid can also serve as a source of embolism to the eye.

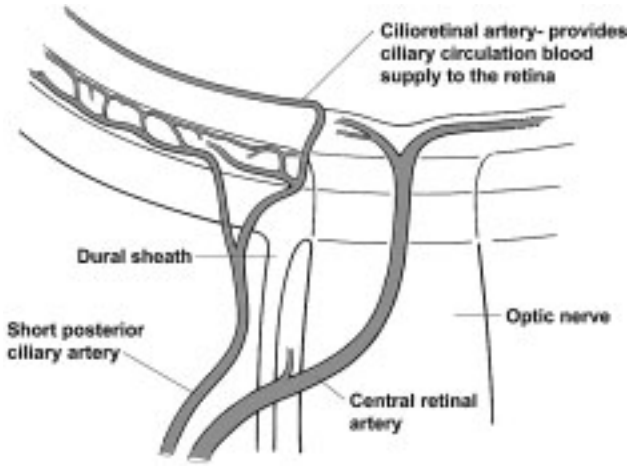
Figure 5-2. The internal carotid artery supplies the globe by way of the ophthalmic artery, through two major branches: The central retinal artery and the posterior ciliary arteries. The central retinal artery penetrates the dural sheath with the central retinal vein and enters the optic nerve, providing the blood supply to the internal surface of the retina. The ciliary arteries supply the choroid and the optic disc via a circumferential set of connecting arterioles (the circle of Zinn-Haller) that penetrate the sclera around the optic nerve.

Figure 5-3. The posterior ciliary arteries supply the choroid and the retrolaminar area of the disc. The central retinal artery supplies the retina.

The ciliary arteries provide blood supply to the choroid and the retrolaminar area of the optic nerve. In approximately one-third of persons, one or more ciliary arterioles penetrate the retina at the disc margin, and provide a variable amount of blood supply to the retinal ganglion cell and nerve fiber layer. In even fewer instances, a large segment of the retina is supplied by a major blood vessel (superior or inferior branch to the retina) that appears to be a branch of the central retinal artery, but is actually a ciliary artery. Rarely, the retina has a totally ciliary blood supply.[3]

Despite the fact that ciliary and central retinal arteries are both branches of the ophthalmic artery, occlusion of ciliary arteries appears rarely as a manifestation of embolic disease, whereas ciliary artery occlusion is common with arteritis. Embolic occlusion of the central retinal artery is common, but is much less commonly the result of arteritis.

Figure 5-4. A. **The cilioretinal artery provides ciliary circulation blood supply to the retina. Here you see the artery entering at the lateral aspect of the disc.** B. **Remember to look for the cilioretinal artery leaving the disc. In this case, the cilioretinal artery is shown temporally; it has a hook-like appearance.** C,D. **This woman has bilateral cilioretinal artery vessels (*arrows*) that extend toward the macula. Notice that she also has "little red discs" (cupless, hyperemic "discs-at-risk"). In the event of a complete central retinal artery occlusion (CRAO), these cilioretinal arterial branches may provide the only blood available to the retina. The location of these vessels determines whether significant vision is preserved. Furthermore, occlusion of the cilioretinal arterioles, especially in the papillomacular bundle, may cause serious vision loss.** E. **This man has a large cilioretinal artery that supplies the superior temporal portion of his retina. The left arrow points the origin of the cilioretinal artery, and the right arrow points to its course.**



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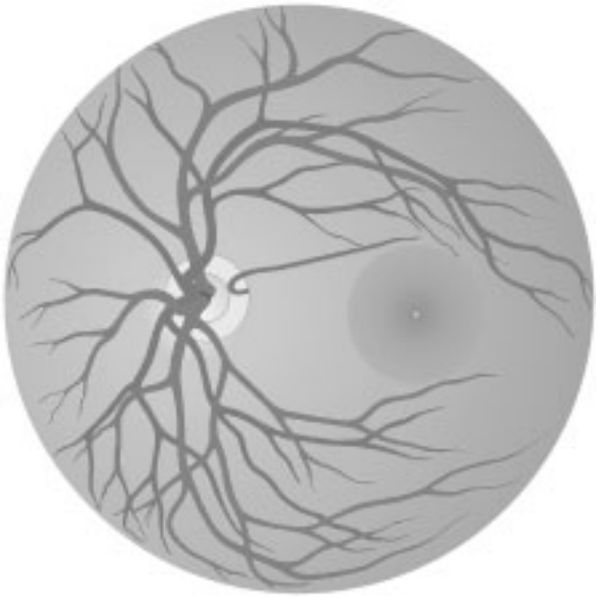

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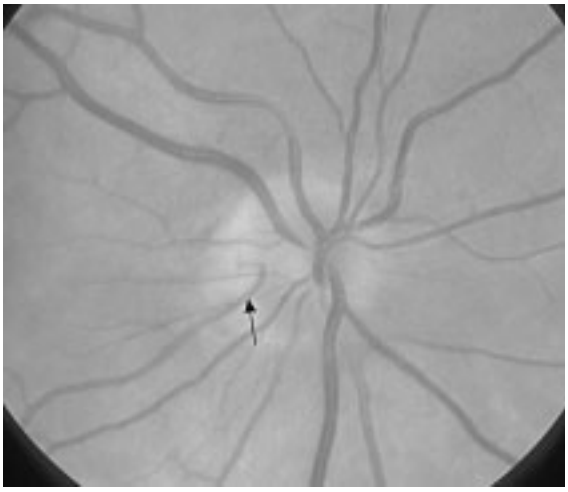

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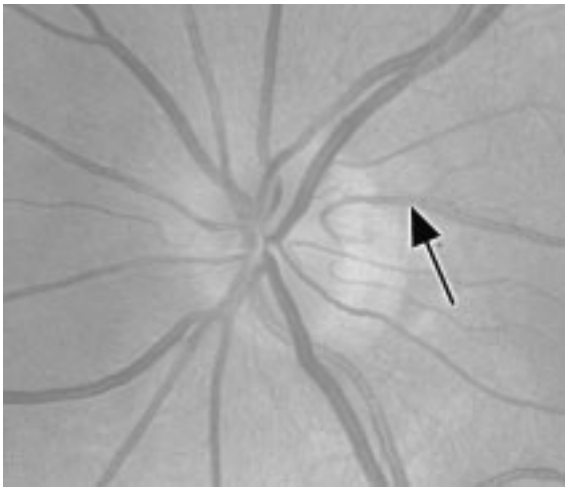

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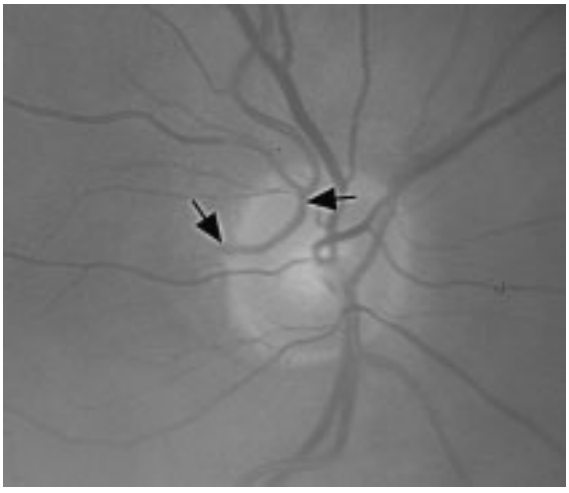

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Blood Supply to the Optic Disc

The deep optic disc has a choroidally derived (posterior ciliary) blood supply in the laminar and retrolaminar area, whereas the visible surface of the disc derives its blood supply from small branches of the central retinal artery (see Chapter 2, Table 2-2). Axons converging on the margin of the disc derive their blood supply from superficial radial peripapillary capillaries.

Evaluating a Patient for Suspected Vascular Disease

Evaluation of a patient with vascular disease affecting the eyes should always start with blood pressure in both arms; unequal blood pressures can signal central vascular disease such as aortic atherosclerosis or inflammation. Evaluation of the heart, including heart rate, regularity of heart rate, and auscultation of the heart for murmurs and extra sounds (such as an S3) is equally important.

Where should you listen for bruits? Bruits can be auscultated at the supraclavicular region as well as all along the carotid artery. The bruit is usually high-pitched and may be focal over the carotid bifurcation. Occasionally, a bruit can be heard over the eye. To do this, use the diaphragm, because the lid tissue may plug the hole in the bell. Always have the patient close both eyes and then open the one *not* being auscultated to eliminate the noise produced by muscle contraction.

Viewing the Fundus for Vascular Disease—General Principles

What should you notice about the disc and retinal vasculature in those patients in whom you suspect vascular disorders? First, view the disc itself: Is it normal, swollen, or pale? Next, view the blood vessels: Are the arteries and veins of normal caliber? Follow each individual artery out from the disc to at least the first branch. Is there evidence of vascular occlusion? Are the veins of normal caliber? Is there evidence of embolic material? Are there crossing changes? Is there perivascular nerve fiber layer swelling? Do you observe a hemorrhage? Are there arterial pulsations or venous pulsations (see Chapter 2)?

WAYS TO STUDY BLOOD FLOW AT THE BEDSIDE—FINGER OCULAR PLETHYSMOGRAPHY

One way to test blood flow at the bedside is to do a crude assessment of blood flow to the eye. Look at the disc through the ophthalmoscope, and get the central retinal artery and vein into view. Apply the slight pressure of your finger through the lid on the lateral sclera. Very slight pressure causes the retinal vein to collapse. Normally, a moderate pressure on the sclera causes the central retinal artery to pulse, or "wink." The first collapse of the artery is the diastolic pressure. In patients with underlying occlusive atherosclerotic disease, a very slight pressure occludes or causes the central retinal artery to pulse or occlude. If the central retinal artery is occluded, there is no pulse, no matter how hard you press on the sclera through the eyelid.[4]

View the collapse of the central retinal vein (see Video 5-V-1A on the accompanying CD-Rom) and the winking of the central retinal artery (see Video 5-V-1B on the accompanying CD-Rom).

Ophthalmodynamometry is rarely performed these days: It measures the pressure exerted on the globe by a piston depressed into the sclera (like finger ocular plethysmography) and gives a numerical pressure. This technique can be helpful when looking for carotid artery disease. The procedure is most easily performed by two people. One person holds the ophthalmodynamometer plunger against the lateral sclera, depressing the plunger gradually and continuously increasing the amount of pressure. The other person views the central retinal artery through a dilated iris with the ophthalmoscope. First, the vein collapses, and then the artery begins to "wink" or pulse at the examiner. The point at which the artery begins to wink is the diastolic reading. The plunger is pulled back until the winking stops, and then the person who is doing the observation says "under." The plunger is again pushed down until the winking starts and the observer says "over." When more pressure is applied to the globe and systolic blood pressure is exceeded, the arteriole blanches and stops pulsating. By gradually reducing the pressure, the arteriole fills again, and this point is the systolic reading. The observer again gives the signal of "over" or "under" while the other person exerts pressure using the plunger and notes the numerical reading.

Although it is possible to measure pressures in millimeters of mercury while simultaneously looking at intraocular pressure, most readings are done to compare one side with the other. Variation between the two sides is usually less than 15%[5]; however, 5% of patients have an ophthalmic artery which is a direct branch of the middle meningeal artery. Thus, this test is invalid in 1 patient in 20, because the middle meningeal artery is a branch of the external carotid system.

These techniques have been rarely used to study the blood flow to the eye since the advent of magnetic resonance angiography, ultrasonography (color ocular blood flow Doppler and transcranial Doppler), and, particularly, fluorescein angiography.

OTHER WAYS TO VIEW THE VASCULATURE AND BLOOD FLOW TO THE EYE

Originally described by David et al.,[6] as well as Hollenhorst and Kearns,[7] the arm-to-retina time in fluorescein angiography was determined by two observers watching with the direct ophthalmoscope or indirect ophthalmoscope as fluorescein was injected. Normal arm-to-retina time is between 10 and 16 seconds, and a delay of more than 1–2 seconds between sides was a possible indication of carotid artery disease.[7] David et al. determined that the difference between the two eyes is not more than 1 second, with a mean difference of 0.5 seconds.[6] Presently, high-speed photography has replaced this simple viewing technique. Today, the photographers note the time of injection as time 0, with each photograph seconds or minutes from the time of injection. The arm-to-retina time gives the physician an indication of the speed of circulation to the eye, and is prolonged in congestive heart failure as well as when there is atherosclerotic or inflammatory disease producing a significant block of the carotid or other vessels.

Of course, there are more sophisticated ways to assess the blood flow to the eye. First, imaging techniques such as magnetic resonance imaging and magnetic resonance angiography show anatomic detail of the internal carotid artery without angiocatheterization; this technique does not usually show the anatomic detail of the ophthalmic artery, let alone the blood flow to the disc. Ultrasonography, including orbital colored Doppler and

transcranial Doppler, assesses the ophthalmic artery blood flow and often the posterior ciliary arteries behind the disc. Fluorescein angiography probably remains the gold standard for assessing blood flow to the nerve and retina.

Transient Monocular Vision Loss or Amaurosis Fugax

Amaurosis derives from the Greek word αμαυρωοσζ, meaning blindness. Fugax is the Latin form of the Greek word φυγαχ, for fleeting—which together means: "fleeting blindness." Transient monocular blindness is commonly, but not invariably, due to recurrent embolization. The phrase *amaurosis fugax* has been so attached to embolic causes of vision loss that the term *transient monocular blindness* or *transient monocular vision loss* is preferable.

The source of emboli may be directly arterial or venous. Arterial emboli arise from a cardiac ventricular, atrial, or valvular source; from a "shagbark" atherosclerotic aorta; or from more distal vessels, classically the internal carotid artery. Embolic presentation of transient monocular blindness is usually quite abrupt, and frequently there are repetitive incidences. Because atherosclerotic major arterial occlusion is more gradual, there is a greater likelihood of collateral arterial supply and no visual symptoms.[5] Vasospastic disease may cause episodic amaurosis, but embolic causes need to be sought assiduously. Nonetheless, migraine can, on rare occasions, cause monocular amaurotic events. If the source is from the venous side, it occurs via the right heart and a patent foramen ovale. The clinical circumstance is repeated Valsalva maneuvers, causing a venous to arterial right-to-left shunt through a patent foramen ovale.

Caveat: The use of the term *amaurosis fugax* carries a lot of diagnostic emotional baggage; it implies

Table 5-1. Causes of Transient Monocular Blindness

- Ocular
  - Tear film abnormality
  - Transient elevation of intraocular pressure
  - Cells or blood in the anterior chamber
- Optic disc disease (transient, seconds-long vision obscuration)
  - Papilledema from whatever cause of increased intracranial pressure
  - Optic nerve drusen
  - Optic disc congenital anomalies (coloboma)
  - Myopia
- Optic nerve disease
  - Compressive optic neuropathies—occasionally gaze-evoked blindness
  - Orbital hemangioma or osteoma
  - Papilledema
  - Thyroid eye disease
- Vascular
  - Carotid artery atheromatous emboli
  - Anastomotic (external carotid) arterial emboli (stump syndrome)
  - Venous and right-to-left shunts (watch for relationship of events to Valsalva maneuver)
  - Retinochoroidal collaterals
  - Cardiac sources (account for the majority of emboli)
    - Valvular—including post-rheumatic valvular disease; mitral valve prolapse; bicuspid aortic valve
    - Tumor—(atrial myxoma)
    - Patent foramen ovale
    - Atrial septal aneurysms >1 cm
  - Aortic arch "shag-bark" atherosclerosis
  - Vasculitis—temporal arteritis; Takayasu arteritis
  - Hypotension from arrhythmia, drugs, postural changes, or blood loss
    - Frank Yatsu's rule of forties: mean BP <40 mm Hg; heart rate <40/min or >160/min
  - Vasospasm (including migraine)
- Hematologic abnormalities
  - Hypercoagulable states
    - Antithrombin III
    - Factor V Leiden deficiency
    - Protein C and S deficiency
    - Polycythemia
    - Sickle cell disease
    - Hyperhomocystinemia
    - Thrombocytopenia purpura
  - Antiphospholipid antibodies
    - Anticardiolipin antibodies
    - Lupus anticoagulant
  - Thrombocytosis
- Metabolic causes
  - Diabetes
  - Hypertension
- Iatrogenic
  - After cardiac catheterization, cardiac bypass
  - Carotid angiography, carotid endarterectomy

Note: Although some of these events do not truly cause blindness, the patient may overdo his or her alarm and describe visual changes as vision loss.

an embolic cause. Because emboli have been attributed largely to an atherosclerotic carotid artery, there tends to be an arrest of differential diagnostic thought if nothing is found in the carotid artery. The table of causes of transient monocular vision loss emphasizes that there are *many* pathophysiologic events that have the potential to cause transient loss of vision in one eye.

As embolic material passes through a vessel or vessels in the retina, it triggers retinal depolarization, producing spots or flashes described as looking like sparklers, shooting stars, or, as one patient said, "looking like minnows flashing away from the edge of a pond when one steps near." If the emboli stick, they cause monocular altitudinal, quadrantic, or other segmental losses of vision. The "shadelike" vision loss (like a curtain coming up or down or, rarely, from the side) is a staple complaint, but an embolic source is not always found.

Dr. Shirley Wray systematically reviewed more than 850 cases of transient monocular blindness and made several observations about these cases, as well as developed a classification system that allows us to think about transient monocular blindness caused by vascular occlusion.

Table 5-2. Types of Transient Monocular Blindness (Wray's Classification)

Features	Type 1: transient retinal ischemia	Type 2: retinal vascular insufficiency	Type 3: vasospasm	Type 4: unclassifiable multiple etiologies
Age group	Any age	Older age	Younger and older ages	Any age
Cause	Embolus (thrombus) from carotid artery, heart, or aorta; antiphospholipid antibodies	Extracranial arterial occlusive disease or internal and external carotid artery	An intermittent retinal vascular insufficiency without permanent impairment of retinal perfusion	Heart defects, underlying systemic lupus erythematosus
Onset	Abrupt	Gradual	Abrupt to gradual	Abrupt
Provoking features	None	Systemic hypotension; venous hypertension; steal phenomenon	Migraine	None known
Vision loss	Complete or partial —curtain ascending or descending; sideways moving blind	Complete or partial; acuity normal, but contrast changed; bright objects brighter; flickering edge to objects; glare of white paper; colored lights	Complete or progressive visual field narrowing	Partial
Duration of event	Secs–mins	Mins–hrs	Mins	Variable—secs, mins
Recovery	Complete	Complete	Complete/some loss	Complete

Features	Type 1: transient retinal ischemia	Type 2: retinal vascular insufficiency	Type 3: vasospasm	Type 4: unclassifiable multiple etiologies
Pain	No	Yes—aching over orbit, face worse upright	Frequently—before, during, or after	No
Mechanism	Embolus	Hypoperfusion	Vasospasm of optic artery or central retinal artery	Multiple
Other features	Total vision blackout	Visual aberrations	Peripheral loss sparing central visual field	—
Risk of vision loss/death	Permanent vision loss <3%/annum	Higher risk of stroke and myocardial death	Variable	—
Risk factors	Generalized arteriosclerotic vascular disease; fibromuscular hyperplasia; angiitis, systemic lupus, Behçet's syndrome, moya moya syndrome; hypercoagulable state	Severe atherosclerosis; Takayasu's arteritis; giant cell arteritis	Migraine; giant cell arteritis; periarteritis nodosa, eosinophilic vasculitis	Systemic lupus
General examination	Auscultation of neck, eye	Blood pressure, palpation of arteries	Livedo reticularis	Splinter hemorrhages of fingernails
Other ocular findings	Look for signs of embolism in conjunctiva	Rubeosis of iris, poor pupillary light reflex, ischemic uveitis (not steroid responsive)	Anterior ischemic optic neuropathy, retinal infarction	None
Fundus examination	Retinal emboli; central retinal artery occlusion, branch retinal artery occlusion, anterior ischemic optic neuropathy (AION)	Low pressure retinopathy—dot/blot hemorrhage, microaneurysms, segmental narrowing of veins, pulsating retinal artery, anterior ischemic optic neuropathy; cupping, choroidal infarct	During attack look for narrowing of the arteries first, with subsequent narrowing of venous circulation (see Video 5-V-2 on the accompanying CD-Rom)	No defects appreciated
Fluorescein angiogram	May reveal emboli, normal	Marked prolongation of arm-to-retina time, slowed arteriovenous time	Narrowing of arteries during attack, normal in between	Normal

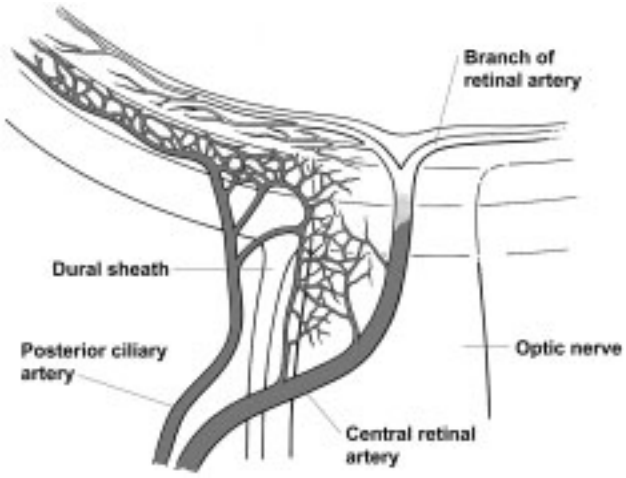
Source: Adapted from SH Wray. Amaurosis fugax. In RJ Tusa, SA Newman (eds), Neuro-ophthalmological disorders. New York: Marcel Dekker, 1995; SH Wray. Visual aspects of extracranial disease. In EF Bernstin (ed), Amaurosis Fugax. New York: Springer 1988;72–89; SH Wray. Transient monocular blindness. In J Bogousslavsky, L Caplan (eds), Visual Symptoms (Eye) in Stroke Syndromes. Cambridge: Cambridge University Press 1995;68–79.

Arterial Occlusion

CENTRAL RETINAL ARTERY OCCLUSION

Occlusion of the central retinal artery produces abrupt loss of vision and a characteristic fundus appearance. The nerve fiber layer becomes opaque and obscures the vessels to some extent. This opacification is owing to cloudy swelling of the ganglion cells and axons, and is not interstitial edema. In those individuals who have cilioretinal arteries that supply the retina surrounding the optic disc, there may be patches of pink, healthy-appearing retina. The arterial vessels are narrowed, and the blood forms blocklike segments that resemble boxcars or cattle trucks. Finally, the macula takes on a bright red appearance, as contrasted with the surrounding pale ischemic retina. The "cherry-red" macula is owing to the preservation of the normal choroidal blood supply and the contrast of the healthy oxygenated tissue with the infarcted pallid tissue. A cherry-red macula of different cause can be seen with other genetic conditions (see Chapter 10, What Is That in the Macula?, and Chapter 11, Practical Viewing in Children).

Figure 5-5. (opposite page) A. **An embolus usually occludes the central retinal artery, often at the lamina cribrosa.** B. **When the central retinal artery is occluded, the entire retina is pale. The intact choroidal circulation (perfused by branches off of the short posterior ciliary arteries) beneath the macula maintains the normal macular color. Most of the time, embolic material is not seen in the central retinal artery because it is just behind where you are viewing on the disc.** C. **In CRAO, the macula is red (hence, "cherry-red spot") because the choroidal circulation beneath the macula is intact. The surrounding retina is pale because of swelling of the infarcted retinal ganglion cells and axons.** D. **Close-up of the cherry-red macula.** E. **Another CRAO with a cherry-red macula. (Photograph courtesy of Paula Morris, CRA.)**



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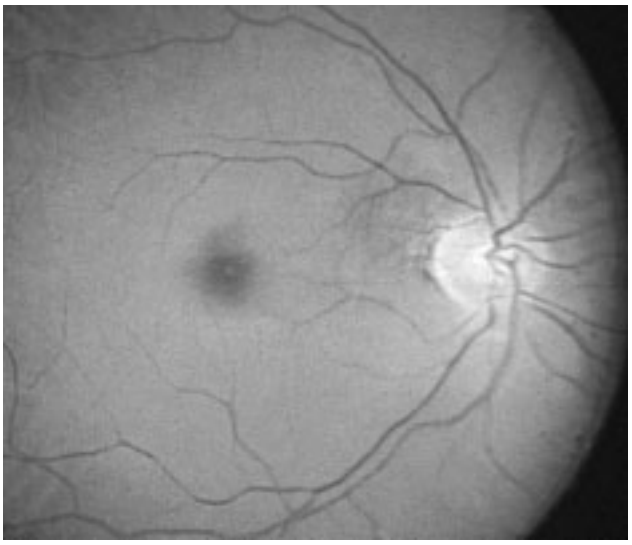

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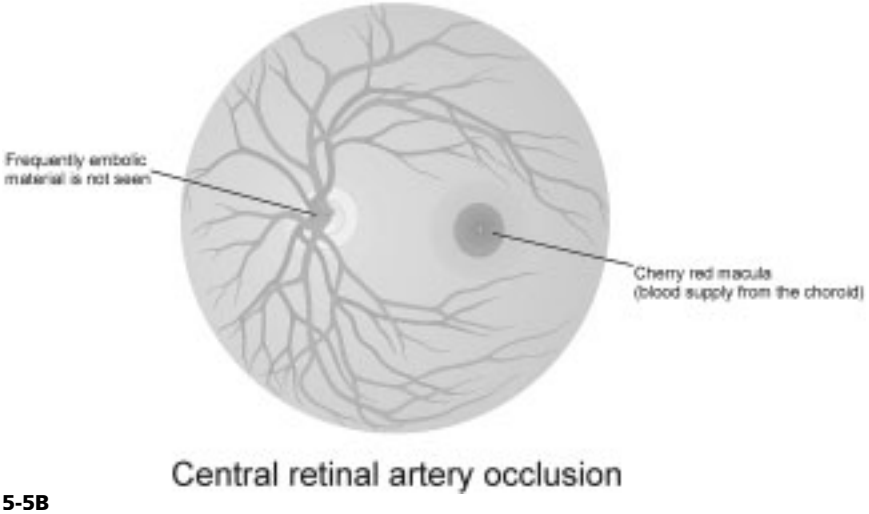

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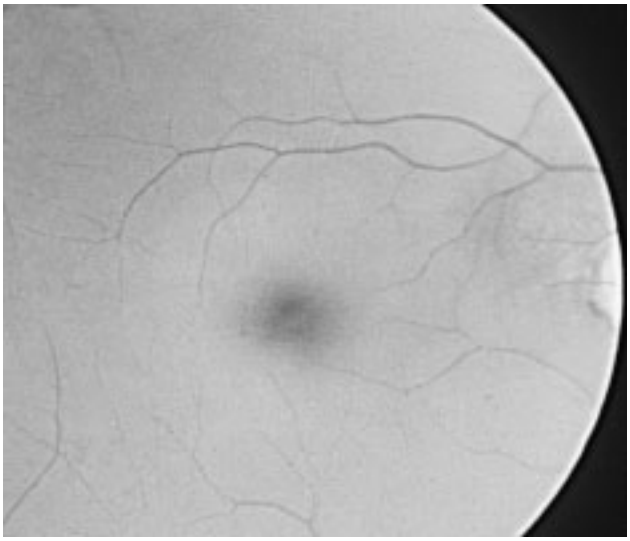

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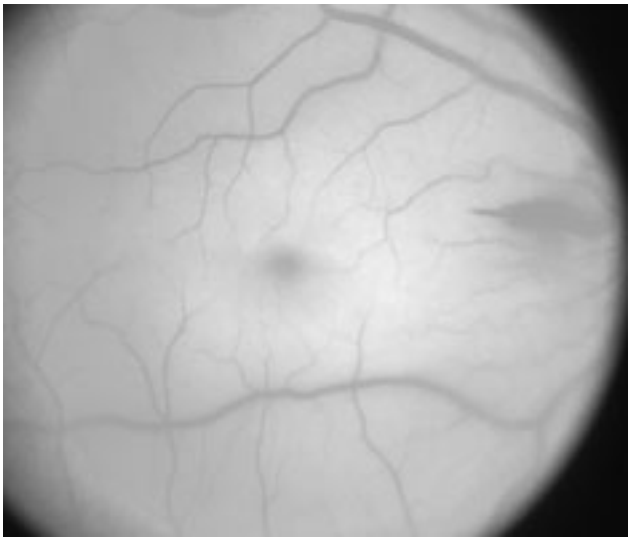

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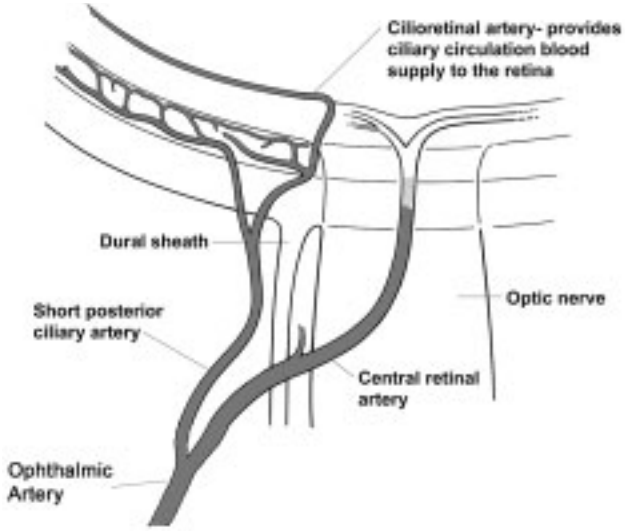

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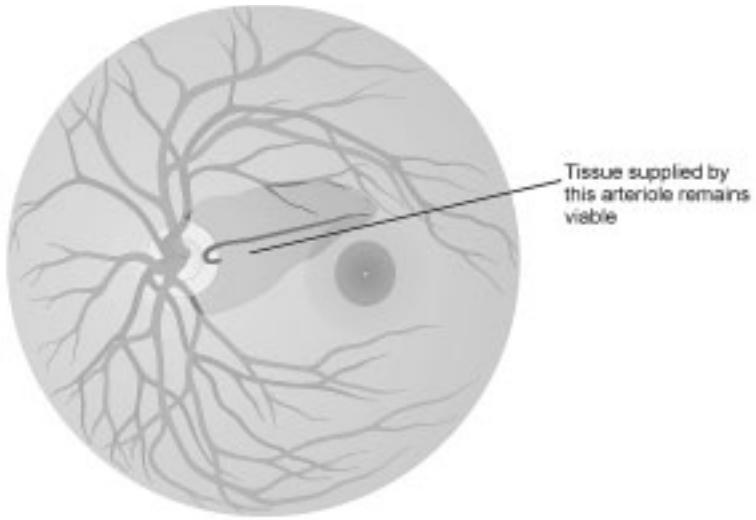

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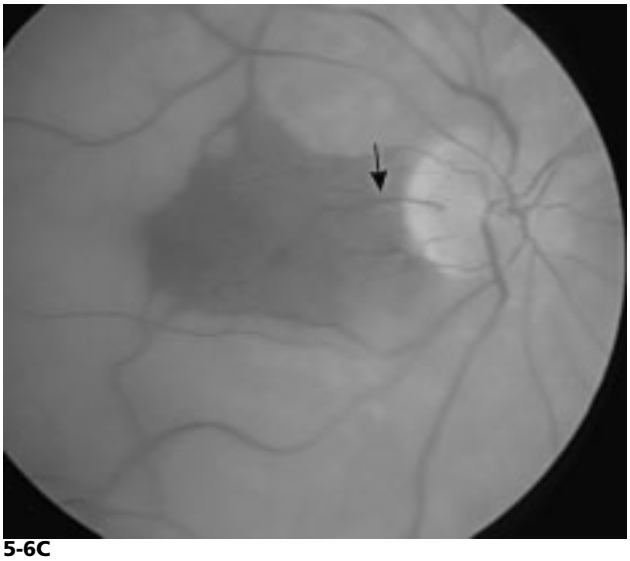
Figure 5-6. A. **During a CRAO, the presence of a cilioretinal artery allows for preservation of some retinal tissue.** B. **The retina is pale in a CRAO, but when a cilioretinal artery is present, there is a tongue of normally perfused tissue along the cilioretinal artery.** ***Continued***

Figure 5-6. ***Continued.*** C. **If there is a cilioretinal artery, the entire retina is pale, except for those retinal elements supplied by the cilioretinal artery, which remain normal in color. In these cases, visual acuity may be maintained despite a striking loss of visual field. This is the optic fundus of an artist who was able to continue working with central vision preserved by the cilioretinal artery (*arrow*).** D. **Another CRAO with cilioretinal artery sparing.** E. **The visual field from the patient in** (D) **would have been completely obliterated by a CRAO. However, because the cilioretinal artery was there and was not occluded, a small central visual field remained, leaving the patient with excellent central vision.**



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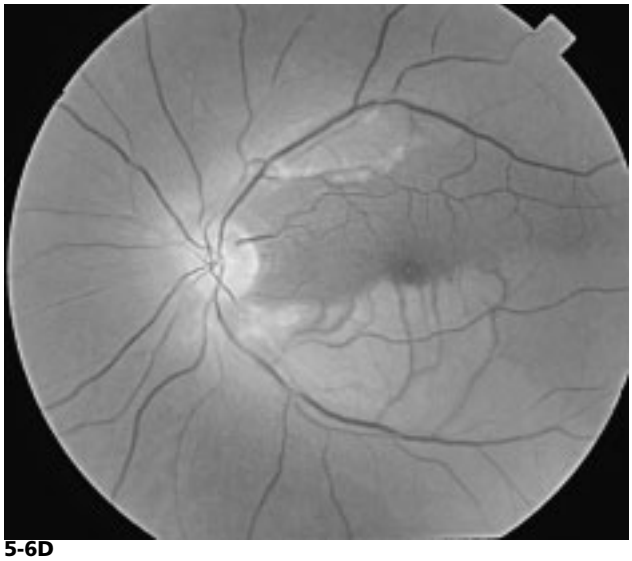

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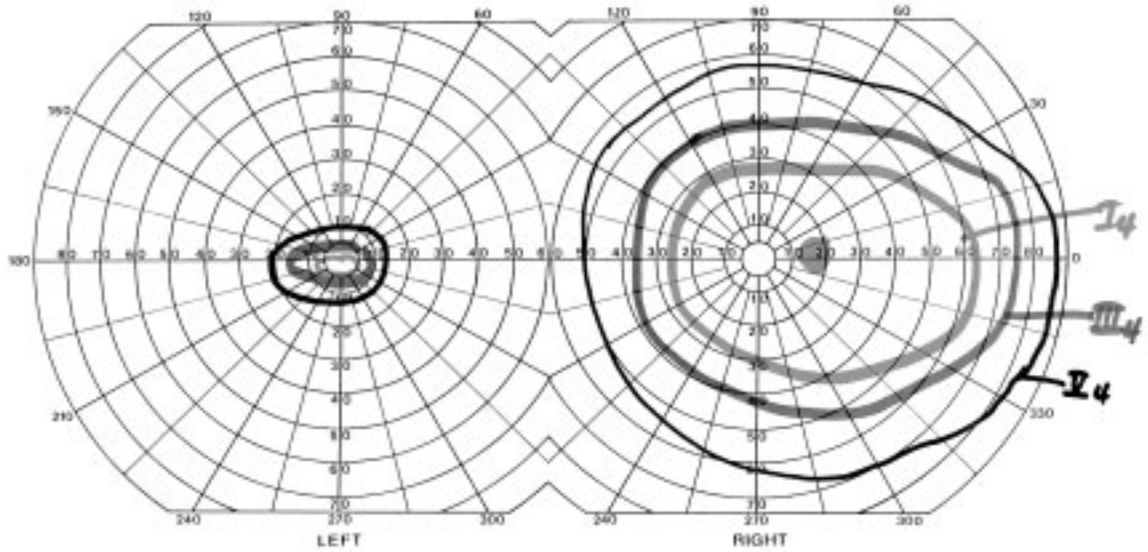


5-6E

The retinal tolerance time for total ischemia of monkey retina is 96–120 minutes after complete occlusion of the central retinal artery, followed by reperfusion.[2] If a patient has a full-blown picture of CRAO by the time you first see the eye, it is highly unlikely that any intervention will succeed in returning vision.

Table 5-3. Treatment of Acute Central Retinal Artery Occlusion

Carbogen 15% CO_2 and 100% oxygen
IV Acetazolamide 1 g followed by:
Anterior chamber paracentesis
Possible tissue plasminogen–activating factor (t-PA)
Hyperbaric oxygen (experimental)

Rarely, the treatment sequence shown in Table 5-3 restores vision. The duration of vision loss is critical, of course.

Days after the occlusion, pallor of the disc ensues with arterial narrowing and variable vascular sheathing. Hemorrhages are uncommon. Aside from optic disc pallor, what might you expect to see months after a CRAO? Optic disc pallor and atrophy are invariably present, along with arteriolar narrowing. Experimental CRAO does not cause peripapillary atrophy or reduction in the size (width) of the neuroretinal rim; this fact may help to determine the cause of undiagnosed optic atrophy, because glaucomatous changes in the disc are associated with peripapillary atrophy and reduction of the neuroretinal rim.[8]

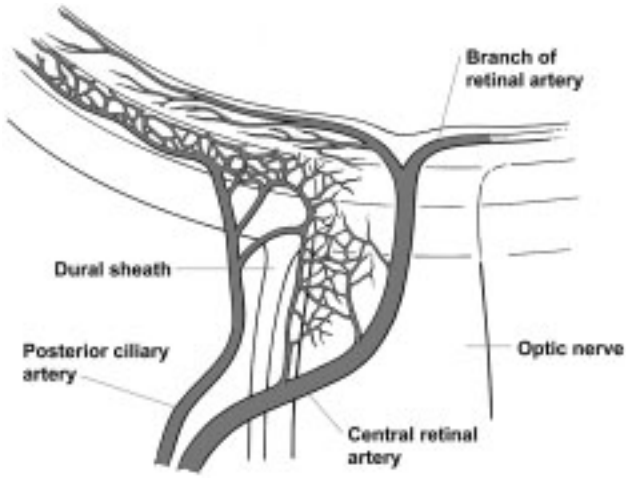
CRAO always should be considered embolic until proven otherwise. Clues to the source of an embolus are discussed with branch retinal artery occlusion (BRAO), in which, with rare exception, embolic occlusion is the cause. Other causes of

CRAO to consider are atheromatous occlusion of the central retinal artery, inflammatory vascular occlusion such as temporal arteritis or polyarteritis nodosa, central retinal artery vasospasm, and poor flow to the eye as the result of high intraocular pressure or decreased perfusion pressure by extracranial disease or hypotension.

Emboli caught at the level of the optic disc or those that migrate more peripherally may have characteristics that allow one to identify a probable source. Many more emboli occur and pass through the vessels without "sticking" than are ever appreciated. Ultrasonography can give one appreciation of an upstream "chirping" of continuing spontaneous embolic events from downstream atherosclerotic plaques. This embolic noise may be worsened with carotid palpation or massage, rough carotid auscultation, and during arteriography or even shaving the neck with an electric razor.

BRANCH RETINAL ARTERY OCCLUSION

When a branch of the central retinal artery is occluded, the arcuate nature of the distribution of the nerve fiber layer is clearly demonstrated, as is the horizontal separation of the superior and inferior arterial blood supply to the retina. Instead of a cherry-red macula, there can be a hemi–cherry-red macula. It is likely you will see the cause of the vascular occlusion at the point of obstruction or broken up in multiple smaller downstream vessels. Many emboli migrate through the capillaries and leave only small hemorrhages, a nerve fiber infarct, or nothing in their wake. As opposed to CRAO, which may not always represent embolic occlusion, BRAO is virtually always the result of embolic events until an exhaustive source for embolic sources has proven negative. Intravascular coagulopathy (anticardiolipin antibodies) may rarely produce branch artery obstruction. Rarely, BRAO is associated with a viral infection.[9]



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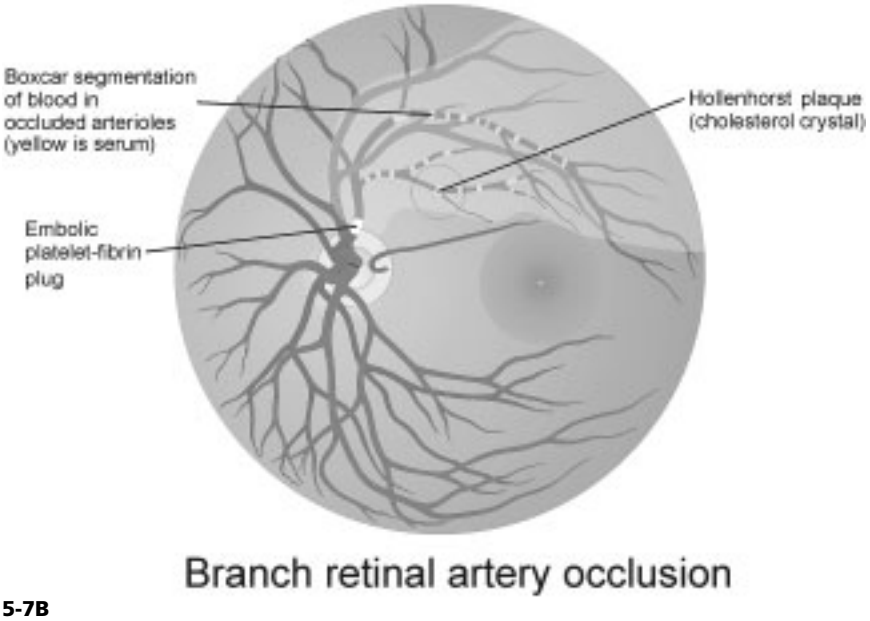
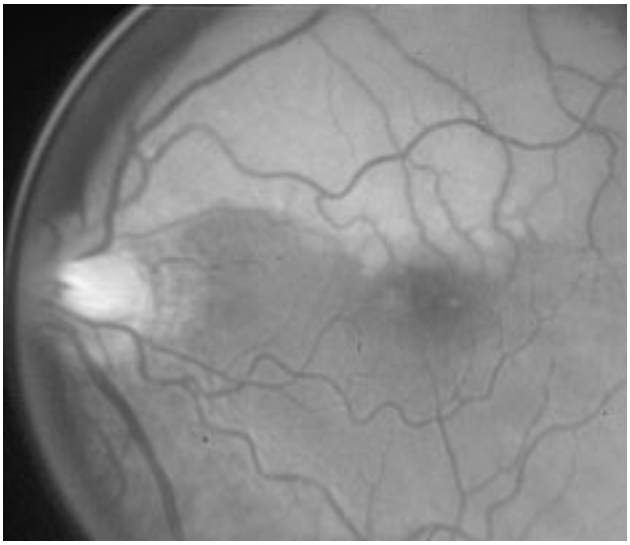


5-7B

Figure 5-7. A. **A BRAO is literally an occlusion of one of the branches from the central retinal artery.** B. **The retina is pale where the branch retinal artery is occluded, giving a demarcation line between the healthy retina and the infarcted pale retina.*Continued***

Figure 5-7. *Continued*. C. **Here is a superior temporal BRAO causing pallor of the retina and a "hemi-macular cherry-red spot."** D. **The patient had an inferior nasal visual field defect corresponding with the superior temporal occlusion.** E. **This patient had an inferior temporal BRAO owing to an embolism.** F. **The corresponding fluorescein angiogram shows a cut-off of the retinal artery and disc staining, indicating ischemia to the disc as well.**



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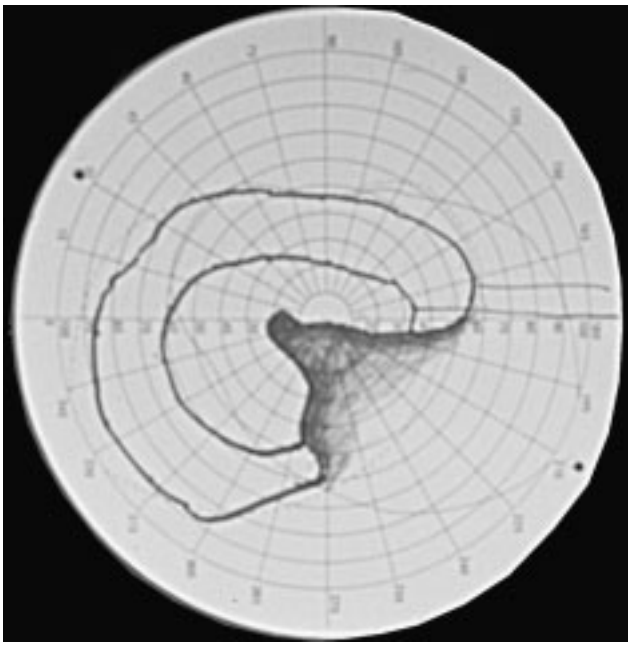

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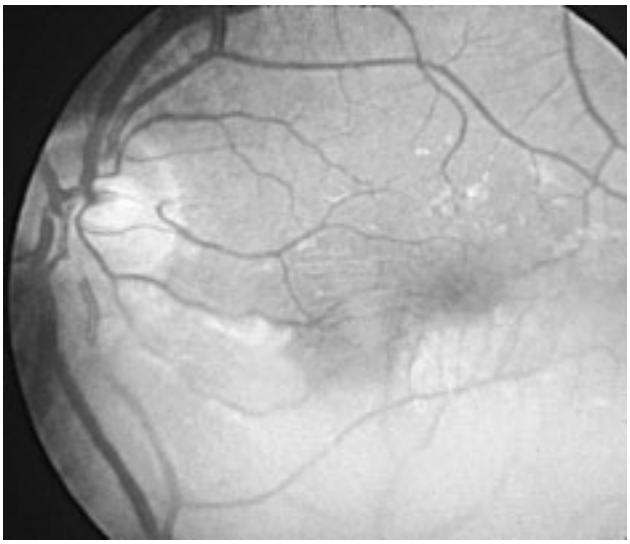

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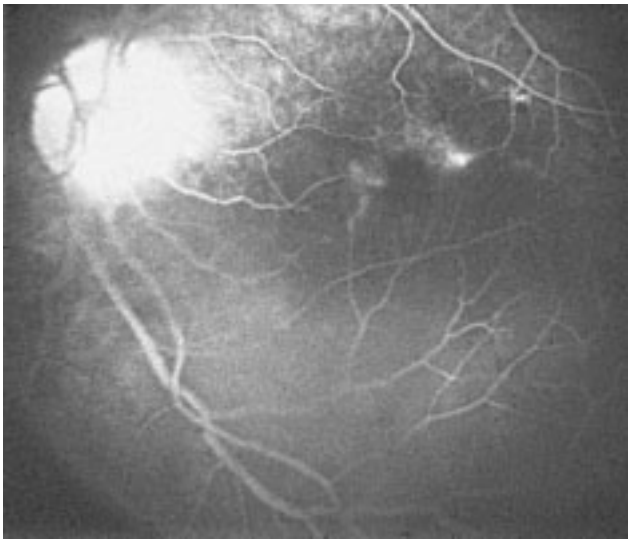

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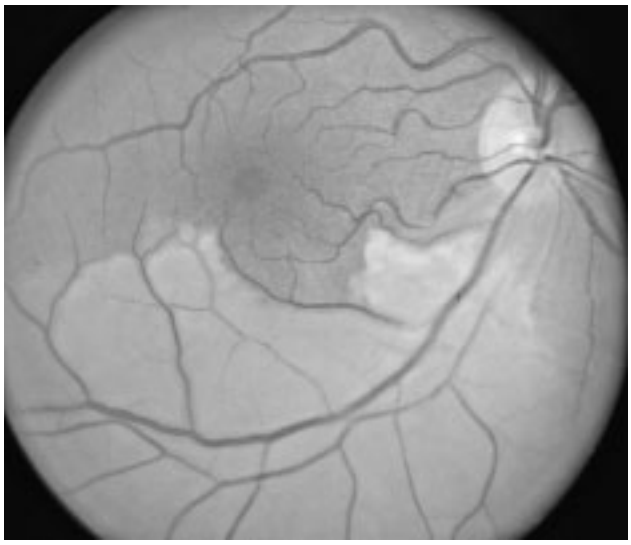

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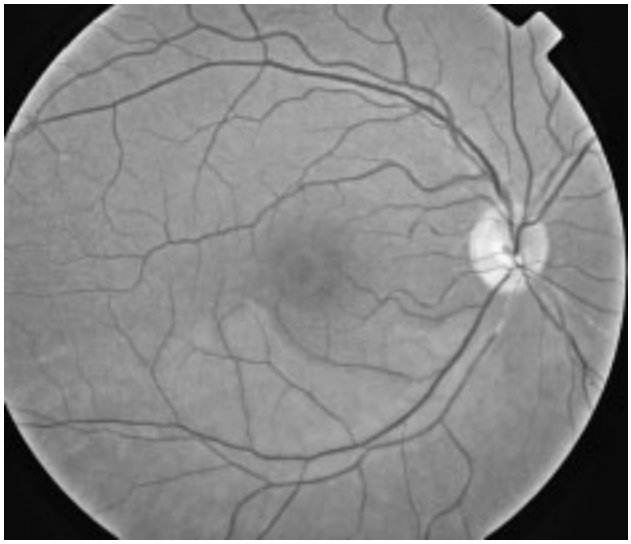

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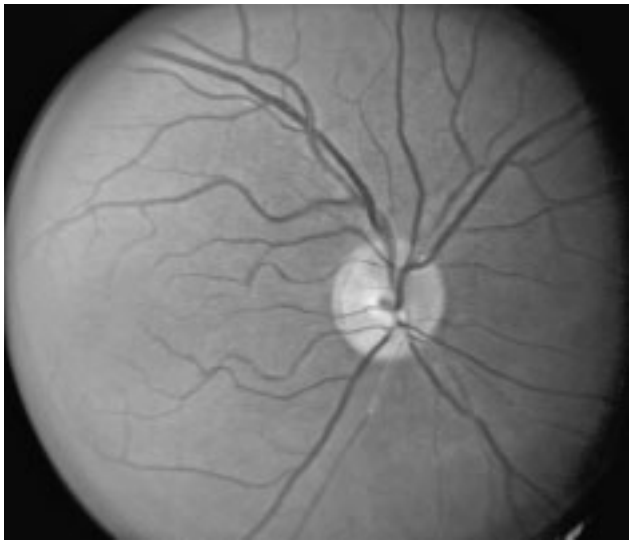
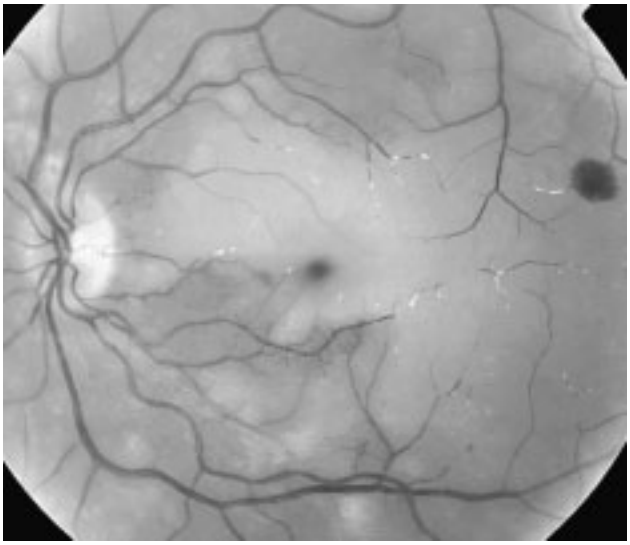


5-8C

Figure 5-8. A. **This woman had a BRAO caused by vasculitis. The retina is pale, but the disc appears almost normal.** B. **One month later, the pallor of the retina is resolving, and the disc is starting to pale slightly.** C. **Three months later, one cannot detect any retinal pallor; however, the disc is pale inferiorly and somewhat cupped.**

Figure 5-9. A woman with sarcoid in her lacrimal gland underwent steroid injections into her lacrimal gland. She suffered acute visual blurring when the steroid entered her central retinal artery through an arterial anastomosis in the orbit, between the external carotid circulation and the central retinal artery. A. **The retina is pale from multiple small BRAOs; there is a blot hemorrhage off of the right.** B. **The red-free photograph accentuates the pallor with multiple small occlusions.** C,D. **An early fluorescein angiogram shows cut-offs of multiple retinal arterioles.** E. **Late in the angiogram (10 minutes elapsed), some of the vessels have stained but there is still poor filling of other vessels.**



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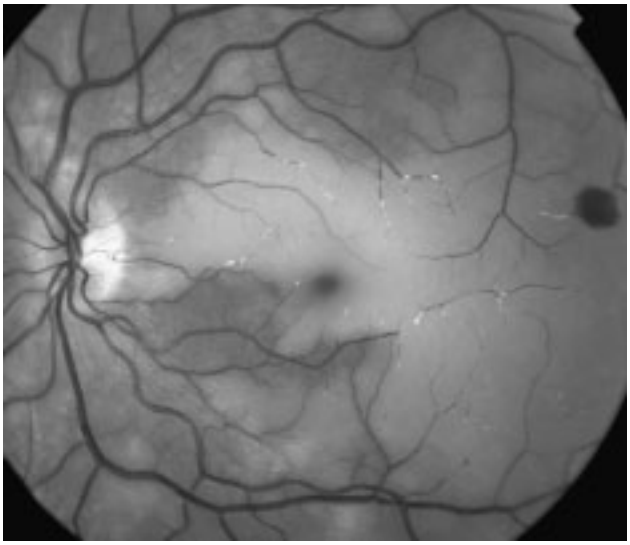

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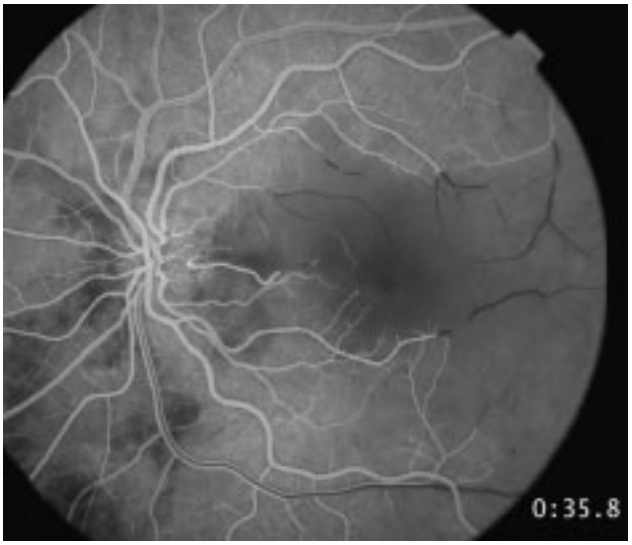

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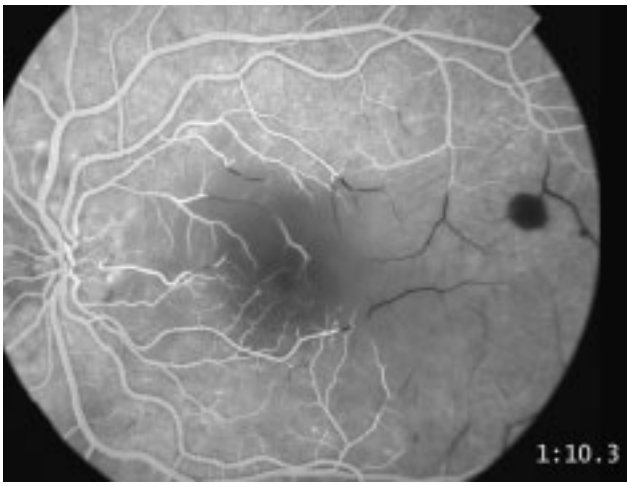

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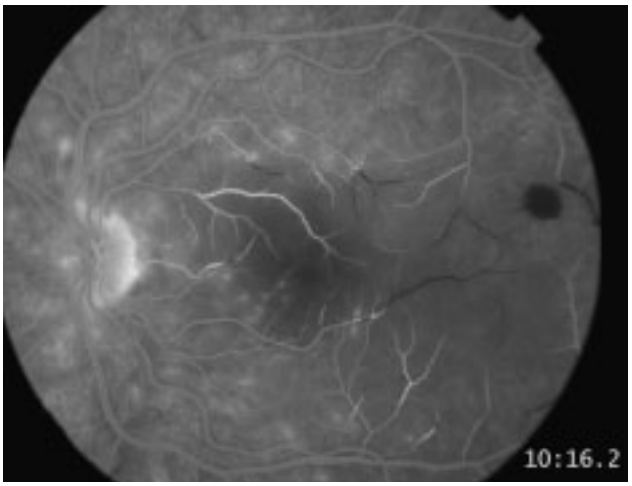

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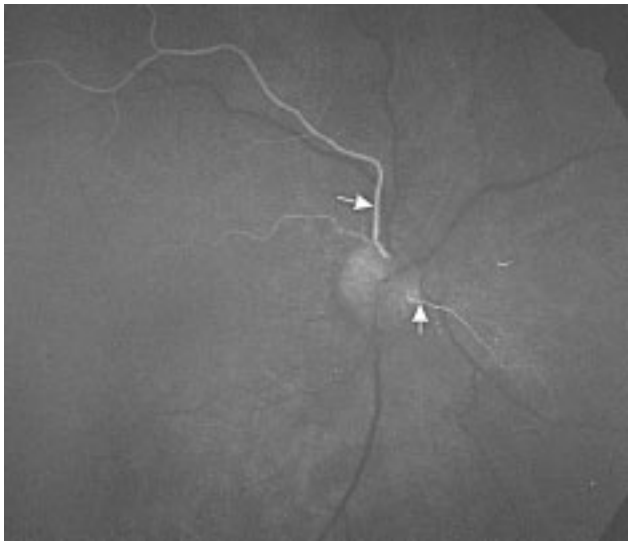

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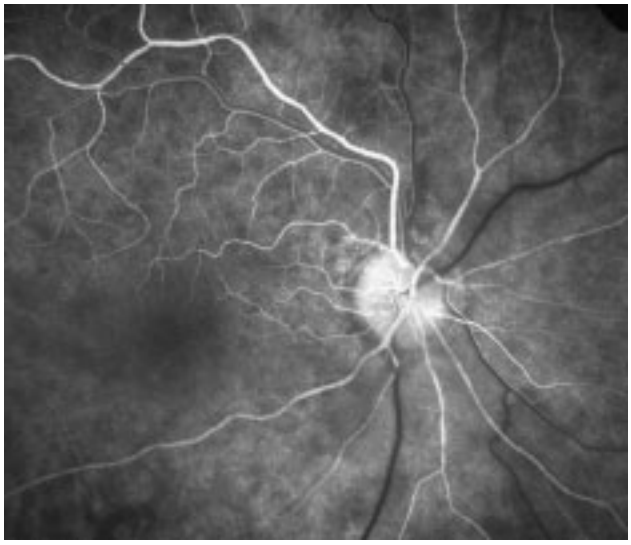

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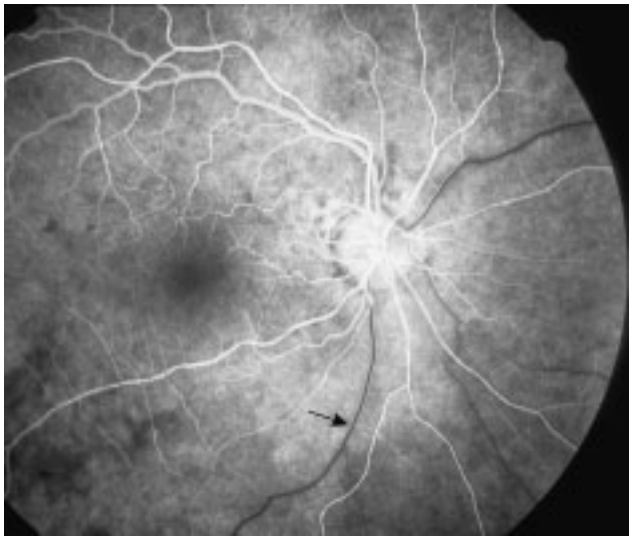


5-10C

Figure 5-10. A. **In this inferior branch retinal artery occlusion, you see the superior branch retinal artery and the cilioretinal artery filling first (*arrows*) on this fluorescein angiogram.** B. **The rest of the retinal arteries fill afterward.** C. **The flow is slow in the inferior branch circulation related to the arterial occlusion; note that the veins are still in the phase of "laminar flow" (the stripe down each side of the vein) (*arrow*).**

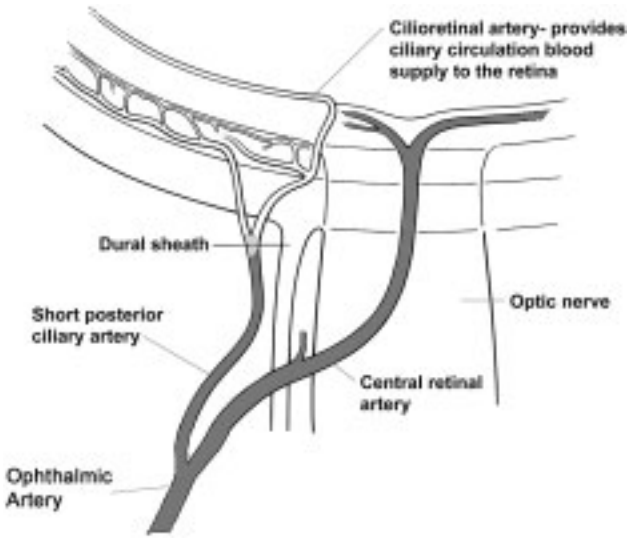
Venous stasis retinopathy can occur as a complication of an embolic BRAO.[10]

CILIORETINAL ARTERY OCCLUSION

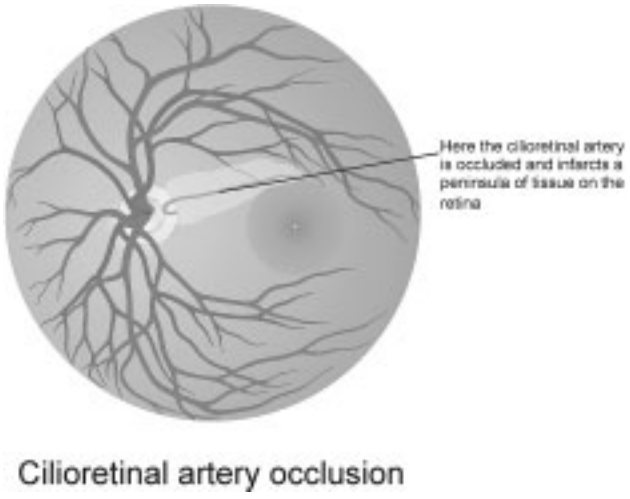
On occasion, the cilioretinal artery alone is occluded. The posterior ciliary vessels that penetrate the lamina cribrosa to supply the retina (cilioretinal artery) become affected in giant cell

arteritis, resulting in a characteristic tonguelike retinal infarct that proceeds from the edge of the disc out onto the retina and meanders usually along the papillomacular bundle. Although in older individuals the most important cause to look for is giant cell arteritis, other causes can be present as well, including embolic occlusion or trauma to the posterior ciliary arteries. The visual field defect is commonly a paracentral scotoma when the occlusion is temporal off of the disc toward the macular area.

Figure 5-11. A. **Although embolic occlusion is possible, occlusion of the cilioretinal artery in an individual older than 65 years of age is evidence of giant cell arteritis until proven otherwise. The central retinal artery, once it has pierced the sclera, loses its elastic lamina, whereas the ciliary artery has an internal elastica, which is a major point of inflammation in giant cell arteritis.** B. **A drawing of an occlusion of the cilioretinal artery shows a pale peninsula of infarction jutting in toward the macula.** C. **This woman had papilledema with progressive visual field loss. She underwent an optic nerve sheath decompression, but suffered a cilioretinal artery occlusion during the surgical procedure. You can see the pale retina just temporal to the swollen disc (*arrows*).** ***Continued***



5-11A



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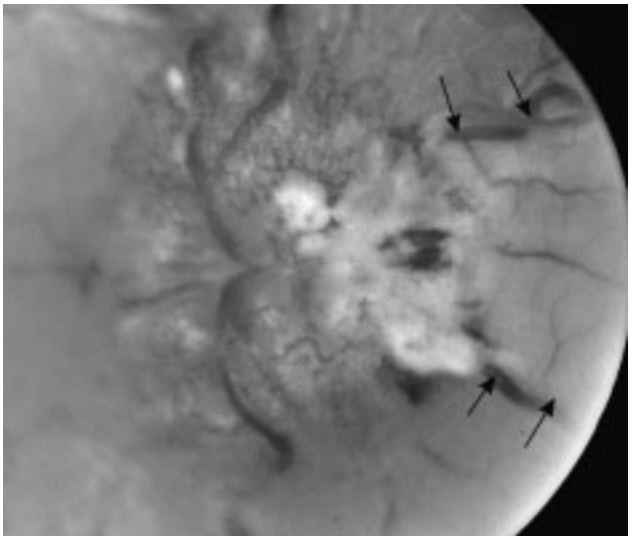
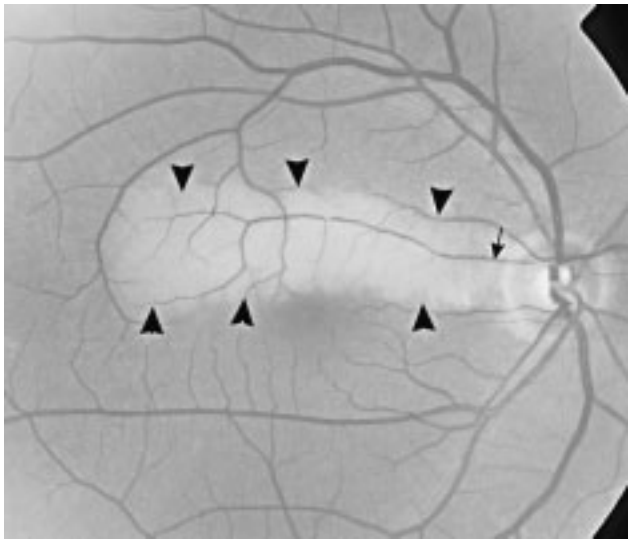


5-11C

Figure 5-11. ***Continued.*** D. **This man presented with acute central vision loss and an isolated cilioretinal artery occlusion. An extensive evaluation for temporal arteritis and an embolic source was unrevealing. The arrowheads outline the infarcted tissue; the arrow points to the cilioretinal artery.** E. **This man had biopsy-proven giant cell arteritis and presented with an isolated cilioretinal artery occlusion. Notice that there are also cotton-wool spots on the disc and that the disc is slightly swollen. The arrows point to the cilioretinal artery occlusion.**



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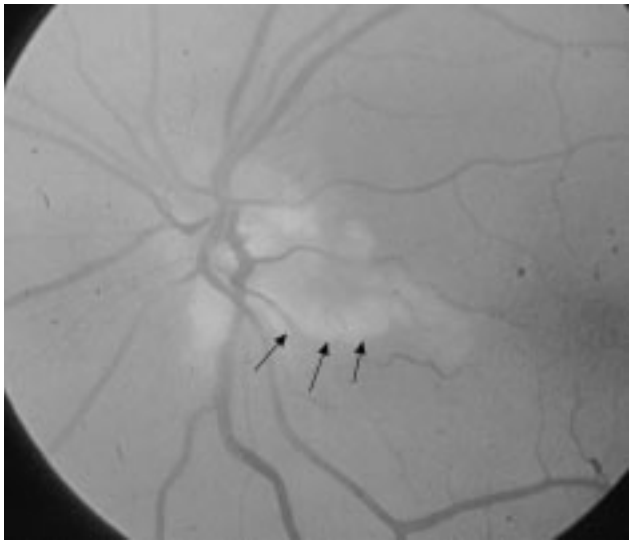


5-11E

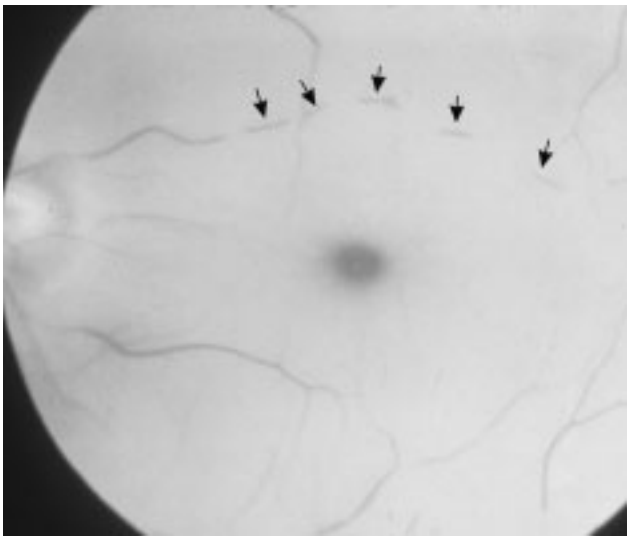
The result of occlusions of the branch retinal artery or cilioretinal artery is ischemia to the retina at retinal arteriolar bifurcations, in which emboli lodge for various periods of time, leading to nerve fiber layer infarcts of varied ages, dot and blot hemorrhages, and white-centered hemorrhages known as *Roth's spots* . Roth's spot hemorrhages probably occur most commonly today in the setting of artery-to-artery embolization and in shaken baby syndrome, but have acquired a mythical status as being characteristic of subacute bacterial endocarditis. Any time these hemorrhages are seen, one should give some thought to subacute bacterial endocarditis, but recall that they are seen in a mul-

titude of settings (see discussion of Roth's spots in Chapter 7).

OTHER SIGNS OF ARTERIAL OCCLUSION

Boxcar Appearance

A boxcar appearance of a segmented column of blood indicates slow flow or abnormal flow in a vessel. Segmentation of cells occurs most commonly in the veins, but can also be seen in the arteries. Other causes of a boxcar appearance include hyperviscosity syndromes and cardiac failure. In fact, at the time of cardiac arrest, one can ophthalmoscopically look for segmentation of the blood columns in the retina to evaluate the effectiveness of the resuscitation.[5]



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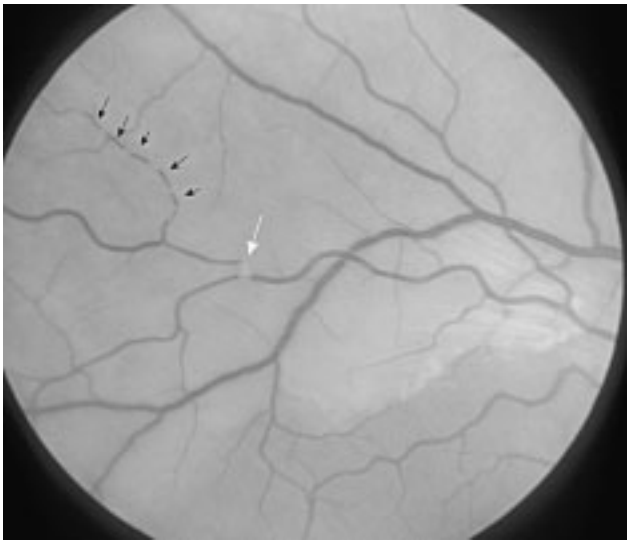
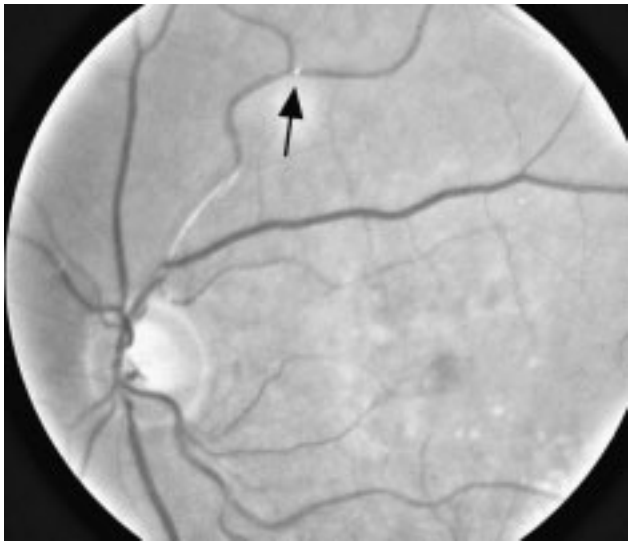


5-12B

Figure 5-12. A. **Here is a cherry-red macula from a CRAO—notice also the boxcar formations within the retinal arteries (*arrows*).** B. **This woman had a BRAO. You can appreciate the embolus in a branching retinal artery (*white arrow*). Boxcar formation is visible here, also (*black arrows*).**

Cholesterol Emboli

Cholesterol emboli, crystals known as *Hollenhorst plaques*, are parts of the grumous material found on the surface and within the cavity of ulcerated atherosclerotic plaques. These crystals within an arteriole glisten and have a refractile quality as the light is played over them. Colors are bright yellow-white to coppery, depending on the amount of blood passing in front of them.



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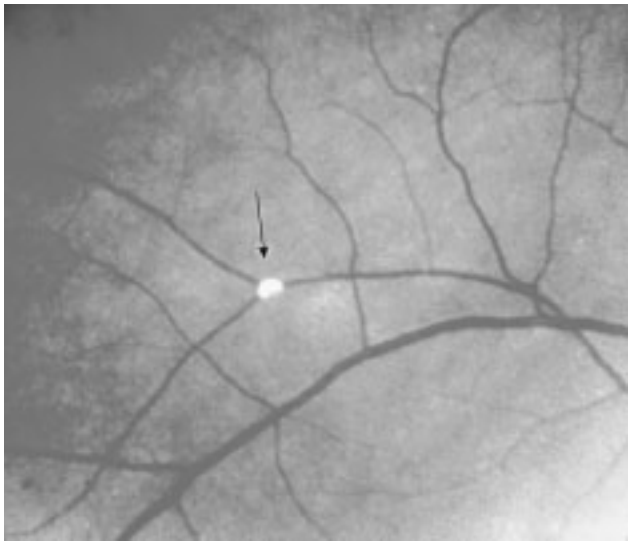

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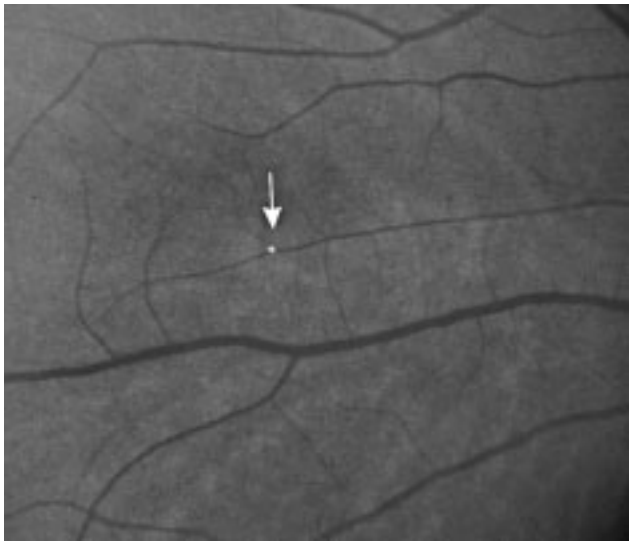


5-13C

Figure 5-13. A. **A Hollenhorst plaque is a yellow-orange plaque often seen at branch points of arteries. This patient had a BRAO due to a Hollenhorst plaque related to carotid vascular disease (*arrow*).** B. **This plaque is shiny. There was no associated BRAO, and it was found incidentally. Evaluation showed carotid vascular disease.** C. **This plaque (*arrow*) is hard to see—you would need to rotate the light back and forth to pick up a flicker of reflection.**

Dr. Robert W. Hollenhorst was an ophthalmologist who practiced at the Mayo Clinic. He had an abiding interest in vascular disease. In 1961, Hollenhorst stated the following:

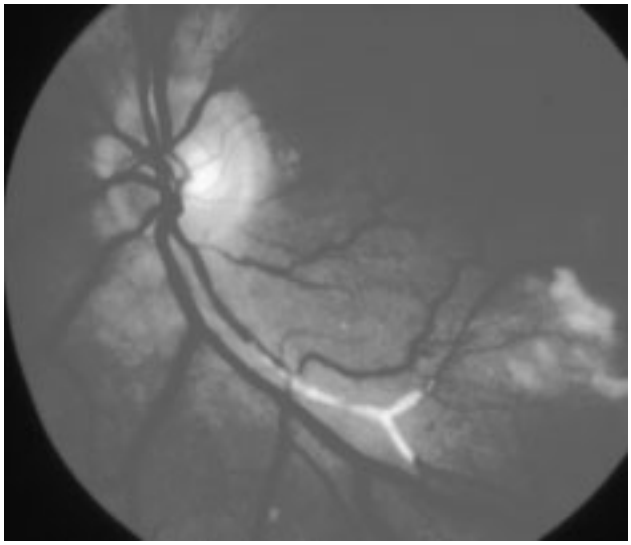
Among 235 patients who had occlusive disease within the carotid arterial system and 93 patients with clinical symptoms and signs of involvement of the vertebral-basilar system, 31 (9.4%) had from a single plaque to several dozen bright plaques that

were orange, yellow, or copper in color and situated at various bifurcations in some of the retinal arterioles . . . these plaques had a characteristically bright orange-color and reflected the light of the ophthalmoscope often in a heliographic position and tended to lodge simultaneously at several bifurcations of the same arteriole as though they were fragments of a larger plaque. [11]

Hollenhorst also offered the following advice for viewing the plaques with the ophthalmoscope[7]:

1. The plaque reflects the light brightly in one direction more than the other—so if the light is turned to different angles, the plaque will shine brighter (therefore, turn your ophthalmoscope in different directions as you are viewing the retinal arterioles in order to see some of the smallest plaques).
2. If you compress the globe and view the plaque within the vessel you will see a bright reflection flashing on and off with each pulsation.
3. Occlusion of an entire arteriole by a large plaque is infrequent (therefore, most of these do not occlude the artery).
4. If you see a plaque at one proximal bifurcation, look downstream because they tend to break off and lodge in smaller and more distal bifurcations.
5. The plaque may look larger than the vessel. Although the cholesterol plaque is wider than the blood column, it is not wider than the arteriole.

The importance of recognizing a Hollenhorst (cholesterol) plaque is that at least 90% of patients with visible embolic plaques have vascular disease, and 15% die within the first year of this finding and 55% are dead within 7 years. The cause of death is most frequently heart disease.[12]

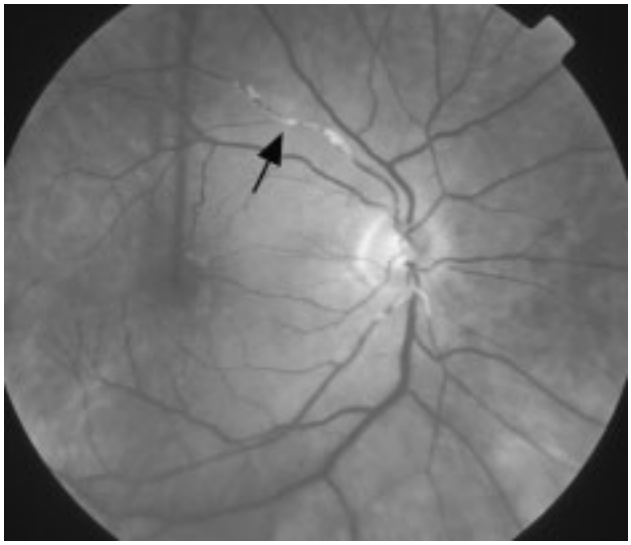


5-14A

Fibrin-Platelet Emboli

Fibrin-platelet emboli are common and simply reflect other collections of embolic material, long in clotting material and short in refractile cholesterol crystals.

Figure 5-14. These patients all had platelet fibrin emboli causing BRAO. Although the retinal pallor subsided, the emboli remain. A. **This clot outlines an entire arteriole to a branch. There are also cotton-wool spots distally.** B. **The occlusion is along an arteriole (*arrow*).** C. **This occlusion is just past a branch point (*arrow*).**



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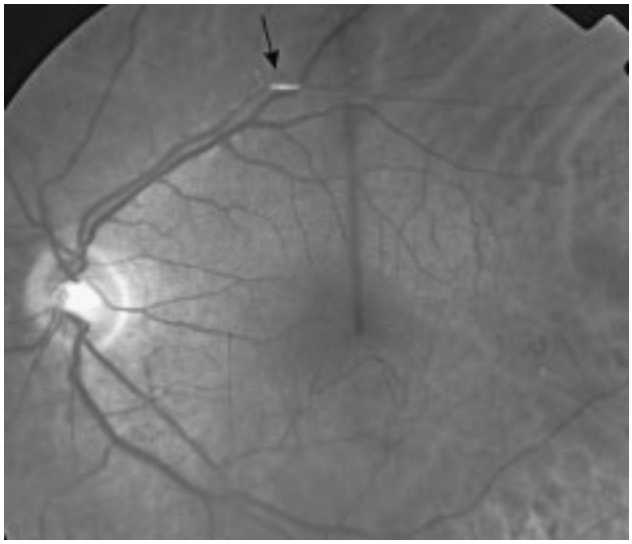
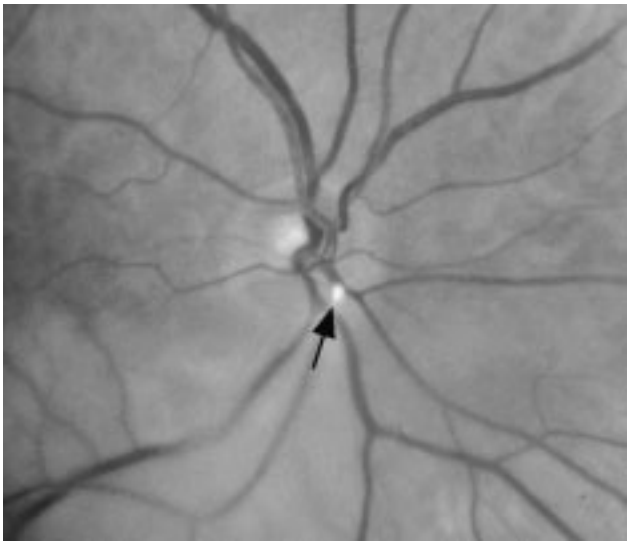


5-14C

Evaluation of patients with fibrin-platelet emboli should include a full evaluation of the heart valves (e.g., floppy mitral valve, rheumatic disease, systemic lupus), carotid artery disease (including carotid artery plaque), and hypercoagulable workup. Look for a patent foramen ovale.

Calcific Emboli

Calcific emboli are fragments from a damaged valve. These are uncommon, or at least are recognized uncommonly. In contrast to the yellow- or copper-colored refractile emboli of Hollenhorst, these particles tend to be irregular and flat white. Calcific plaques tend to occlude the blood vessel right on the disc. The occlusion usually presents as arterial occlusion and less commonly as transient monocular vision loss.



5-15

Figure 5-15. Look at the inferior branch of the central retinal artery on the disc and you will see a calcific embolus (*arrow*). (Photograph courtesy of Shelly Cross, M.D.)

Talc Emboli

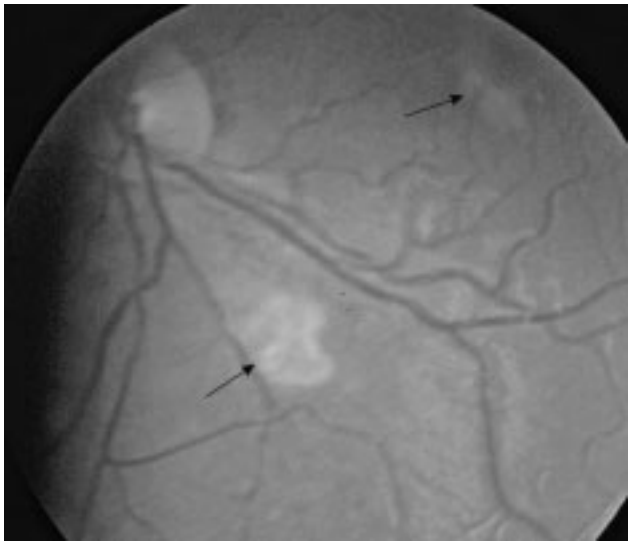
Talc emboli in drug addicts are not common, despite the common use of talc to cut heroin. The distribution suggests that talc emboli are the result of passage of talc through a patent foramen ovale to both retinas after intravenous injection. Cough or other Valsalva maneuvers cause increased right heart pressure and a right-to-left shunt.

Tumor Emboli

Tumor emboli come from the surface of an atrial myxoma. Although rare, the diagnosis of atrial myxoma is urgent because of the extreme friability of the tumor and inexorable embolization until it is removed.

Fat Emboli

Fat emboli in the retina occur basically in two clinical settings. The first, but by no means a common occurrence, is with flat bone and long bone fractures. Even when fat emboli were looked for by indirect ophthalmoscopy in a group of orthopedic vehicular accident patients, only 4% of the group had evidence of retinal fat embolism.[13] Chest, neck,



5-16

throat, and conjunctival petechiae are also seen. Fat emboli also occur with pancreatitis, in which large quantities of serum lipids occur with lipase in the blood stream. Patients with fat emboli to the brain frequently have an episode of what looks like a confusional state owing to a metabolic encephalopathy; showers of fat emboli to the brain may produce multiple focal neurologic signs and even reversible decorticate posturing or asterixis (see Chapter 14).

Figure 5-16. Fat emboli are rare. Here you see the occlusion of a vessel along with a large, ameboid cotton-wool spot (*arrow*). This fat embolus was seen in a 29-year-old man with hemorrhagic pancreatitis who presented with an acute confusional state. His confusion cleared, but he was left with petechiae on his chest and fat emboli in the retina without vision loss.

Table 5-4. Assessing Embolic Type

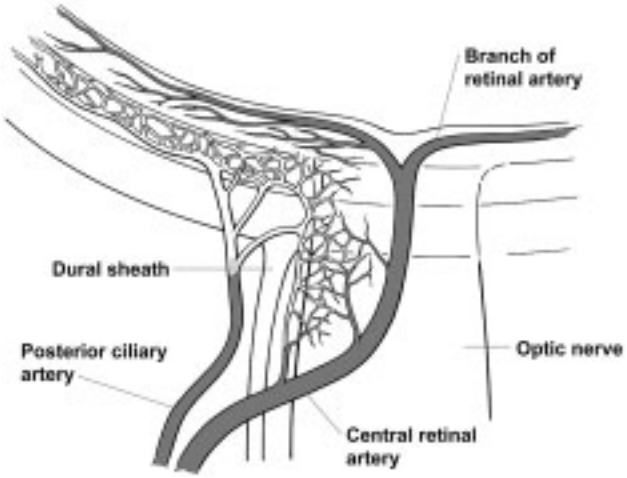
	Type of Embolus					
	Cholesterol	**Calcific**	**Platelet/fibrin**	**Fat**	**Myxoma***	**Talc**
History	TMB	TMB and/or vision loss	TMB and/or vision loss	Confusion, usually incidental	TMB + neurological events; subacute bacterial endocarditis without rheumatic history	No symptoms
Risk factors	Hypertension, smoking; older age	Rheumatic heart disease	Heart disease or carotid disease; systemic lupus erythematosus; fibromuscular dysplasia	Pancreatitis, surgery on long bones	—	Intravenous drug abuse
Appearance	Shiny, bright yellow; bifurcations	Dull white; usually larger vessel—on disc	Long, smooth segments with ends	Multiple infarcts	White material in the central retinal artery	Fine speckles of white in vessels
Source	Carotid artery	Heart—aortic or mitral valve	Valve or carotid artery	Long bone fracture, pancreatitis	Myxoma of left atrium	Drug use and patent foramen ovale
Evaluation	Auscultate carotid, carotid duplex, angiogram	Auscultate heart, echocardiogram, electrocardiogram	Carotid artery and heart evaluation	Serum amylase, urine for fat globules	Heart evaluation, echocardiogram	Echocardiogram
Treatment	Carotid endarterectomy or aspirin	Anticoagulation	Aspirin, carotid endarterectomy, anticoagulation	Self-limited	Anticoagulation, open-heart surgery	Avoid IV drug abuse

TMB = transient monocular blindness.
*Data in this column from DG Cogan, SH Wray. Vascular occlusions in the eye from cardiac myxomas. Am J Ophthalmol 1979;80:396–403.

POSTERIOR CILIARY ARTERY OCCLUSION

When the posterior ciliary artery is occluded two things may happen: If a branch of a person's posterior ciliary artery extends into a cilioretinal artery, you may see a typical cilioretinal artery occlusion. More frequently, when the posterior ciliary artery is occluded, an infarction of the disc ensues. Review the discussion of disc swelling associated with anterior ischemic optic neuropathy (see Chapter 3).

Figure 5-17. A. **Notice that when the posterior ciliary artery is occluded there is loss of blood flow to the optic disc, the choroid, or both. The ciliary artery has its elastic lamina (unlike the central retinal artery), and therefore is susceptible to giant cell arteritis.** B. **When the disc loses its blood supply, swelling takes place and a stroke to the optic nerve occurs called *anterior ischemic optic neuropathy*.**



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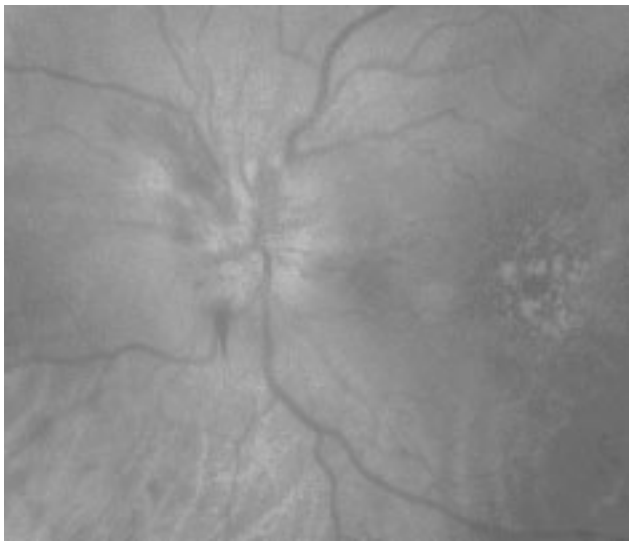
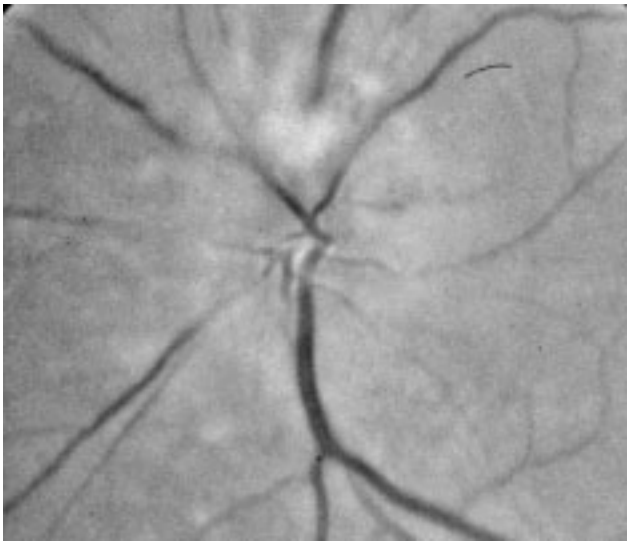


5-17B

Figure 5-18. Fluorescein angiography is sometimes helpful and shows changes of the small vessels on the disc and late staining. A. **The clinical appearance of NA-AION is a swollen disc.** B. **Typical fluorescein angiogram of NA-AION early on shows lack of filling of the posterior ciliary arteries (*arrowheads* outline the nonfilling choroid) and early disc staining.** C. **Later, the disc stains and leaks owing to the breakdown of the blood retinal barrier.**



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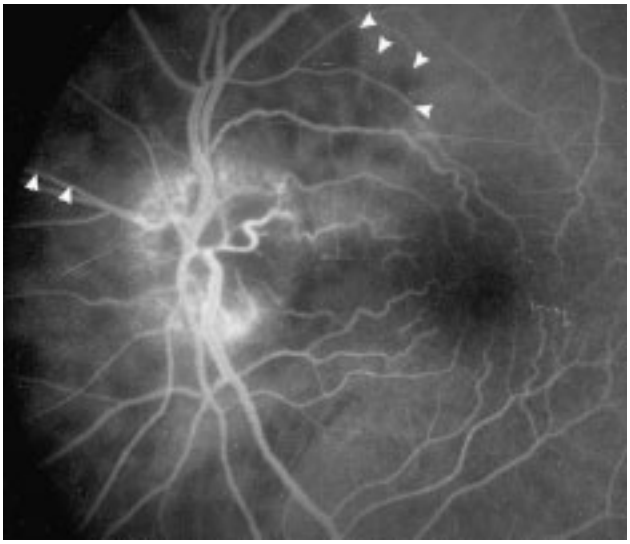

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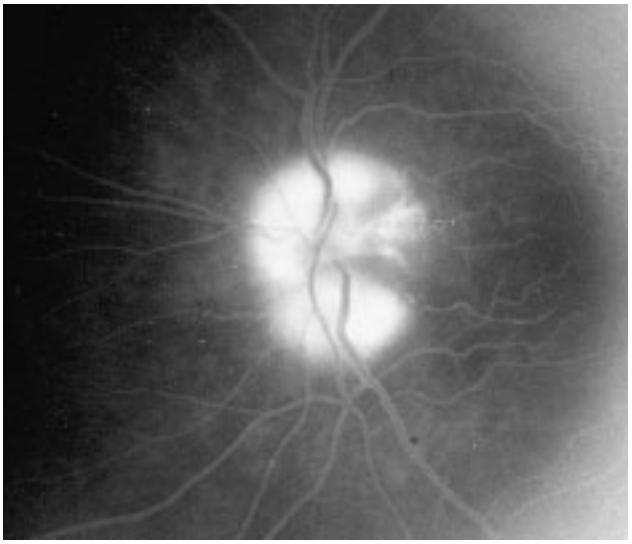


5-18C

Arnold and colleagues showed a significant delay in the onset of dye appearance as well as prolonged time to the filling of the prelaminar optic disc in patients with anterior ischemic optic neuropathy (AION).[14] They also found that other causes of disc swelling, such as optic neuritis, did not have this delay.[15] Hayreh showed that the disc lies in a "watershed" between the lateral and medial posterior ciliary arteries.[2] Lack of flow

between these two circulations can sometimes be demonstrated on fluorescein angiography.

Because nonarteritic (NA)-AION and arteritic AION sometimes cannot be differentiated one from the other, a Westergren erythrocyte sedimentation rate is essential. C-reactive protein and fibrinogen testing can also be helpful.[16] In general, the erythrocyte sedimentation rate and C-reactive protein are normal in NA-AION. If they are elevated, a temporal artery biopsy may be needed. Studies have looked at the value of a negative temporal artery biopsy in the face of elevated erythrocyte sedimentation rate and found an association with underlying malignancy, inflammation, and infection.[17–19] Glucose and blood urea nitrogen and creatinine are also of some help. In the young, look for homocystinemia, which has been associated with AION.[20]

Arteritic Anterior Ischemic Optic Neuropathy (Giant Cell Arteritis)

Arteritic AION (giant cell or temporal arteritis) is a disease seen, with only rare exceptions, in older individuals with a lower limit of 50 years of age. Usually, they are older than 65 years, and most are 70–90 years old. Arteritic AION is an important cause of transient monocular vision loss or acute blindness in the elderly. This type of ocular stroke can usually be prevented with steroids; therefore, it is extremely important to know about this cause of disc swelling and to recognize not only the disc appearance, but also the entire clinical syndrome. Here, ophthalmoscopy is key in identifying a medical emergency. Temporal arteritis causes many observable and testable abnormalities.

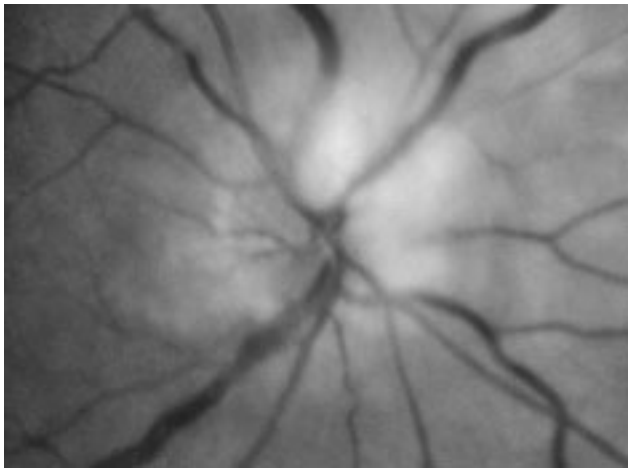
Table 5-5. Ophthalmologic Findings in Temporal Arteritis

On the disc
Acute anterior ischemic optic neuritis—acute disc swelling
Posterior ischemic optic neuropathy—no acute swelling, but pallor follows
In the retina
Ischemic retinopathy with cotton-wool spots
Central/branch retinal artery occlusion
Cilioretinal artery occlusion
Ischemic choroidopathy
Orbital ischemia
Orbital cellulitis and pseudotumor
Other eye findings
Corneal edema
Iritis
Hypotony
Pupil
Afferent and efferent defects
Tonic pupil
Cranial nerve ischemia, especially oculomotor nerve
Ocular muscle ischemia

Source: Adapted in part from reference 16.

Although appearance of the disc in arteritic AION is sometimes indistinguishable from NA-AION, there are a few clues in the disc appearance. First, if the disc has a very chalky white appearance, this should suggest arteritis. Second, if you see a concomitant occlusion of the cilioretinal artery, the diagnosis is temporal arteritis until proven otherwise. The combination of retinal cotton-wool spots and AION should lead you to perform a fluorescein angiogram. There is also a characteristic pattern to the fluorescein angiography, including occlusion of posterior ciliary arteries and choroidal nonperfusion.[21]

Figure 5-19. A–C. **Chalky white swollen disc suggests temporal arteritis in these three cases. The chalky white swelling is owing to the complete wipeout of blood flow to these discs due to arteritic occlusion of the posterior ciliary arteries from giant cell arteritis.**



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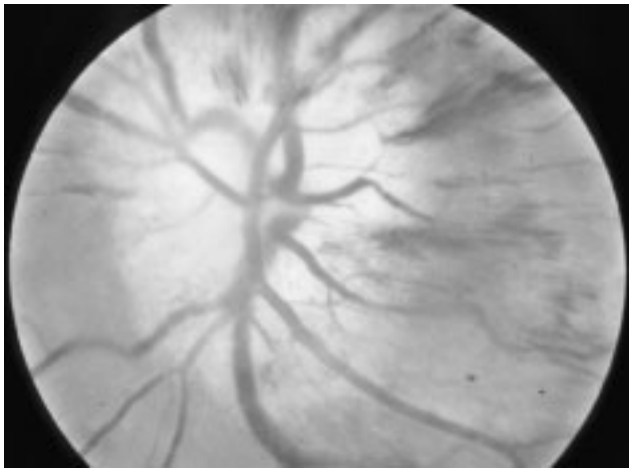

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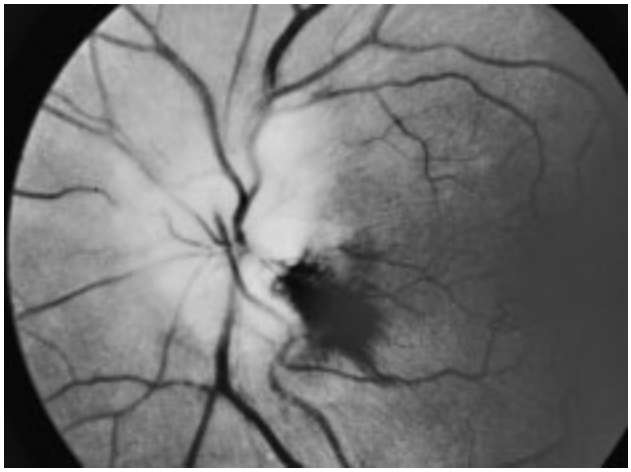
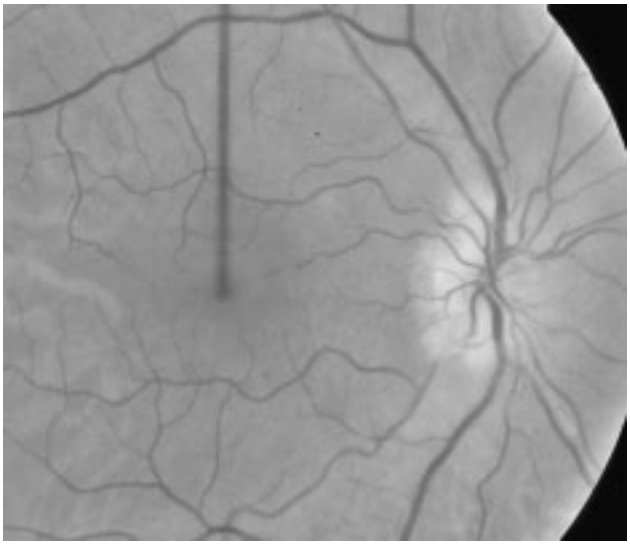
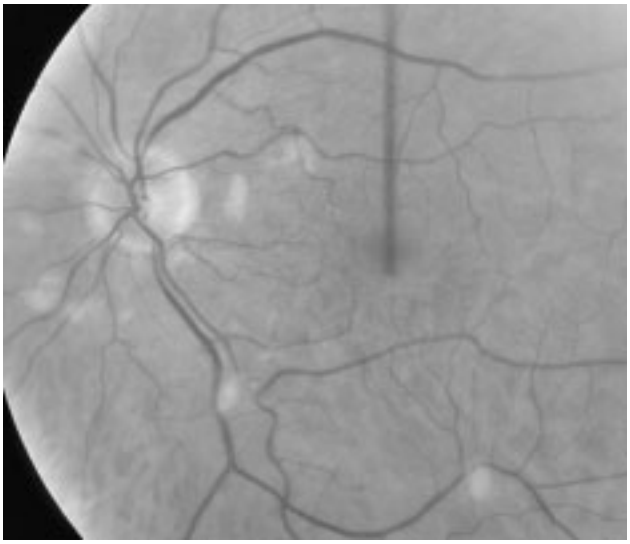


5-19C

Figure 5-20. This man presented with painless vision loss with acuity of 20/60 in the right eye. He had no other symptoms of polymyalgia rheumatica or temporal arteritis. A swollen disc (A, **right eye) consistent with early AION and cotton-wool spots owing to retinal microinfarcts (**B, **left eye) prompted a temporal artery biopsy, confirming the diagnosis of temporal arteritis. A cotton-wool spot occurring in isolation in the right age group should lead to an evaluation for temporal arteritis.** C. **Fluorescein angiogram shows a typical patchy pattern of posterior ciliary infarction causing poor flow in the choroidal circulation, typical of temporal arteritis, in the same patient. The arrows show areas between nonperfusion and perfusion.** D. **Fluorescein angiogram in temporal arteritis.**



5-20A



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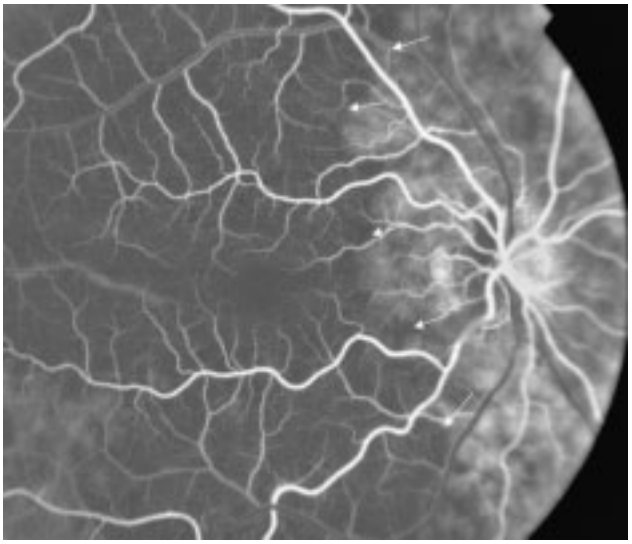

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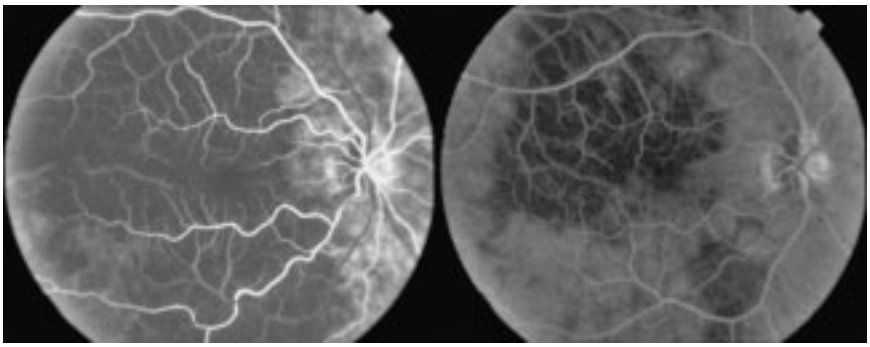
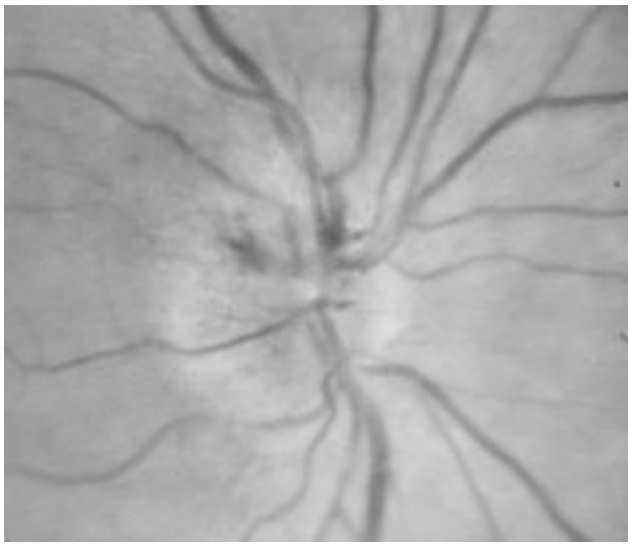


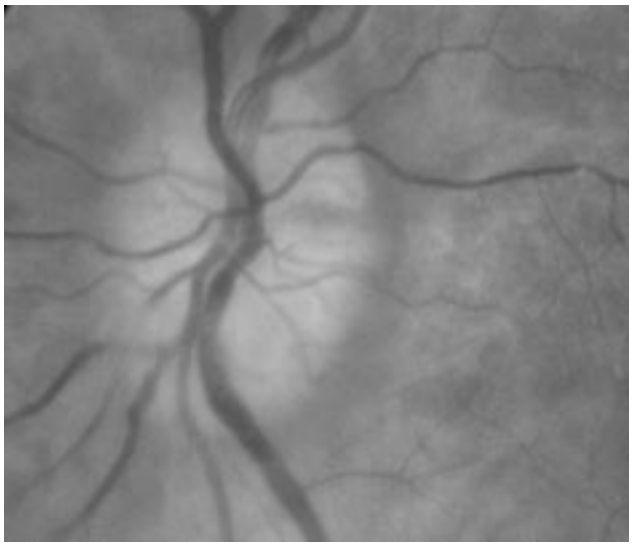
5-20D

Learn to differentiate the two types of AION—arteritic and nonarteritic. Although both can be related to posterior ciliary artery occlusion, the pathophysiology of the swelling is different, and so is the treatment. The failure to diagnose arteritic AION can lead to severe, permanent blindness, and the condition is thus a true ophthalmologic emergency. Examination of an eye with arteritic AION shows loss of visual acuity—in fact, in studies comparing NA-AION to arteritic AION, the arteritic form shows much greater immediate loss of visual acuity.

Figure 5-21.



5-21A



5-21B

Table 5-6. Differentiating Arteritic and NA-AION

Characteristic	NA-AION (see Figure 5-21A)	Arteritic AION (see Figure 5-21B)
Age	Usually older than 45 years	Usually older than 65 years
Sex	Men and women	Women >men
Risk factors	Diabetes, hypertension, smoking, small cup-to-disc ratio, hypotension, anemia	Polymyalgia rheumatica
Symptoms	Visual blurring, dimming	Same
Headache	Absent	Present—new and persistent

Characteristic	NA-AION (see Figure 5-21A)	Arteritic AION (see Figure 5-21B)
Jaw claudication	Absent	Present—the most common symptom
Scalp tenderness	Absent	Present
Temporal artery tenderness	Absent	Present
Weight loss	Absent	Present
Polymyalgia rheumatica—aching but no tenderness in the shoulders and hips, especially neck pain; fatigue, fever, night sweats	Absent	Present
Visual acuity	Variably decreased	Usually severely decreased
Visual field	Variably altitudinal, constriction	Usually severely affected
Disc	Swelling globally or sectorially—may be hyperemic and pale segmentally	Usually very pale swelling, chalk white disc
Fluorescein angiogram	Late disc staining	See patchy choroidal filling around disc
Evaluation	Erythrocyte sedimentation rate usually normal, normal fibrinogen and C-reactive protein	Elevated erythrocyte sedimentation rate in 90%, elevated C-reactive protein, must do temporal artery biopsy
Treatment	Aspirin	Corticosteroids—high dose
Outcome	Usually improves somewhat	Little improvement

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