Summary

1. A useful type of skiascope has been re-described.
2. It has been used for routine hospital refraction work for over thirty years and has proved a valuable time-saving device.
3. Figures provided by two hundred and fifty cases in which both trial frame and skiascope were used have been compared.
4. A high degree of correlation was found.
5. It is suggested that this device might be employed in the construction of refraction curves from unselected samples of the population.
6. The skiascope readings tended to be lower (*i.e.*, more myopic) than the lens method.

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PATHOGENESIS OF THROMBOSIS OF THE CENTRAL RETINAL VEIN AND OF CONSECUTIVE GLAUCOMA*

BY

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GLAUCOMA may be termed, analogously to eclampsia, a "disease of theories." Its clinical manifestation is far from being uniform, let alone its much discussed aetiology. The chief symptom is increased ocular tension, the cause whereof has been ascribed by former authors to an occlusion of the root of the iris, the circulation of the off-leading vein being impaired, and stasis developing within the eye. In opposition to this view, modern investigators look for general connections, being effective besides this local one, and believe such have been found in the system of blood-vessels. Clinical classification corresponds to the assumed connection inasmuch, as inflammatory glaucoma characterised by capillary vasoneurosis, simple glaucoma chiefly manifesting with persons suffering of arteriosclerosis, and finally glaucoma consecutive to thrombosis of the central retinal vein, called also haemorrhagic glaucoma, have been distinguished. Pathogenesis of the latter

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will be discussed subsequently. Blood-pressure was determined by applying Plesch's tonoscillograph, a device rendering satisfactory insight into the state of the walls of the vessels.

A survey of the cases including mostly people of advanced age (42-78 years), whose systolic pressure increased (140-270 mm. of mercury, *i.e.*, 4.59-10.62 inches), and whose tonoscillograph was characterised (in 70 per cent.) by a curve of considerable amplitude, and disclosed curiously enough, 70 per cent. developing the disease in the left eye.

Twenty-three out of the 50 cases suffering from thrombosis of the central retinal vein, developed glaucoma. Detailed consideration reveals that in 16 of the cases blood-pressure surpassed 180 mm. of mercury (3.14 inches) and in 19 the amplitude of the oscillogram came up, or surpassed 15 mm. (0.57 inch). Concerning vision, absence of sensation of light and counting of fingers at a distance of half a metre (18.18 inches), indicated that the main branch of the central retinal vein had been obliterated by the thrombosis, while in almost every other case, wherein no glaucoma followed thrombosis, vision remained much better, a sign of the thrombosis being only partial.

Histological examination of 15 eyes, removed on account of absolute glaucoma, disclosed the angle of the chamber to be normal, so glaucoma could not have been caused by occlusion of the iris-root. In 7 cases the central retinal vein displayed grave alterations (endothelium proliferated), in 5 cases the arterial walls had thickened extremely, possessing partly a particularly developed adventitia, and disclosing hyaline degeneration. The artery appeared to be normal in 2 of the cases. Comparing histological and tonoscillographic findings, a coincidence of large tonoscillographic amplitude and destroyed precapillaries with thickened walls, and endothelial proliferation was disclosed, while a normal tonoscillogram corresponded to capillaries with normal structure of their wall.

These observations prove that in cases of thrombosis of the central retinal vein, the entire system of vessels is altered to a considerable degree, the musculature of the arteries being deficient in elastic elements, a circumstance, sequence whereof is the large amplitude of the tonoscillogram. The wall of the small vessels (arterioles, precapillaries) is thickened, its endothelium showing hyaline degeneration and hyperplasia. These alterations necessarily cause grave metabolic trouble in the eye.

Thrombosis of the central retinal vein is followed by glaucoma, if the main branch has been obliterated. As Wessely and others, myself included, have proved, the ocular tension at the moment of thrombosis of the impaired eye is lower than that of the other one, and glaucoma develops only gradually during several weeks

time. The origin of this type of glaucoma differs doubtless from that of the acute form, the increase of tension of the latter being instantaneous. Every thrombosis of any organ whatsoever is instantaneous, and acid, lactic acid, acetic acid, citric acid, etc., are formed within the territory afflicted, and this applies to the eye similarly.

It is permitted to assume that the effect of such acid substances causes the vitreous body which is in an essentially colloid state, to swell, ultimately producing glaucoma.

This possibility has been discussed by several authors, but is still undecided. According to the opinion of Duke-Elder and Goedblaed, leading authorities in this field, the vitreous body is incapable of such a degree of hydration, that glaucoma may be caused by it. Our investigations applying Krogh's osmometer, prove that the hydration of the vitreous body against physiological salt-solution, is 98.5 mm. of water (7 mm. of mercury) (3.85 inches and 0.27 inches). Simultaneously with our research, Lenti, an Italian investigator, found by application of the same method similar results.

By a second series of determinations the hydration of the vitreous humour against the aqueous humour was determined, results being essentially the same, namely, 97.8 mm. of water.

By a third series, the hydration of the aqueous was investigated without result, as had been foreseen, it containing practically no protein, and therefore no hydrationable colloid matter being present.

These investigations having proved the presence of a measurable hydration of the vitreous body, it was determined subsequently in presence of 1 per cent. of lactic acid (the normal content of the vitreous and aqueous humour of lactic acid being around 30-50 per cent. milligrams) (0.07 per cent. grains). It was found out, that it corresponded to 166.0 mm. of water equal to 12 mm. of mercury (6.47 and 0.471 inch respectively). The result of this final serial (Diagram), is a proof of the vitreous body being capable of increasing ocular tension by the influence of pathological products of metabolism, obviously as a sequence of a shift of the pH. Consequently in cases of thrombosis of the central retinal vein, it may cause glaucoma to arise.

How far could these experimental results be utilised for therapeutic purposes? Alas, an eye blind from consecutive glaucoma of central retinal vein thrombosis has, owing to the unbearable pain, to be removed. The pain-alleviating effects of X-ray irradiation are well known, although the cause is not. This method of foreign authors of treatment of eyes tormented by absolute glaucoma, has to be regarded as a great advance, as in many cases removal could be avoided by its application, although the tissues do not soften by it. We applied this treatment in 3 cases of haemorrhagic glaucoma. Irradiation of 50 per cent. H.E.D., twice repeated, did in one of these cases not alleviate pain and the eye had to be removed; in another case the pains stopped altogether after a single irradiation, and in one case, the patient has been free of pain for 5 years, having received two irradiations and the tension of his eye is below normal value.

Accepting the validity of the assumption that consecutive glaucoma following thrombosis of the central retinal vein, is really due to swelling of the vitreous body, the possibility of reversing this process could be considered, as generally the colloidal state is reversible under favourable chemical conditions. It seems that X-ray treatment exerts besides its pain-alleviating effect another influence, diminishing swelling in cases of absolute glaucoma and therefore should always be applied.

Summary

Thrombosis of the central retinal vein occurs in individuals of advanced age, whose blood-pressure is high (180 mm. of mercury or above), the amplitude of their tonoscillograms exceeding 15 mm.

The histological examination of the central retinal vein discloses

its wall to have thickened, its endothelium displaying hyaline degeneration and proliferation, the adventitia disclosing hyperplasia of connective tissue.

In such cases thrombosis of the central retinal vein is followed by glaucoma, its main branch being obliterated.

Glaucoma forms in such cases by accumulation of pathological products of altered metabolism (carbonic acid, lactic acid, acetic acid, citric acid, etc.), the vitreous body swelling gradually by their influence. Under normal physiological conditions, hydration corresponds to 98.5 mm. of water, and under the influence of lactic acid augments to 166.0 mm.

X-ray irradiative treatment of haemorrhagic glaucoma is indicated.

SIGNIFICANCE OF VENOUS PULSATION OF THE EYEGROUND*

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PULSATION of the eyeground has been known since 1853 (van Tricht, Coccius), but the origin of this phenomenon is still much discussed. There can be no doubt as to the pathological nature of arterial pulsation. Under normal conditions diastolic pressure of the central retinal artery surpasses ocular tension, and in consequence, circulatory flow is not impaired, but if ocular tension increases, as for instance with glaucoma, and surpasses diastolic pressure of the central retinal artery, which diastolic pressure is about half of the value of that of the brachial, being about 30 mm. of mercury, the flow being obstructed, arterial pulsation starts. The same is the case if the ocular tension being normal, the diastolic pressure decreases considerably; then the normal ocular tension becomes relatively higher than the diastolic pressure of the central retinal artery, and pulsation ensues as in cases *e.g.* of insufficiency of the aorta, collapse or grave anaemia.

In opposition to the pathological nature of arterial pulsation of the eyeground, venous pulsation is regarded dogmatically as being physiological. Two theories prevail concerning its origin. According to one of them, spontaneous venous pulsation is caused

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