The Neuro-Ophthalmology of Cerebrovascular Disease*

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The neuro-ophthalmology of cerebrovascular disease is a vast plain of neuro-ophthalmic vistas, encompassing virtually all areas of disturbances of the eye-brain mechanism. This paper will be restricted to those areas of the neuro-ophthalmology of cerebrovascular disease which one might consider advances in its clinical diagnosis and treatment.

Most practitioners of medical and surgical neurology give little thought to that aspect of medicine generally accepted as the ideal approach to any disease—prevention. Usually when one is presented with an illness of the central nervous system, it seems to be a *fait accompli.* Although prevention is by no means new, certain aspects of it qualify as advances. There is one advance in cerebrovascular disease in which prevention plays a significant role. This is the recognition and surgical correction of atherosclerotic lesions of the extracranial carotid system which threaten the patient with that bane of antiquity—the "stroke."

Neuro-ophthalmology, largely by virtue of the carotid origin of the ophthalmic artery, plays a valuable role in the recognition, evaluation, therapy, and prognosis of disease of the extracranial internal carotid artery. Even this markedly restricted aspect of the neuro-ophthalmology of cerebrovascular disease is far too extensive to review adequately in this paper. I have therefore selected for discussion certain aspects of our neuro-ophthalmic approach to extracranial carotid disease. Some of these are well known; others are less obvious and frequently overlooked in our evaluation of patients. They all, however, are important pieces to the puzzle the patient may present. A wide variety of afflictions of the eye occur by virtue of its arterial dependence on the internal carotid artery. It is also logical to assume that changes in the distribution of the ophthalmic artery may reflect changes taking place in other channels of the internal carotid artery—the middle cerebral, the anterior cerebral, and depending upon anatomic variations, the posterior cerebral artery. This paper will discuss these afflictions, those common as well as rare, those well recognized, and those frequently overlooked.

Historically, the recognition of the eye as an index of cerebrovascular disease presents an interrupted course. Virchow is credited with the first autopsy correlation of ipsilateral blindness with carotid thrombosis; Gowers in 1875 demonstrated embolization as a source of central retinal artery and middle cerebral artery occlusion, resulting in monocular blindness and contralateral hemiplegia; Chiari followed in 1905 with his identification of the carotid bifurcation as a common source of atheromatous emboli to the cerebral circulation; in 1914 Ramsey Hunt emphasized the significance of transient symptoms involving the ipsilateral eye and contralateral extremities as strong evidence of ischemia. Thus by the turn of the century, the stage was set for incrimination of the extracranial internal carotid artery as a major source of "strokes." Embolization was known as a basis for ipsilateral eye and contralateral extremity symptoms and signs; the carotid bifurcation was known as a source of emboli; and transient symptoms were recognized as reflections of ischemia—a stroke prodrome or warning was discovered. Yet it was for Fisher in 1951 to rekindle interest in extracranial carotid

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disease with his emphasis on transient ipsilateral visual and contralateral extremity symptoms as precursors of future strokes. It is this reawakening which has led directly to the current advances in the medical and surgical neurologic care of extracranial internal carotid disease.

Amaurosis fugax, "fleeting blindness," has become a household phrase of those involved in the diagnosis and care of patients with carotid disease. The clinical picture of amaurosis fugax is reasonably straightforward. It consists of transient monocular painless visual loss. Much has been made of the character, duration, mode of onset, and resolution of the visual loss. Perhaps too much emphasis has been placed on such characteristic patterns as the window shade or picket fence effect. As a result, we find that many patients we see have already been "well educated" by housestaff. The potential patterns of visual loss are many. They include 1) an upper altitudinal loss of vision, "the window shade"; 2) a lower altitudinal loss of vision, "the picket fence"; 3) a generalized peripheral loss of vision; 4) a total blackout of vision; and 5) a central blurring of vision. The onset is most frequently abrupt; the curtain seldom drops or rises slowly. Occasionally, the event is associated with photopsia—crude visual hallucinations, usually in the form of showers or flecks of light but suggestions of geometric character will sometimes be seen. The key factors differentiating this photopsia from occipital disease and migraine are its clear unilaterality, the patient's age, and a detailed analysis of the history, which excludes migraine as a consideration and supports amaurosis fugax. The event need not be simply a blackout; dimming with a sensation of color may occur with green and yellow having popularity. In my experiences, color sensation has been uncommon.

The duration is generally brief, lasting two or three minutes, or rarely, five-to-ten minutes. We have found a common tendency for patients to misjudge the time sequence with frequent exaggeration of the period of visual loss. As this tendency to misjudge the duration of visual handicap may be bothersome diagnostically, we have adopted a simple time confirmation method. It consists of instructing the patient that you are going to begin to count and he is to assume that this is the onset of his visual symptomatology. We encourage the patient to "relive" the experience and with the use of our verbal clock, determine the average duration of visual loss. The rule is to find a duration of from one and one-half to two or three minutes despite the patient's initial claim of five, ten minutes, or longer of impairment. A watch second hand or stop watch could also be used; however, the vocal metronome seems helpful.

Although emphasis has been placed on the association of ipsilateral eye and contralateral extremity signs and symptoms, it should be recognized that their actual temporal association is unnecessary diagnostically and infrequent clinically. The eye symptoms and signs in isolation as evidence of cervical internal carotid disease are, in all likelihood, far more common than many practitioners realize. The work of Lubow and associates at Ohio State regarding "retinal strokes" underlines this concept. On rare occasions, transient homonymous visual impairment may be a reflection of internal carotid disease by virtue of a carotid origin of the posterior cerebral artery. Correct diagnosis will depend upon associated symptoms and signs.

The precise pathophysiology of these brief alterations of visual function continues to excite some debate. It seems certain that most are based upon emboli of either platelet aggregates or atherosclerotic debris. The exact point at which the embolus works its evil is less certain. As will be discussed, visible emboli in central retinal arterioles must play a role; whether they are the sole inciting force is less certain. Emboli to the choroid, not apparent clinically, may be important. The role of dynamic reduction of blood flow in the production of visual symptoms of carotid disease is probably small. It does, however, in selected but infrequent instances, probably play a significant role. Total carotid occlusions obviously cause some transient visual symptoms; generally, the symptoms cease following the stabilization occurring postocclusion.

Our diagnostic evaluation of patients with symptoms of transient visual loss consists of the careful analysis and integration of the specific physical signs with the presenting and elicited symptoms. Although we have defined amaurosis fugax as transient painless monocular visual loss, occasionally, residual deficits of vision remain. In addition, a number of patients with cervical internal carotid disease present not with transient ipsilateral eye symptoms but with fixed deficits.

Needless to say, the diagnostic evaluation of all patients with eye symptoms and signs suggesting ipsilateral carotid disease must begin with documentation of visual function—this includes best

corrected visual acuity, pupillary reactivity, and quantitative visual field evaluation. Although we palpate neck vessels, much less than total absence of vessel pulsation is lightly regarded. Auscultation is considered an important adjunct, with realization that bruits at sites other than the suspected symptomatic area may be significant. A bruit in isolation, however, is of dubious benefit.

The final, but perhaps most valuable, aspect of the neuro-ophthalmic diagnostic evaluation of patients suspected of harboring atherosclerotic disease is the dilated funduscopic examination with the recording of retinal artery pressures. If one is fortunate enough to be present during an amaurotic event, funduscopy may reveal white platelet emboli or bright cholesterol plaques passing through the central retinal arterioles. As this is a distinctly uncommon opportunity, one must usually be satisfied with residue which remains behind—most commonly, bright cholesterol material lodged at arteriole bifurcations. Hollenhorst, who first recognized the significance of retinal emboli in 1961, recorded a 33% incidence of these "Hollenhorst plaques" in patients with symptomatic cerebrovascular insufficiency.

Ophthalmodynamometry (ODM) should be routinely performed following a thorough funduscopic survey. The technique of ODM was first devised by Baillart in 1917 to measure central artery pressure. Svien and Hollenhorst popularized its use in 1956. One must keep in mind that ODM's are not a measurement of absolute pressures. This is, by and large, not a disadvantage as their primary benefit is a relative comparison of one eye with the other. We, as do many others, commonly record only the diastolic reading and routinely perform the ODM's in the sitting position. Before we consider the asymmetry significant, we require a 15% difference when the readings are below 40 units and a 20% difference when the readings are above 40 units. Any readings below 20 units are considered abnormal. The basic mechanism of ODM is the simple increase of intraocular pressure to levels above the central artery pressure. Needless to say, either increased or decreased intraocular tension will falsely alter the reading obtained. For this reason, tonometry—the recording of intraocular pressure—is essential in conjunction with ophthalmodynamometry. Despite great care in technique, false negative readings abound. Our experience has suggested that significant ophthalmodynamometric asymmetry indicates extreme stenosis, if not actual occlusion, of the symptomatic internal carotid artery. Ophthalmodynamometry plays a definite, though limited, role in the diagnosis of atherosclerotic cervical internal carotid disease. With the value of ODM's in perspective, we continue to use them routinely.

A discussion of amaurosis fugax is not complete without a brief review of the differential diagnosis. Although almost all transient monocular visual loss is due to internal carotid arterial disease, there are other considerations which include temporal arteritis, migraine and migraine equivalents, glaucoma, papilledema, Raynaud's disease, and other emboli. It is seldom difficult to identify these additional sources of transient monocular visual loss if they are appropriately sought.

Amaurosis fugax, although the hallmark of occlusive internal carotid disease and certainly its most common symptomatic neuro-ophthalmic presentation, is by no means the only eye manifestation encountered in internal carotid vascular disease. The following discussion will describe a number of less commonly recognized clinical syndromes caused by occlusive internal carotid disease.

Retinal stroke, although commonly an integral aspect of the syndrome of amaurosis fugax, certainly occurs in the absence of prior symptomatic transient monocular visual loss; there can be little doubt that the occurrence strongly suggests atherosclerotic disease of the cervical internal carotid artery. The work of Lubow and associates at Ohio State in 1972 has shown, angiographically, a 95% incidence of carotid bifurcation disease in patients having retinal strokes as compared to asymptomatic age-matched controls in which angiography demonstrated a 25% incidence of bifurcation abnormalities. What do retinal strokes consist of? They consist of occlusive disease of the retina, previously relegated to ophthalmic practice. It has become apparent, however, that many "retinal strokes" are of embolic origin and manifest cholesterol plaques exactly like those seen in amaurosis fugax.

Central retinal artery and artery branch occlusions, as well as more distal cholesterol emboli, producing peripheral defects frequently unappreciated by the patient, constitute the retinal stroke. Their clinical manifestation is abrupt, usually painless, persistent monocular visual loss. Blindness and optic atrophy frequently follow retinal strokes. In our brief historical review, one may recall Gowers' allusion to ipsilateral optic atrophy and blindness associated with contralateral hemiplegia. Carotid disease is obviously likely with this association. What

must not be forgotten is that isolated blindness and optic atrophy may also reflect cervical internal carotid disease. Other funduscopic alterations causally related to cervical or extracranial internal carotid disease occur. It is not commonly recognized that ipsilateral carotid occlusive disease may serve to prevent the expression of both hypertensive and diabetic retinopathy. When a patient is seen with remarkably asymmetric hypertensive or diabetic retinopathy, consideration of the possible presence of occlusive internal carotid disease should follow.

Ischemic retinopathy, recognized as evidence of chronic retinal ischemia by Kearns and Hollenhorst in 1963, is a syndrome consisting of a retinal picture similar to diabetic retinopathy with dilated veins, some resultant blot hemorrhages and microaneurysms, low ophthalmodynamometric values, and at times, severe orbital pain. Ischemic retinopathy can be differentiated from diabetic retinopathy by the fact that it is unilateral and that there is no biochemical evidence of diabetes mellitus. Obviously, diabetes and the Kearns ischemic retinopathy may coexist. The significance of ischemic retinopathy is its reflection of severe impairment of internal carotid as well as collateral circulation to the eye and orbit. Not uncommonly, the major trunks from the aortic arch are the site of the vascular occlusion.

There are three additional presentations of eye signs reflecting occlusive vascular disease which generally indicate, as does ischemic retinopathy, a more severe and diffuse vascular embarrassment of orbital as well as central retinal circulation. These are ischemic inflammation, "pseudouveitis"; ocular hypotony; and neovascular glaucoma.

Ocular inflammation resembling uveitis may result from chronic ocular ischemia secondary to diffuse occlusive vascular disease, involving not only the internal carotid but the collateral channels as well. This syndrome is characterized by dilatation of episcleral veins, a turbid anterior chamber, iris synechiae, corneal precipitates, and edema. On occasion, vitreous hemorrhage may occur and cataracts may rapidly develop.

In circumstances where acute reduction of orbital blood flow affects more specifically the ciliary body, reduced production of aqueous humor results leading to ocular hypotony and potentially phthisis bulbi.

Chronic ischemia in the eye is also a stimulus to new vessel production. Prolonged reduction of orbital blood flow may result in proliferation of neovascular tissue on the surface and angle of the iris. This will often culminate in occlusion of the anterior chamber angle and a malignant form of secondary glaucoma referred to as neovascular or hemorrhagic glaucoma.

It is obvious that the last three syndromes reflecting eye involvement, secondary not simply to carotid stenosis but most certainly to more severe carotid occlusive disease, as well as occlusive disease of the usual orbital collateral channels, may occur either in sequence or in combination. Their incidence in reality is quite low. Ischemic retinopathy, a less severe manifestation of the same process, is reported in only 5% of unilateral carotid occlusions. It is wise, however, to realize that eye signs other than simple transient or permanent monocular visual loss may point to disease of the cervical carotid vessels.

In conclusion, one should mention the occurrence of unilateral Horner's syndrome in a not insignificant number of unilateral internal carotid occlusions. This quite likely represents involvement by edema and ischemia of the carotid sympathetic plexus in the adventitia.

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