Origin of disc new vessels assessed by videofluorography*

N A JACOBS, C A STEELE, AND K B MILLS

From Manchester Royal Eye Hospital, Manchester

SUMMARY Ten patients with disc neovascularisation of various aetiologies were studied to ascertain the origin of their new vessels. Fluorescein angiography was carried out with an image intensified video camera. A retinal artery derivation was demonstrated for the first time and was seen in three cases. Six further patients showed a retinal venous supply, and finally there was one from a choroidal source.

The formation of retinal new vessels in response to ocular ischaemic¹ of inflammatory² disease is well recognised. In 1948 Michaelson³ stated that new vessels are associated nearly always with retinal veins. Henkind¹ concurred that retinal new vessels arise generally from veins and rarely from arteries. Regarding disc neovascularisation, he noted that, apart from a retinal origin of the vessels, a ciliary origin exists in certain cases. Asdourian and associates⁴ as well as Kohner *et al.*⁵ have confirmed a choroidal or posterior ciliary derivation of new vessels from the disc in some instances.

This investigation was designed to identify the source of disc neovascularisation. A videofluorescein angiographic technique similar to that described by Haining⁶ was employed.

Materials and methods

Ten patients with significant disc neovascularisation of varying aetiologies were included (Table 1). Because the equipment was available for only a short period suitable patients such as could be found were collected in advance. There were seven diabetics, two cases of chronic ocular ischaemia associated with carotid artery obstruction, and one of unknown inflammatory aetiology with peripheral vascular sheathing. All gave their informed consent.

The Topcon TRC 50VT variable angle retinal

camera was used. A Visual Contact 590 Newvicon tube video camera with a microchannel plate image intensifier was attached. Recordings were made with a Sony U-matic tape machine after intravenous injection with 2.5 ml of 25% fluorescein sodium dye.

Results

The recordings obtained were initially slowed to one-quarter of real time by the technical services division of New Scotland Yard. Subsequent assessment was carried out in the audiovisual department at Charing Cross Hospital, where editing facilities allowed infinite adjustment of playback rate. Picture quality was satisfactory in view of the low operating light levels of 10^{-2} to 10^{-3} lux. Resolution under these conditions was about 300 pixels horizontally and 225

Table 1 Summary of the cases with their disc new vessel origin

Case no.	Age	Eye	VA	Origin of disc new vessels	Aetiology
1	44	L	6/6	Retinal vein (Fig. 1)	IDD† 20 years
2	48	L	6/24	Retinal vein	IDD 21 years
3	47	L	6/12	Retinal vein	IDD 36 years
4	62	R	6/9	Retinal vein	Chronic ocular ischaemia
5	77	R	6/12	Retinal vein	Chronic ocular ischaemia
6*	58	R	6/5	Retinal vein	Inflammatory vasculitis
7	65	R	6/24	Retinal artery (Fig. 2)	IDD 18 months
8	36	L	6/9	Retinal artery	IDD 17 years
9	54	L	6/12	Retinal artery	IDD 24 years
10	42	R	6/9	Choroidal (Fig. 3)	IDD 20 years

*This paper was given under another title and in a different form at the Eighth International Symposium on Microsurgical Anastomoses for Cerebral Ischaemia in Florence on 14-17 September 1986.

Correspondence to Mr N A Jacobs, FRCS, The Royal Eye Unit, Coombe Road, Kingston upon Thames, Surrey.

*No photocoagulation treatment given.

†Insulin dependent diabetes.

Fig. 1A

Fig. 1C

Fig. 1 Videofluorographic stills showing new vessel origin from the retinal vein in the left eye of case 1. (A) Late arterial phase before filling. (B) Early fluorescence of net (small arrows) and onset of venous lamellar phase in superotemporal branch (large arrow). (C) Late venous phase and complete new vessel fluorescence.

vertically, being approximately half the maximum ideally attainable by the video camera.

A majority of six patients had a new vessel supply derived from the retinal venous circulation. Filling began coincidentally with the onset of venous lamellar flow at the disc (Figs. 1A, B, C). This group comprised three diabetics, both cases of chronic ocular ischaemia, and the case of inflammatory

aetiology. Next were three further diabetics, all showing the filling of new vessels simultaneously with the branches of the central retinal artery (Figs. 2A, B, C). Finally, one diabetic showed filling of new vessels synchronously with two cilioretinal arteries (Figs. 3A, B, C).

Discussion

Ocular neovascularisation is mediated by a vasoformative substance, as first proposed by Michaelson.³ Recent work⁷ has brought the identification of such a substance tantalisingly close. However, there are proponents of other concepts, from the mechanical⁸ to the Darwinian.⁹ The optic disc is a frequent site of neovascularisation in diabetic eye disease.¹⁰ Absence of both the anatomical and functional blood-retinal barrier¹¹ at this site might be relevant. Though a through flow of ocular fluid into the optic nerve head has been demonstrated only in rabbits,^{12,13} there is indirect evidence of this phenomenon in primates.^{11,14} If it does exist, vessels related to the disc would be exposed to a greater concentration of vasoformative substance than elsewhere.

Shimizu *et al.*¹⁵ have related the degree of retinal ischaemia to the site of new vessel formation. Thus ischaemia was moderate with retinal new vessels only, more severe with disc new vessels, and was seen to be profound with rubeosis. Interestingly, they observed that retinal new vessels were smaller when disc new vessels coexisted, and that in turn disc new vessels were small and retinal new vessels almost absent when associated with rubeosis. This appears to tally with the interpretation placed by Ashton¹⁶ on a study of central retinal vein occlusion carried out by

Fig. 1B

Fig. 2A

Fig. 2 Videofluorographic stills showing new vessel origin from the retinal artery in the right eye of case 7. (A) Early arterial phase with filling of new vessel net feeder (arrow). (B) Full arterial phase with outline of net area (arrows). (C) Full venous phase and complete new vessel fluorescence.

Smith¹⁷ prior to the advent of fluorescein angiography—namely, that new vessels, as well as being a passive response to the presence of vasoformative substance, also actively remove this factor from the eye by a process of dialysis. Therefore their presence on the disc would tend to prevent sufficient quantities of vasoformative substance from reaching the drainage angle to provoke rubeosis, and vice versa.

Fig. 2B

Fig. 2C

For a fluorescein study to yield information useful in a report such as this, recording must begin prior to the arrival of dye and contain as much sequential information as possible. Thus ordinary sequence photography is severely limited by the rate of flash recharge. A cinematographic approach at the normal rate of 26 frames per second or above would be valuable, but there are practical difficulties.⁶ Video fluoroscopy with a rate of 25 frames per second is both documented and practicable,⁶ especially with the availability of sophisticated technology for analysis. Its feasibility was demonstrated on a normal volunteer. Cilioretinal filling was well displayed, and nasal branches of the central retinal artery were seen to fill before the temporal branches.

A retinal artery derivation of disc new vessels has not been reported previously. Three patients showed this, suggesting that it may be a common occurrence (Fig. 2). With normal angiographic methods it would be difficult to differentiate a uveal from a retinal arterial supply. Retinal venous filling of disc new vessels is well recognised¹³ and was seen in six of the patients in this study. Although such late angiographic filling may be explained by an epipapillary capillary origin, we discount this possibility for two reasons. First, the new vessel filling coincided in each case with the lamellar venous filling of retinal veins at the disc. Secondly, in two cases (1 and 5) where neovascular complexes were especially large, filling proceeded rapidly in the absence of discernible peripapillary arteriovenous shunts (Fig. 1). Finally, one patient showed a choroidal origin of disc new vessels (Fig. 3). Using rapid sequence angiography, Asdourian and associates¹ described such a choroidal origin in four diabetics and in one patient with carotid

Fig. 3A

Fig. 3 Videofluorographic stills showing new vessel origin from the choroid in the right eye of case 10. (A) Background choroidal phase with two cilioretinal arteries (small arrows) and large new vessel stalk (large arrow). (B) Very early arterial phase with enhancement of earlier features. (C) Full venous phase with fluorescence of neovascular complex periphery and filling of intervening channels marked by a vertical line moving posteriorly towards the disc (arrows).

insufficiency. The Japanese work described above,¹⁵ along with an earlier study¹⁸ from the same department, led those authors to conclude that disc new vessels invariably have a choroidal origin. Again, standard fluorescein angiographic techniques were employed.

Fig. 3B

Fig. 3C

Whether any clinical significance may be attached to the disc new vessel origin is unknown. Perhaps this knowledge could indicate the likely response to treatment. It is usually supposed that photocoagulation destroys a proportion of viable retinal tissue, allowing improved oxygenation of the remainder and thereby removing the stimulus for the release of angiogenic substance. Even though the presumably oxygen-rich outer retina is selectively damaged, this treatment may lead to a greater oxygen tension for the inner retina.³ This supposition is by no means proved, and other possibilities exist. Photocoagulation is known¹⁹ to alter the permeability of the blood retinal barrier, and may allow a leakage of angiogenic substance into the choroid. In that case disc new vessels originating from the choroid might be expected to respond poorly, since leaking angiogenic factor could continue to act as a stimulus. Other work²⁰ has revealed an important inhibitory role of the pigment epithelium in neovascularisation. Alteration of the normal cell layer population has been shown to increase this inhibitory activity. Perhaps treatment alters the pigment epithelial cells in this way. Whichever mechanism is at work, disc new vessels with an arterial origin may prove most likely to bleed, and would therefore be best excluded from methods of photocoagulation involving occlusion by direct application.

Notwithstanding aetiological and therapeutic conjecture, disc new vessels may be derived from the retinal artery, the retinal vein, or the choroid.

References

- 1 Henkind P. Ocular neovascularisation—the Krill Memorial Lecture. *Am J Ophthalmol* 1978; **85**: 287–301.

- 2 Shorb SR, Irvine AR, Kimura SJ, Morris BW. Optic disc neovascularisation associated with chronic uveitis. *Am J Ophthalmol* 1976; **82**: 175-8.
- 3 Patz A. Retinal neovascularisation: early contributions of Professor Michaelson and recent observations. *Br J Ophthalmol* 1984; **68**: 42-6.
- 4 Asdourian GK, Goldberg MF, Busse B. Optic disc neovascularisation of uveal (choroidal or posterior ciliary) origin. *Arch Ophthalmol* 1977; **95**: 998-1003.
- 5 Kohner EM, McLeod D, Marshall J. Diabetic eye disease. In: Keen H, Jarrett J, eds. *Complications of diabetes*. London: Arnold, 1982: 51.
- 6 Haining WM. Video funduscopy and fluoroscopy. *Br J Ophthalmol* 1981; **65**: 702-6.
- 7 Taylor CM, Weiss JB, Kissun RD, Garner A. Effect of oxygen tension on the quantities of procollagenase-activating angiogenic factor present in the developing kitten retina. *Br J Ophthalmol* 1986; **70**: 162-5.
- 8 Stefansson E, Landers MB, Wolbarsht ML. Oxgenation and vasodilatation in relation to diabetic and other proliferative retinopathies. *Ophthalmic Surg* 1983; **14**: 209-26.
- 9 Cassel GH, Groden LR. New thoughts on ocular neovascularisation: a neurally controlled regenerative process? *Ann Ophthalmol* 1984; **16**: 138-41.
- 10 Taylor E, Dobree JH. Proliferative diabetic retinopathy—site and size of initial lesions. *Br J Ophthalmol* 1970; **54**: 11-8.
- 11 Tso MOM, Shih C-Y, McLean IW. Is there a blood-brain barrier at the optic nerve head? *Arch Ophthalmol* 1975; **93**: 815-25.
- 12 Fowlks WL. Meridional flow from the corona ciliaris through the pararetinal zone of the rabbit vitreous. *Invest Ophthalmol Vis Sci* 1963; **2**: 63-71.
- 13 Hayreh SS. Posterior drainage of the intraocular fluid from the vitreous. *Exp Eye Res* 1966; **5**: 123-44.
- 14 Peyman GA, Apple D. Peroxidase diffusion processes in the optic nerve. *Arch Ophthalmol* 1972; **88**: 650-4.
- 15 Shimizu K, Kobayashi Y, Muraoka K. Midperipheral fundus involvement in diabetic retinopathy. *Ophthalmology* 1981; **88**: 601-11.
- 16 Ashton N. Neovascularisation in Ocular Disease. *Trans Ophthalmol Soc UK* 1961; **81**: 145-61.
- 17 Smith RJH. Thrombotic glaucoma, a clinico-pathological study. *Acta Concilium Ophthalmologicum* 1954; **17**: 1164-75.
- 18 Muraoka K, Yokochi K. Origin of newly formed vessels from the optic disc. *Nippon Ganka Gakkai Zasshi* 1976; **80**: 1152-9.
- 19 McNaught EI, Foulds WS, Johnson NF. The permeability of the posterior blood ocular barrier after xenon photocoagulation: a study using labelled dextrans. *Br J Ophthalmol* 1981; **65**: 473-7.
- 20 Glaser BM, Campochiaro PA, Davis JL, Sato M. Retinal pigment epithelial cells release an inhibitor of neovascularization. *Arch Ophthalmol* 1985; **103**: 1870-5.

Accepted for publication 25 March 1987.