Homonymous hemioptic hypoplasia

Fundoscopic features in standard and red-free illumination in three patients with congenital hemiplegia

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Congenital lesions of a cerebral hemisphere may involve its optic tract primarily or trans-synaptically. Such lesions produce a distinctive retrograde hypoplasia in each optic nerve and retina (Fig. 1, overleaf) which we have identified ophthalmoscopically and have named *homonymous hemioptic hypoplasia*. This report describes and illustrates fundoscopic features of this neuro-ophthalmological anomaly viewed in standard and red-free illumination in three Caucasian patients with cerebral hemiatrophy.

Clinical data

Each of the three patients was a young epileptic adult with spastic paralysis and underdevelopment of the left arm and leg, left homonymous hemianopia, and the distinctive fundoscopic changes that are the subject of this report. Two of the patients had fixation nystagmus and mildly defective visual acuity (Table I); the amplitude of the nystagmus was greatest on right lateral gaze, and there were

Table I *Clinical findings in three patients with homonymous hemioptic hypoplasia and left-sided congenital hemiplegia*

Case No.	1 22-year-old female	2 25-year-old female	3 15-year-old female
Site of defect	Right hemisphere	Right hemisphere	Right hemisphere
Type of homonymous hemianopia	Left (total)	Left (total)	Left (total)
Visual acuity	Right Left	Right Left	Right Left
Fixation nystagmus	Pendular, horizontal, rotary	Fine, horizontal, jerky, with gaze right or left	None
Strabismus	Esotropia, alternating	None	None
Optokinetic reflexes*	Abnormal to left	Abnormal to left	Abnormal to left
Type of epileptic seizures	Lifelong, grand mal	Lifelong, infrequent, grand mal	Lifelong, severe, grand mal Petit mal
Mental status	Mild retardation	Mild retardation	Moderate retardation

*The direction of the *rapid* phase of optokinetic nystagmus is indicated as abnormal (movement of optokinetic stimuli is opposite the side indicated).

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FIG. 1 Pattern of distribution of nerve fibres (white lines) in the ipsilateral and contralateral fundi viewed from the front. The dysplastic side of the brain, the involved portion of the visual pathway, and the corresponding (blind) homonymous hemiretinae contain no visual fibres. Contrast the pattern of nerve fibres entering the ipsilateral disc (located in the "seeing" hemiretina) with the pattern of the nerve fibres entering the contralateral disc (located in the "blind" hemiretina).

The normal (A) and hypoplastic zones (B and C) of the retinae are indicated in each fundus (below) and in cross-sectional diagrams of the retinal layers (above, left):

(A) Normal hemiretina;

(B) Hypoplastic retina in contralateral fundus that contains no ganglion cells but is traversed by nerve fibres from the seeing hemiretina;

(C) Hypoplastic retina in both fundi that contains neither ganglion cells nor nerve fibres

frequent macrosaccadic movements towards the left as if the patients were attempting to compensate for their hemianopia. Evoked optokinetic nystagmus was defective or absent in all three patients when stimuli were moved toward the patient's right. The homonymous hemianopia in each patient was absolute with vertical borders that overlapped slightly into the left halves of the visual field.

Appearance of the ocular fundi

The patients' fundi were studied in standard and red-free illumination, by direct ophthalmoscopy, and in magnified (single and stereo) fundus photographs made with Kodachrome II (colour) and Kodak Plus-X (black and white) films. Photographs were taken using colour film; from these colour transparencies, black and white negatives were made using a Kodak Wratten No. 65 green filter; and these, in turn, were printed on Kodak Ectomatic SC-F paper. The changes in the ocular fundi ipsilateral and contralateral to the cerebral lesion are summarized in Table II, and the appearance of these fundi, in black and white photographs made with red-free light, are demonstrated in Figs 2, 3, 4, and 5 (overleaf).

Table II *Comparison of fundoscopic features in eyes ipsilateral and contralateral to the hemispheric defect*

<i>Fundoscopic features</i>		<i>Ipsilateral eye</i>	<i>Contralateral eye</i>
Optic disc	Shape	Round	Usually oval (vertically)
	Size	Slightly small	Horizontally small
	Colour	Mild temporal pallor	"Butterfly" or horizontal-band pallor
	Margins	Visible temporally	Sharp nasally and temporally
	No. of vessels	Diminished temporally	Diminished nasally and temporally
Nasal hemiretina	Appearance in red-free light	Nerve-fibre pattern decreases between disc and hemiretinal border	Arcuate nerve-fibre pattern on dark background between disc and hemiretinal border
	Parafoveal light reflexes	Distinct nasally	Absent or indistinct
	No. of vessels	Normal	Diminished
	Colour density	Light (normal) hue	Darker hue
Temporal hemiretina	Appearance in red-free light	Mottled or "marbled" without nerve-fibre reflexes	Normal nerve-fibre pattern on light background
	Parafoveal light reflexes	Indistinct	Normal temporally
	No. of vessels	Diminished	Normal
	Colour density	Darker hue	Light (normal) hue
Hemiretinal border	Visibility	Indistinct (blended) throughout	Distinct near fovea temporally

Discussion

The changes in the retinal nerve fibres and the optic disc with homonymous hemioptic hypoplasia, as described in this report, are the fundoscopic analogues of congenital hemianopia. Topographically, these changes in the ipsilateral and contralateral eyes correspond to histologically established patterns of retrograde, homonymous, ganglion-cell degeneration in laboratory animals (Van Buren, 1963a) and man (Gartner, 1951; Van Buren, 1963b). This hemiretinal loss of ganglion cells, which is so striking in horizontal microscopic sections of the macula, occurs (1) directly, after degeneration of an optic tract (from congenital or acquired diseases), or (2) trans-synaptically, after congenital (or perinatal) degeneration of the optic radiations (Van Buren, 1963b).

FIG. 2 Photographic appearance of fundi taken with red-free light and printed on high contrast black and white paper. The patient (Case 1) had right cerebral hemiatrophy with left spastic hemiplegia and hemianopia.

The left (contralateral) fundus (top) shows transverse pallor of the disc, horizontal optic hypoplasia, exposed nasal and temporal disc margins, and a double-contoured nasal disc edge (a). The surrounding retina looks dark and is blind. The visible nerve fibres entering it above and below come from the distant ("seeing") half of the fundus. Temporal to the macula the retina looks almost white and has striated-nerve-fibre reflexes that diverge from the retinal raphe. The white arrows outline the portions of the fundus that are devoid of nerve-fibre reflexes, and instead appear mottled and dark. The boundary between the "seeing" and "blind" hemiretinas can be seen above and below the fovea. Note the reduced number of retinal vessels on the nasal side of the disc and contrast this with the number of vessels on the nasal side of the right disc (below). Also note, nasal to disc, the course of the most nasal nerve-fibre bundles entering the disc.

The right (ipsilateral) fundus (bottom) has a round disc surrounded by normal appearing nerve-fibre reflexes arising from the "seeing" retina in which the disc is located. The disc's vascularity is normal. The fundus gradually becomes darker as the macula and the boundary (dotted line) between the hemiretinas is approached. Temporal to the macula the fundus appears dark and mottled, and is without striated-nerve-fibre reflexes.

OPTIC DISC CHANGES WITH ACQUIRED AND CONGENITAL OPTIC TRACT DEGENERATION

Previous accounts of ophthalmoscopic signs of direct and trans-synaptic degeneration in patients with homonymous hemianopia have focused upon asymmetrical pallor of the optic discs, Wilbrand and Saenger (1917) correctly describing avascularity and pallor of the nasal and temporal sectors of the contralateral optic disc (on the side of the hemianopia)

FIG. 3 Macular appearance in red-free light of contralateral (above) and ipsilateral (below) eyes in patient in Case 1. In the contralateral fundus, note the contrast between "seeing" and "blind" halves of the parafoveal retina. In each, the intersection of dotted lines indicates the centre of the fovea, the white arrow indicates the direction of the optic discs, and the black arrows indicate the course of axons on their way to the optic disc. In the ipsilateral fundus contrast between seeing and blind sides of the macula is minimal, but the circular parafoveal light reflex is discontinuous temporally, and nerve-fibre reflexes can be seen on the nasal side. Uncrossed (Un-X) fibres and crossed (X) fibres join in the patient's only optic tract and compose the total visual pathway.

and the normal appearance of the ipsilateral disc. These and additional disc changes were observed in our patients with *homonymous hemioptic hypoplasia*. The pallor of the *contralateral disc* was restricted to a horizontal (bowtie-shaped) band that was nearly devoid of small vessels and neural tissue overlying the nasal and temporal disc margins. These pale areas in the contralateral disc normally contain only those nerve fibres that decussate in the chiasm. The reduced horizontal diameter of the disc in two of our patients reflects hypoplasia of the midzone and suggests retrograde axonal loss occurring early in life.

FIG. 4 Hypoplastic optic discs and surrounding retinas in patient in Case 2.

The left optic disc is pale in the typical transverse band (see upper right photograph) and its surrounding retina is dark. Superiorly and inferiorly, the greyiness of the retina in the left fundus is produced by the overlying nerve-fibre bundles from the distant ("seeing") hemiretina. The difference between the "seeing" and "blind" halves of the parafoveal area is clearly visible in the lower photograph (arrows), reproduced from a colour transparency using a red-free filter.

The right ipsilateral optic disc is slightly pale in the top photograph (the "pallor" in the lower photograph is due to the high contrast photographic paper). The retina surrounding the entire disc is grey, indicating that the ganglion cells and axons of the retina in which the disc sits are normal. There is no clear-cut difference between the "blind" and "seeing" halves of the right fundus, but the parafoveal light reflex is dim temporally.

The darker hue of the hemianopic retina surrounding these discs indicates reduction in optical density from atrophy or hypoplasia of the ganglion-cell and nerve-fibre layers. These ophthalmoscopic changes alone (*i.e.* those described for the contralateral disc) are distinctive enough to diagnose (1) retrograde loss of the eye's crossed-fibre projections from a defect at the level of the chiasm or above, and (2) an accompanying temporal hemianopia.

The *ipsilateral* disc appeared normal in colour and vascularity in two of our patients, and mildly pale in the third. The lighter hue and radiating multilinear light reflexes of the retina surrounding the ipsilateral disc indicated normal development of the ganglion-cell and nerve-fibre layer in that portion of the retina. In two of our patients, the flatness, roundness, and reduced size of the ipsilateral disc suggested a developmental cerebral defect, occurring early in life, with retrograde hypoplasia of half of the visual fibres (non-decussating fibres from the temporal hemiretina) normally contained in an optic nerve.

FIG. 5 Hypoplastic optic discs in patient in Case 3, photographed in standard illumination (above) and in red-free light (below). The retina surrounding the ipsilateral disc (R) is lighter and the disc diameter is smaller than on the contralateral side. The contralateral disc (L) shows typical transverse-band pallor and corresponding nasal and temporal loss of retinal nerve fibres. Note the double-contoured disc edges in both fundi (straight arrows), a sign suggesting retrograde hypoplasia of optic axons. Nerve-fibre reflexes around the right disc are normal, and are seen above and below the left disc (curved arrows indicate only part of these fibres; the remainder are blurred out by the defective focus of the picture)

PREVIOUS RETINAL STUDIES OF RETROGRADE NERVE-FIBRE ATROPHY WITH RED-FREE LIGHT

The appearance of normal and degenerated nerve fibres in the retina was studied in con-

siderable detail by Vogt early in the 20th century. First, he reported that filtering out of the red wave lengths from the light used in direct ophthalmoscopy heightened the visibility of superficial layers of the retina, accentuating particularly the nerve-fibre reflexes (Vogt, 1913). He later described a special light source developed by the Zeiss Optical Company and provided details of its application in studies of superficial reflexes of the retina (Vogt, 1917, 1921). Recently, Ito, Ozawa, Suga, and Mizuno (1969) have combined magnifying photography with Vogt's red-free technique in a study of optic neuritis and several retinal vascular diseases.

Laubert (1927), recognizing that Vogt's method could be used to identify the retrograde patterns of nerve-fibre loss from long-standing optic tract lesions, reported red-free fundoscopic features of left homonymous hemianopia in a 41-year-old luetic patient whose optic tract lesion had been discovered 4 years earlier. Laubert correctly described nerve-fibre defects at the disc margins and at the nasal and temporal atrophic peripapillary zones in the left fundus. He claimed that he saw, in the ipsilateral fundus, arc-shaped fibre-free strips which bridged the blind hemiretina and entered the optic disc superiorly and inferiorly. These findings in the ipsilateral fundus of Laubert's patient were not seen in our patients. Laubert did not recognize the hemimacular changes, the changes along the vertical (hemianopic) border, the details of the arcuate bundles of the contralateral fundus, or the changes in the retinal vascular patterns that we have documented in this report. He claimed that his findings in the retinal nerve-fibre layer were evidence of optic tract disease, but was apparently unaware that similar findings occur with congenital occipital lesions as well as with lesions of the optic tract. Oddly, neither Laubert nor other writers reconfirmed his observations or made more than passing mention of them in publications dealing with causes of descending optic atrophy or diagnosis of lesions in the anterior visual pathways.

RETINAL SIGNS OF CONGENITAL HEMIANOPIA (HOMONYMOUS HEMIOPTIC HYPOPLASIA)

The hemiretinal nerve-fibre changes in our three patients could represent effects of congenital damage to the optic tract, the optic radiation, or both, for each had neurological manifestations of cerebral hemiatrophy. Cerebral hemiatrophy is an organogenetic defect usually attributed to foetal vascular insufficiency. Pathological changes in the involved hemisphere include atrophy (hypoplasia) sometimes combined with cyst formation.

The fundoscopic changes of homonymous hemioptic hypoplasia defined in this report must occur in all patients with a congenital hemianopia, regardless of its cause. These ophthalmoscopic findings have been overlooked previously for several reasons:

- (1) They are too subtle to be recognized readily in standard illumination;
- (2) The type of detailed examination required to see them is difficult to do in a child who may be retarded and may have fixation nystagmus;
- (3) Red-free ophthalmoscopy is hardly ever employed by the ophthalmologist or neurologist who examines these children;
- (4) The refined technique of red-free fundus photography combined with magnification is relatively new and has apparently not been used in the examination of this type of patient.

GENERAL OBSERVATIONS ON OPTIC HYPOPLASIA AND ITS PATHOGENESIS

The description of homonymous hemioptic hypoplasia as a particular type of optic hypo-

plasia has important implications for the pathogenesis and classification of optic hypoplasia in general. The striking histological feature of most eyes with hypoplastic optic nerves is the absence of retinal ganglion cells and nerve fibres from the otherwise normal-appearing retina (Kreibig, 1959). This absence of ganglion cells may represent a *retrograde hypoplasia*. In two of our patients, the nasal and temporal portions of the hypoplastic disc (of the eye opposite the cerebral lesion) were bordered by a concentric pigment ring and scleral crescent similar to those recently described as adjacent to the hypoplastic discs of patients with the *septo-optic dysplasia* of de Morsier (1956), a congenital syndrome of pituitary dwarfism, congenital nystagmus, bitemporal or other visual field defects, and absence of the septum pellucidum (Hoyt, Kaplan, Grumbach, and Glaser, 1970; Ellenberger and Runyan, 1970). The double contour of the hypoplastic disc edges in patients with septo-optic dysplasia or anencephaly, and in our patients with cerebral hemiatrophy, seems to indicate a retrograde rather than an embryogenic form of optic hypoplasia.

RED-FREE FUNDOSCOPY AND RED-FREE PHOTOGRAPHY IN OPHTHALMOLOGICAL DIAGNOSIS

By a red-free photographic method we have demonstrated for the first time the fundoscopic anatomy of a relatively common condition, congenital hemianopia. We also have observed similar nerve-fibre-layer changes in patients with acquired optic tract lesions. Currently we are applying this photographic refinement of Vogt's red-free funduscopy in the study of other congenital and acquired diseases affecting axons in the optic nerves, optic discs, and retinas. The method offers, for the first time, objective morphological indices for the analysis and description of diseases in a clinically neglected layer of the retina.

Summary

Congenital lesions of a cerebral hemisphere that interrupt its visual pathway produce a topographically distinct pattern of (direct or trans-synaptic) retrograde axon degeneration in each optic nerve and retina. The fundoscopic signs of this *homonymous hemioptic hypoplasia* are described and documented photographically in standard and red-free illumination in three patients with congenital hemiplegia and hemianopia.

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