RETINAL VEIN OBSTRUCTION*

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At the root of the clinical phenomena to be described, lies a singular haemodynamic arrangement to be found in the central retinal vein. Within a space of a few millimetres, the pressure in this vessel drops from around 20 mm. Hg at the optic disc, to levels ranging from zero in the upright position, to 10 mm. in recumbency. The examination of the vein, however, reveals no special device whereby this high-pressure gradient is maintained. After entering the nerve-head, the vein traverses the lamina cribrosa and then maintains its central position within the optic nerve for a further distance of a few millimetres. The lamina cribrosa, being able to withstand these pressure differences, is the only structure in the course of the central retinal vein capable of acting as a "throttle" device to maintain this pressure gradient. Being unyielding within this pressure range, the interstices of the lamina cannot be anything but fixed in size. Poiseuille's formula would suggest that, in order to bring about a 50 per cent. reduction of pressure after emission through the lamina cribrosa, the diameter of the vein would have to be reduced by only some 16 per cent. In keeping with this inferred "throttle" action of the lamina cribrosa are the observations that, in cats and dogs, pressure variations in the perioptic subarachnoid space below 18 mm. Hg failed to affect the pressure of the central retinal vein at the nerve-head (Gibbs, 1936). The conclusion that the pressure gradient within the retinal vein is maintained by a high "flow resistance" is inescapable, though for the purpose of the thesis to be presented, its precise topology is immaterial.

Two clinical phenomena occasionally encountered in association with obstruction of the central retinal vein must now be considered:

(A) PRESERVATION OF GOOD VISION.—The following cases illustrate sparing of vision despite ophthalmoscopic evidence of severe embarrassment of the retinal venous circulation.

Case 1 (Mr. Greaves).—When the optician supplied this patient with glasses, he indicated his wish to see her again after one year. In compliance with this request, she called after

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this interval, and he was surprised to find evidence of central retinal venous obstruction (Fig. 1). When questioned she admitted that she had recently become aware of a trifling diminution of vision in the left eye, and this was found to be reduced to 6/12.

FIG. 1.—Central retinal venous obstruction revealed by fundus photograph in Case 1.

This case thus confirms that extensive extravasation can occur in retinal venous obstruction with no catastrophic damage to the retinal function. A profuse retinal haemorrhage, especially in the region of the macula, will lead to an appreciable lowering of vision, but Case 1 suggests that, after resolution of the haemorrhage, the visual acuity may be expected to return to normal were the haemorrhage the sole reason for loss of vision. A retinal haemorrhage in retinal venous "thrombosis" can disappear and "leave no discoverable residue" (Foster Moore, 1924).

Case 2 (Mr. Leigh).—On July 11, 1961, "mistiness" appeared suddenly in a part of the lower temporal quadrant of the right field of vision. Gradually this mist condensed into an opacity "like a black line" which totally obliterated vision in this part of the field. In a space of a few hours vision returned to normal, but the scotoma recurred for several hours on each of the following few days. When the fundus photograph (Fig. 2) was taken on July 18, the uncorrected visual acuity in the right eye was 6/6 (ptly.).

FIG. 2.—Fundus appearance one week after first examination in Case 2.

(B) AMAUROSIS FUGAX.—Sudden, brief episodes of obscuration of vision of the affected eye, ranging from slight “veiling” to complete “blindness”, is not an uncommon symptom preceding established venous obstruction.

Case 3 (Mr. Leigh).—Recurrent transient obscurations of the vision of the left eye for 2 months were followed by persistent amblyopia attributable to retinal venous obstruction.

Case 4 (Mr. H. Ridley).—For the last two years there had been brief episodes of repeated severe obscuration of vision of the eye, which was now the seat of central retinal vein obstruction. Examination was negative, except for moderate hypertension.

Among eighteen cases of amaurosis fugax briefly reported by Uhthoff (1925), there was an unspecified number of cases of “retinal venous thrombosis”. Similar examples can be found among clinical histories cited by Morgan (1953) and Stephenson (1956). The fleeting nature of amaurosis and the complete recovery of vision between attacks are also features which characterize the common form of amaurosis fugax due to retinal circulatory insufficiency caused by carotid occlusion.

It seems highly probable, therefore, that amaurosis fugax preceding obstruction of the central retinal vein may be similarly due to transient retinal ischaemia caused by a reduction of either arterial or capillary circulation. This transient retinal ischaemia in response to central retinal venous obstruction is presumably engendered by a local veno-vasomotor reflex which can be visualized as one of the factors whereby retinal venous homeostasis is maintained.

Veno-vasomotor Reflex

In a carefully controlled study, Haddy and Gilbert (1956) demonstrated that raising the systemic venous pressure in the foreleg of a pentobarbital anaesthetized dog elicits reflex “small vessel” constriction. After procaine block of the limb, the “small vessels” fail to constrict in response to venous obstruction. Arterioles, capillaries, and venules were regarded as the “small vessels” in these studies, and the authors placed the resistance at the arteriolar level. The presence of a “venous small vessel” reflex had previously been suggested by Girling (1952), who used an entirely different technique. Haddy (1956) demonstrated that raising the renal venous pressure in a laparotomized dog elicited a renal vascular constriction. Since the same manoeuvre failed to produce a significant resistance change in denervated kidneys, he inferred the existence of a renal venous-arteriolar reflex.

A similar veno-vasomotor reflex mechanism, if present in the eye, would presumably be initiated by baroreceptors so arranged in the retinal veins that they would be activated by changes in radius of these vessels. The magnitude of transmural pressure, *i.e.* excess of intraluminal over intra-ocular pressure, would determine the change in the radii. Such a low-pressure baroreceptor mechanism of the peripheral vascular bed, while interlocked with other factors influencing circulation as a whole, may, however, act independently and in a contrary direction to that of other factors controlling

the system. Kurus (1952) and Wolter (1957) demonstrated that small retinal veins were well provided with terminal nerve plexuses, which might be assumed to be in continuity with the baroreceptors.

Two important points emerge from these studies:

(i) The maximum rate of flow through the central retinal vein is probably fixed within narrow limits;

(ii) A veno-vasomotor reflex may be an important factor controlling rate of flow through the central retinal vein.

CENTRAL RETINAL VENOUS OBSTRUCTION.—This occurs when the maximum rate-of-flow capacity has been reduced, either by a rise in the viscosity of the blood, or by stenosis of the lumen of the vein.

(1) *Raised Viscosity of Blood.*—Given a vascular channel of dimensions to which Poiseuille's formula applies, the relationship—for any given pressure—between rate of flow and viscosity should be inversely linear. Because of the adaptability of the vascular bed, the rate of flow of systemic blood is not readily affected by rises in viscosity. However, changes indicative of a reduced flow become apparent without delay in the central retinal vein in response to an increasing viscosity. This limited ability of retinal venous circulation to accommodate to rises in viscosity is singular, and is presumably due to fixed, high "flow resistance" at the lamina cribrosa. Ophthalmoscopic features characteristic of slowly progressive central retinal venous obstruction are found early in all those medical conditions in which an enduring elevation of blood viscosity is known to occur. These fundus changes are represented by:

- (a) Tortuosity and looping of veins, at first without haemorrhages;
- (b) Dilatation of retinal capillaries with aneurysm formation.

Among such diseases may be mentioned polycythaemia vera, erythrocytosis due to emphysema, sickle-cell disease, Waldenström's macroglobulinaemia, hyperproteinaemia, and diseases such as cystic fibrosis of the pancreas, in which there is erythrocytosis due to pulmonary insufficiency and elevation of gamma globulin; the leukaemias must also be included (Bruce, Denning, and Spalter, 1960). The appearance of retinal veins, therefore, may afford early information on enduring blood "hyperviscosity".

(2) *Stenosis.*—The yielding and backward bulging of the lamina cribrosa in glaucoma might be expected to bring about a stenosis of the central retinal vein as it leaves the eye-ball. The high flow resistance in this region will become even higher, and venous obstruction is likely to take place. The onset of obstruction may be heralded by repeated episodes of amaurosis fugax.

Case 5 (Mr. Stallard).—An otherwise fit man had amblyopia ex anopsia of the right eye. About 3 weeks previously he had to stop driving his car repeatedly whenever his left eye suddenly became blind, the condition persisting for a minute or so. These episodes increased in duration, and after recurring about half-a-dozen times in the course of the day, vision returned to a very limited extent only. He was found to have bilateral chronic simple glaucoma with obstruction of the left central retinal vein.

Verhoeff (1913) was among the first to consider the effect of “traction produced by a receding lamina cribrosa on the central retinal vessels”. A clear distinction between “thrombotic” (“haemorrhagic”) glaucoma and pre-existing glaucoma with central venous obstruction as a complication was made by Redmond Smith (1955), who also drew attention to the frequency of this complication. In differentiating this condition from “thrombotic” glaucoma, he relied on the presence of increased tension in both eyes, and on the absence of rubeosis iridis.

Vannas and Tarkkanen (1960) claim to have been able to demonstrate the presence of pre-existing simple glaucoma in 42 per cent. of their cases of central retinal vein occlusion. No exception can be taken to their statement that “the discovery of central retinal vein occlusion calls for exhaustive examination for primary glaucoma”. The relatively high proportion of pre-existing glaucoma among their cases of venous occlusion may, however, be misleading, since it was based mainly on tonography.

Dobree (1957) drew attention to the occasional coiling and looping of the vein at the disc showing cupping. It is unlikely that this localized morphological abnormality of the vein is indicative of venous obstruction. Wybar (1957) suggested (more probably) that the looping was congenital and rendered visible by cavitation. The normal lamina cribrosa “varies considerably in toughness and resistance”, and the degree of backward bowing of the lamina cribrosa in glaucoma is subject to variation (Samuels and Fuchs, 1952). This may account for the absence of retinal venous obstruction in many cases of glaucoma.

Many other pathological conditions, among which atherosclerosis is pre-eminent, may seriously embarrass the retinal venous circulation by causing some stenosis of the vein in the same situation as in glaucoma (Morgan, 1955).

VENO-VASOMOTOR REFLEX UNDER PATHOLOGICAL CONDITIONS.—An excessive rise in “transmural pressure” in the retinal veins under the conditions prevailing in obstruction might be expected to produce such a degree of retinal arteriolar constriction as to abolish temporarily retinal function. If this ischaemia is of adequate degree and duration, the retina may suffer irreversible damage. The intimate relationship between retinal venous and arterial circulations has been noted before, but the explanation put forward was that the venous “thrombosis” was a *consequence* of transient arrest or of a slowing of the retinal arterial circulation (Leber, 1915). However, in the

light of our recent knowledge of recurrent episodes of retinal circulatory insufficiency in cases of carotid occlusion, this explanation is untenable (Behrman, 1954). Lister and Zwink (1953), who reported several cases of tributary vein thrombosis with corresponding sector field defects, conclude: "It seems reasonable to suppose that the permanent defect in all cases (of retinal venous obstruction) is due to arterial narrowing or occlusion, rather than to the effects of haemorrhage." Foster Moore (1924) had found that, in at least 42 per cent. of his cases, different degrees of loss of sight occurred in an apoplectiform fashion. This manner of loss of vision could be attributed to activity of the veno-vasomotor reflex.

Braendstrup (1950), in a monograph on thrombosis of the retinal veins, observed that "the variations in the visual acuity do not always reflect the ophthalmoscopic picture". Further, there is general agreement with the view expressed by Lister and Zwink (1953) "that as a rule the final vision is approximately the same as at the outset, but there are exceptions". These clinical observations, as also the disappointing results of anti-coagulant treatment, could be explained on the basis of irreversible retinal damage engendered by an abnormal duration and intensity of the veno-vasomotor reflex.

Summary

(1) The pressure gradient within the retinal vein is maintained by a high "flow resistance".

(2) This, by fixing within narrow limits the maximum rate of flow through the retinal vein, accounts for the facility with which retinal venous obstruction occurs in a variety of pathological conditions.

(3) Transient episodes of amaurosis preceding venous obstruction suggest that a veno-vasomotor reflex may be an important factor in controlling rate of flow through the central retinal vein.

(4) Excessive activity of the veno-vasomotor reflex under pathological conditions probably accounts for the variable degree of loss of retinal function which may follow obstruction of the central retinal vein.

(5) The earliest clinical indication of enduring blood "hyperviscosity" is provided by central retinal venous obstruction.

(6) A recession of the lamina cribrosa in glaucoma, by raising further the high normal "flow resistance" in the retinal vein, often causes clinical and ophthalmoscopic manifestations of retinal venous obstruction. This can be the first clinical manifestation of glaucoma.

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