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A CASE OF MONOCULAR HYDROPTHALMIA*

With special reference to its possible relation
to the Sturge-Weber Syndrome

BY

ALEXANDER GARROW *and* ARNOLD LOEWENSTEIN

FROM THE OPHTHALMIC DEPARTMENT, GLASGOW ROYAL INFIRMARY
AND THE TENNENT MEMORIAL INSTITUTE,
WESTERN INFIRMARY, GLASGOW

I.—Introductory

RECENTLY we described a hydrophthalmic eye which had been removed on account of an injury to it. Since then an opportunity of examining another monocular hydrophthalmic eye has come our way. Angiomata were found in the choroid. The bearing of this upon a connection with Sturge-Weber's disease is discussed and also the possible role of space-occupying anomalies of the choroid in the aetiology of hydrophthalmia.

II.—Clinical

The patient is a girl now aged 11 years. She was first seen in the out-patient department of the Glasgow Royal Infirmary, aged $5\frac{1}{2}$ years, with a history of a large right eye of one year duration. It was a typical case of hydrophthalmia affecting one eye only. The tension varied between 40 and 60 mm. Hg. Cyclodialysis

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was performed in July 1934 without effect upon the tension. The eye was trephined in the following November but the high tension persisted. On December 21 trephining was repeated. On that morning, just prior to the operation, the tension was 61.5 mm. and the trephine hole of the previous operation was found to be blocked by iris tissue. The second trephining proved to be satisfactory so far as the tension was concerned, but a year later it was found to be 10 mm., and the hypotony persisted.

Two years later the child was brought to the out-patient department on account of redness of the eye. This was due to blood in the upper part of the cornea. Its lower limit was a straight line and it was concluded that the blood had dissected a path for itself through the part of the cornea which had been split at the trephining operation. It never became absorbed and in the course of time the cornea assumed a brown colour and finally this appearance involved the whole cornea, rendering it opaque. A network of vessels grew over the surface of the upper part of the cornea and the eye became watery and soft and then it began to shrink and it was removed on October 30, 1940.

III.—Pathological

In the case which is the subject of this paper the sections were examined after staining with haematoxylin and eosin and with Weigert's stain, Mallory, Berlin-blue, iron-reaction and von Kossa's calcium stain. The following is a description of the histological findings associated with the many clinical features of the case, namely hydrophthalmia, three decompression operations performed seven years ago, haemorrhage into the substance of the cornea five years ago followed by corneal blood staining and, finally, complete corneal opacity with much superficial and deep vascularity, prolonged pericorneal injection, hypotony for 7 years, and shrinking during the last year.

Cornea.—The epithelium is thickened and there is complete destruction of Bowman's membrane. Blood vessels are present in the usual subepithelial situation of pannus and in all the corneal layers and there is much connective tissue, and an increase of corneal corpuscles. Many of the parenchymatous blood vessels contain red blood corpuscles. It is remarkable that none of the changes found in eyes which have been the seat of blood staining of the cornea were present in our case although the haemorrhage was actually into the substance of the cornea five years ago. No refractile granules, thought to be precipitated albumen from the haemoglobin, and no pigmented granules (haemosiderin or haematoidin) were found. The cornea had been reddish for several months and the resultant opacity had at first a pinkish tinge and was finally a dirty gray: it was at no time of the greenish colour as in true corneal staining.

Descemet's Membrane.—There is an extreme degree of folding as shown in the microphotographs. (Figs. 1 and 2.) As in our case recently published (1941) the staining reaction shows the membrane to consist of layers, and Weigert stain reveals the

FIG. 1.

Defect of Descemet's membrane—connective tissue growing through it.

FIG. 2.

Splitting of Descemet's membrane by cyclodialysis. "a" points to the stump and "b" to the separated wavy piece of Descemet's membrane embedded in the connective tissue which fills the anterior chamber.

presence here and there of delicate wavy fibres (elastic) in the posterior corneal lamellae in close proximity to Descemet's membrane. At one periphery the membrane actually splits into two layers. These remain fairly close to each other for some distance and then separate widely. The posterior layer turns backwards

as if drawn there by the connective tissue in the anterior chamber and has an abrupt end, while the anterior layer is further split into many brush like wavy fibres which pass directly into the fibres of the sclera as it does normally. (Fig 3.) One rupture was found making a gap of 45-60 μ . The torn ends are straight and show no sign of regeneration. There is no tendency to curling of the ends. (Fig. 1.) This may be due to the tissue which entirely fills the anterior chamber which probably prevented the severed elastic lamina from springing apart to assume the curled up appearance

← Fanlike distribution of the margin of Descemet's membrane

FIG. 3.

found when the anterior chamber contains aqueous. The gap between the torn ends is filled with connective tissue from the anterior chamber growing into the corneal lamellae.

At a short distance from the summit of one fold a thin layer of Descemet's membrane measuring 2-2½ μ in thickness is embedded in the connective tissue which fills the anterior chamber. On one summit a small tag of Descemet's membrane measuring 8-10 μ in thickness is seen split off but still attached to the membrane. (Fig. 2.) On the slide it is possible to trace a direct continuation between this tag and the piece of membrane embedded in the connective tissue of the anterior chamber. It is almost certain that this thin layer of Descemet's membrane was split off by the spatula at the cyclodialysis of seven years ago. This is well known clinically. In a large proportion of cases which have been examined by the slit-lamp after cyclodialysis a split off piece of Descemet's membrane may be seen in the aqueous. It is remarkable that this split off layer of the glass membrane has survived for seven years and maintained its distinctive character first in the aqueous and then

surrounded by and embedded in the new formed connective tissue. In this respect the behaviour of the piece of glass membrane has been very different from that of other tissues which have been subjected to the proteolytic (dissolving) action of the aqueous. The disappearance of lens material in the aqueous after operation or trauma is a common experience and even the tough tissue of the sclerotic disappears in the course of time when the disc of a trephine operation slips into the anterior chamber. An exception to this dissolving action of the aqueous on scleral tissue has, however, occurred in the practice of one of us. (A.G.) The trephine operation was performed in 1928. The scleral disc slipped into the anterior chamber and is still seen, apparently unchanged, lying on the iris. It has not interfered with the eye in any way and its continued presence there was confirmed on December 15, 1941 (*i.e.*, after 12 years).

Anterior Chamber.—This is densely packed with connective tissue which so completely fills the chamber that no space is left, except in the depths of some of the concavities formed by the folding of Descemet's membrane where the connective tissue is not quite in contact with the latter. In these places the endothelium is present whereas it is absent where the connective tissue is in contact with Descemet. From this it may be assumed that the folding occurred *in vivo* and is not the result of fixation. Fibroblastic formation is evident in the tissue occupying the whole anterior chamber.

Iris.—This is atrophied and consists mostly of connective tissue with many cells of the fibroblast type, there being infiltration of the anterior part of the iris with lymphocytes. Indeed the iris has been so changed that it is not easy to see where it ends and where the connective tissue filling the anterior chamber begins.

Ciliary body and choroid.—The conditions found appear to have a bearing on the effect of decompression operations. There is great effusion of fluid both in front of and behind the choroid and ciliary body, so much so that the ciliary body is completely separated from the sclera and the fluid infiltration of the ciliary body has resulted in wide separation of its tissue into bundles. (Fig. 4.) The choroid is much swollen. There are spaces in it full of fluid and there is a large effusion both in front of and behind it. The choroid is detached from the sclera and there is a large sub-retinal effusion. Routine ophthalmoscopic examination demonstrates how very frequent is detachment of the choroid in hypotony following a decompression operation, especially with fistulization. When Heine published his first paper in 1905 on cyclodialysis he assumed that the efficiency of the operation was dependent on permanent communication between the supra-choroidal space and the anterior chamber. Salus disagreed with

FIG. 4.

Detachment of the ciliary body from the sclera by oedematous fluid and fibrin.

Heine and maintained that the injury to the ciliary body by the operation made it less active in the production of aqueous. Later Elschnig was able to support Heine's contention by demonstrating histologically the opening between the suprachoroidal space and the anterior chamber in a case of efficient cyclodialysis. Our case demonstrates permanence of the suprachoroidal effusion when hypotony has followed the operation. Apart from the effusion the choroid is much thickened throughout and infiltrated here and there, especially round the vessels, with lymphocytes. Many of the cells have eccentric nuclei with a large amount of eosinophil stained plasma while some of them contain typical eosinophil granules.

Just behind the equator there is a localised swelling of the choroid surrounded by connective tissue and somewhat similar to that near the optic nerve about to be described.

The Angiomata.—Three angiomata were found in the eye. They are quite distinct from each other and differ in structure and situation.

One is in the posterior end of the choroid and surrounds the head of the optic nerve. (Fig. 5.) On one side of the nerve it is $220\ \mu$ in thickness and extends $1\frac{1}{2}$ mms. laterally from the optic nerve. It is covered anteriorly by a sheet of connective tissue $270\ \mu$ in thickness. This angioma consists of veins, enlarged but showing the usual structure of the walls, and a number of them contain red blood corpuscles. A few arteries are seen. The connective tissue sheet, covering this angioma, has a structureless

centre surrounded by an area containing many syncytial cells and there are groups of pigment cells in the central structure-less area.

On the opposite side of the optic nerve the angioma is $81\ \mu$ in thickness, but the connective tissue sheet covering it is thicker than that covering the angioma on the other side. It is wedge shaped and measures $840\ \mu$ at its thickest part near the optic nerve and gradually tapers off for some distance from the nerve.

The second angioma is capillary and intraretinal, and is situated a short distance from the optic nerve. It consists of a group of

FIG. 5.

Fibromatous and angiomatous thickening of choroid on both sides of the disc (retina detached) (low power).

capillaries which are darkly stained, probably due to their blood content or to the lime deposition. Other parts of the retina do not show any such group of capillaries.

The third angioma is situated at the anterior end of the convoluted retina. (Fig. 6.) It is cavernous and consists of many thin walled spaces many of which contain red blood corpuscles. Although it is completely surrounded by the detached convoluted retina it is quite clear that it originates in the choroid. The angioma narrows to a stalk-like proportion and this stalk, which is homogeneous and structureless, can be traced to the anterior end of the choroid. At this point there is thinning and splitting of

FIG. 6.

Calcified angioma (high power) blood containing vessel (a). In both photo-micros sectioning of the calcified material was difficult. Without decalcification (note the stripes).

Bruch's membrane suggesting that the angioma had pushed its way through the membrane there.

Structure of the third angioma.—With Weigert's stain the dark purple walls of many of the vessels contrast sharply with the pinkish stain of others. The latter contain red blood corpuscles while the former do not. In the interior of the angiomatous tumour there are many large vessels cut longitudinally, thin walled, and packed with red blood corpuscles. Their thin walls are faintly stained. Most of the nonvascular tissue is connective tissue with some cells. Many of these are endothelial and are arranged in long rows, sometimes bent or curved. The angioma measures 0.8 mm. in one diameter and 1 mm. in the other. The tumour proved difficult to cut owing to its lime content. The parallel streaking of the sections by the microtome knife is clearly shown in the microphotographs. (Fig. 6.) The calcification of larger vessels is not regular. It is patchy and none of the calcified vessels contain red blood corpuscles. It is not only the vessels of the angioma which are calcified. Many retinal capillaries and pre-capillaries are covered with lime granules, and in places these are like minute hedgehog spines. Large spaces within the angiomatous tissue contain fibrin and dark brown pigment. No ossification or bone corpuscles were seen in it.

In passing it may be noted that it is only the venous type of cerebral angioma which is associated with facial naevi and the latter are also venous in type when associated with congenital glaucoma. Ringland Anderson says that the type may be

designated as part of the manifestation of trigeminal haemangiomas.

Bruch's membrane.—Is completely destroyed in parts. Where present it is covered by a diffuse vascular pigmented tissue.

Lens.—The anterior capsule is much folded and forms a wavy uninterrupted line across the section similar in appearance to Descemet's membrane. (Fig. 7.) There is a broad subcapsular layer of organized exudate with a few cells in it here and there, and behind it a much disorganized lens substance, very few of its fibres being preserved. (Fig. 7.) There is much lime deposit in this organized exudate (Fig. 7) and in the lental substance, most

FIG. 7.

Lens with calcified subcapsular organized exudate.

of its fibres being converted into a connective tissue-like structure. The lime is in granular masses or in layers like an onion corresponding to the anatomical structure of the lens. The anterior epithelium is entirely destroyed while an irregular posterior epithelium is seen here and there. In this subcapsular tissue there are spaces which appear to be due to cystic degeneration, and in it and in the disorganized lens are giant cells and cells with nuclei resembling those of cartilage cells.

Retina.—This is completely detached from the optic disc to the ora serrata and has assumed a convolulus shape running straight forward from the disc through the vitreous chamber. The layers of the detached retina have grown together so that there is no marked limitation between them and the surface has come together so much that it is only here and there that one can see narrow spaces containing all that remains of the vitreous. (Fig. 9.) The

retina shows many remarkable features—an angioma, deposition of lime and the presence of cysts.

The pigment epithelium layer is almost completely destroyed. In the neighbourhood of the optic disc it has proliferated and is in the three layers which merge directly with the broad layer of connective tissue which is in direct contact with and surrounds the disc, and already described in the paragraph on the choroid. Elsewhere the pigment has collected into groups of cells leaving other cells without pigment. Just under such an area Bruch's membrane is much thickened, forming drusen. On the surface of the pigment epithelium layer are many bladder cells, the ghost cells

FIG. 8.

Cyst-like holes in detached retina without epithelial linings. Some calcified capillaries in the centre. 5/8. Hae. E.

of Coats, fatty corpuscular cells. In our case it was not possible to stain for fat because the celloidin process had been used. The retina is not arranged in its normal layers. The latter are mixed up to form a conglomerate mass of cells. These, although arranged in disorder, appear to be mostly quite normal. Some of them, however, are large with sharply outlined round nuclei, stained purple, and much swollen and contain pigment needles.

Retinal Cysts.—In every field one sees many cyst like spaces, ranging from $27\ \mu$ in diameter. (Fig. 8.) They are sharply outlined by a darkly haematoxylin stained margin. In none of them could we see any epithelial cell lining. The lining appeared to be formed by a dense glial tissue although some showed a broad indistinct margin, as if formed from colloid material. Some of the cysts contain pinkish stained plasma but most of them are quite

empty and may have contained fat although this cannot be proved because the fat, if it had been there, has been extracted by the alcohol-ether in the celloidin process. This type of cyst is due to degeneration, probably fatty, and begins as a slit in the tissue which gradually enlarges to form a cyst. It differs entirely from the retinal cysts found in Bourneville's disease. These cysts are lined with epithelium and contain undifferentiated neural elements. They can be seen with the ophthalmoscope when they appear on the surface of the retina. They may burst and the contents, after floating in the vitreous, may become implanted and grow on other parts of the surface of the retina. Microphotographs of unburst and burst cysts may be seen in the paper on a case of Bourneville's disease by Loewenstein and Steel (1941).

Internal limiting membrane.—The surface of the detached retina is covered with a dark purple almost black much folded membrane,

FIG. 9.

Detached retina surrounding a small central vitreous. Retinal surface is covered with a calcified membrana limitans interna.

FIG. 10.

Lime at the inner surface of haem. stained membr. limit. int.

2-3 μ thick. (Fig. 9.) It corresponds in its situation to the *membrana limitans interna*. It is not uniformly calcified, but where not calcified it is much thickened. With the highest magnification one sees that this membrane has on its surface a minute lime deposit. (Fig. 10). In several places the membrane in one section is cut three times—a proof that the surface has many short wave undulations. The sections are 15 μ thick.

Retinal Capillaries.—A group of retinal capillaries was studied in a longitudinal section of the anterior end of the convoluted retina. An unstained section showed a slight roughness of the capillaries and when stained with haematoxylin eosin this roughness was found to be due to minute dark particles arranged in an irregular manner on the capillaries and in the retina immediately

FIG. 11.

Calcified capillaries.

alongside the capillaries. This caused indistinctness of the outline of the vessels. These particles caused the affected capillaries to be rough in appearance. (Fig. 11.) We conclude that they consist of lime, and, if so, this is an interesting analogy with what is known to happen in the analogous cortical vessels in some of the cases of Sturge-Weber's disease.

The evidence of calcification in the retina in our specimens (Fig. 12) resembles closely the appearance shown in Fig. 239 in Spielmeyer's monograph on the histopathology of the nervous system. This figure is a microphotograph of the capillaries in an atrophic corpus quadrigeminum in Little's Disease. In our case the Berlin blue reaction for iron was strongly positive as also was Von Kossa's lime reaction. Spielmeyer's explanation that the iron was later reabsorbed by lime may be valid for the retina too.

We found in the retina another condition similar to that described in brain tissue by Spielmeyer, namely calcified ganglion cells. (Fig. 13.) These are situated close to the completely calcified

membrana limitans interna. The degree of the calcification of these cells varies. In some the individual particles of lime can be recognised (Fig. 13a) in others the lime assumes a delicate needle-like shape (Fig. 13d) while in others there is so much lime that the nucleus is completely covered (Fig. 13b.) In another place

FIG. 12.

Calcified retinal capillaries.

FIG. 13.

Calcified ganglion cells. For description see the text.

FIG. 14.

Amorphous masses of lime in retinal tissue.

the lime deposit had no definite cellular limit, as if the impregnated ganglion cell had become completely degenerated (Fig. 13c) while in other places large round clumps of amorphous lime are seen. (Fig. 14.) Some of the glial cells are also deeply impregnated with lime.

IV.—Discussion

The object of our first paper was to give a description of the changes found in a hydrophthalmic eye. In this case, in addition to the many changes due to hydrophthalmos we found three angiomas. The first is in the choroid at the posterior pole round the optic nerve. Another is in the retina near the optic nerve and the third is in the anterior part of the eye and, although it is almost completely surrounded by folds of the detached retina, a connection can be traced between it and the choroid. The presence of those angiomas raises the question—does it bring this case of hydrophthalmia into the group of anomalies to which van der Hoeve (1923 and 1932) gave the name phakomatoses (Birthmarks).

Furthermore from what follows in this paper on the subject of angioma these questions may be asked. Is monocular hydrophthalmia ever uncomplicated or is it always a part of a syndrome to which, in its fully developed form, the name Sturge-Weber is attached? The features of the fully formed Sturge-Weber syndrome are hydrophthalmia, naevus flammeus of the face, and angioma of the pia mater. When one remembers the similarity of the choroid to the pia mater it would appear to be justifiable to suppose that choroidal angioma is also often a part of

the syndrome, making it hydrophthalmia with cutaneo-meningo-
uveal angioma. Anyone of these alone, or any two or all three of
these may occur either associated or not with hydrophthalmia.

The chances against the detection of an angioma of the choroid
are many. The ophthalmoscopic diagnosis is difficult and un-
certain under the best circumstances. In hydrophthalmia in
which changes interfering with the transparence have usually
occurred it may be ruled out altogether.

The discovery of an angioma of the choroid will therefore depend
upon the chance of getting the eye for pathological examination
and upon the methods employed in that examination. For
example, Ballantyne in 1930 published a case of left monocular
hydrophthalmia with facial naevus occurring in a male infant of
three weeks. It was not until 1940 that he was able to fill in the
picture by examining the excised eye. He found an extensive
angioma of the choroid, the microphotograph of which may be
seen in his 1940 paper and an angioma of cerebral vessels was
inferred. Twitching of the right eyelids and right angle of the
mouth had been reported and confirmed on several occasions, but
calcifications of the inferred cerebral angioma had not taken place,
or had not yet gone far enough for their presence to be revealed
by X-ray examination.

Another example of chance is afforded by the present case. The
opportunity of examining the excised eye and the discovery of
angiomata in it came seven years after our first association with the
case.

In the matter of the method employed in the examination of the
excised eye we would stress the importance of examining the retina
and choroid on the flat and in bulk. In this way one is less likely
to overlook an angioma than in the usual examination of sections.
The following case may be cited as an example of this.

It was one of tuberosc sclerosis of the brain (Bourneville's
Disease). The patient died and one eye was obtained through the
courtesy of Dr. Ivy MacKenzie. Under the microscope the retina
was examined in bulk and a small tumour measuring 1 mm. in
diameter was found in the periphery. It is a typical angioma
(Fig. 15) with lime incrustations on the vessel walls and fatty
changes in the plasm, and in addition, the peripheral part of the
retina is covered with a cloudy organized tissue with many blood
vessels in it containing red blood corpuscles. The small angioma
would easily have been overlooked, even histologically, if the
retina had been examined in the usual way in sections.

There is little doubt that angioma of the choroid is much more
common than is thought. Thus Lindemeyer (1932) refers to 56
cases of choroidal angioma. In 38 of them it was found acci-
dentally in eyes removed for absolute glaucoma, and Dumphy

FIG. 15.

Small retinal haemangioma (1mm. diameter) in a case of Bourneville's disease. (Retina in bulk-stained scarlet red, low power).

(1935) refers to 14 globes from cases of hydrophthalmia with facial naevi. Choroidal angioma was found in ten of them and he suggests that if all eyes enucleated for glaucoma were examined microscopically angioma would be found more often.

In discussing pial angioma, which within the cranium is the analogue of choroidal angioma, Cushing states that a case of naevus of the face with contralateral Jacksonian epilepsy or cerebral palsy of some form justifies the diagnosis of pial angioma even if X-ray examination is negative.

Neuro fibromatosis (von Recklinghausen's disease) is the other member of the phakamotosis group of anomalies which is often accompanied by hydrophthalmia. It is significant that the trigeminal nerve presides over the regions which are the seats of the angiomata under discussion namely, the upper face, the meninges, and the eye. The facial naevi are often strictly delimited to the areas supplied by the branches of the 1st and 2nd divisions of that nerve and the nerve itself may be the seat of neurofibromatosis and this may or may not be accompanied by hydrophthalmia. When von Recklinghausen's disease is accompanied by hydrophthalmia the affected site of the former is usually the upper lid and temple, although neurofibromatosis of the lids and orbit may not be accompanied by hydrophthalmia. Ringland and Anderson analysed the records of 32 cases of hydrophthalmia and

facial neurofibromatosis. The glaucoma was unilateral in every case although congenital glaucoma in general is bilateral in 70 per cent. of the cases. Two cases were examined histologically. Hypertrophied ciliary nerves and a diffuse thickening of the choroid were the changes found accompanied by the characteristic iris-like sheet of tissue in the corneo-iridic angle.

Treacher Collins states that all portions of the ciliary nerves supplying the eye may be affected by congenital neurofibromatosis, but Verhoeff has referred to cases of neurofibromatosis in the choroid and ciliary body and yet no hydrophthalmia.

In a recent paper (1941) Robson, Blackwood, and Cookson describe a case of neurofibromatosis affecting, amongst other parts, the upper lid but unaccompanied by hydrophthalmia. They found general thickening of the choroid with a focal accentuation amounting to a tumour in one part, and consisting of connective tissue containing medullated and non-medullated nerve fibres and nerve cells. This tumour was herniated through the sclera and formed a mass on the outer surface of the eyeball. Van der Hoeve (T.O.S. Vol. 52 p. 341) states that he has seen greyish white masses in the fundus in Von Recklinghausen's disease. May these be growths inwards of a choroidal tumour instead of outwards as in the case of Robson, Blackwood, and Cookson?

Sturge-Weber's disease and von Recklinghausen's disease are then, the two members of the phakomatosis group, which are often accompanied by hydrophthalmia. Is there a common factor as the reason for this? It is tempting to think that one finds it in the choroid. In the former disease the choroid is the seat of angiomas and in the latter disease of neurofibromatosis. Both of these are space occupying, and would thus tend to raise the tension and produce hydrophthalmia in an eye which may be the seat of defects in the size or position of Schlemm's canal, or of persistence of uveal tissue around the corneo-iridic angle. And in both cases the abnormal growth of tissue in the choroid is subject to the influence of trophic disturbance. The theory advanced by Ginsburg and Hudelo is referred to by Ballantyne in his 1930 and 1940 papers. They suggest that in some cases the angiomas may be sufficiently developed to establish the glaucomatous process during antenatal life (hydrophthalmia) while in others the evolution of the neoplasm is delayed until adult life and we get the form of glaucoma met with then. Support for this theory is given by the accidental finding of 38 cases of choroidal angioma in eyes which have been removed on account of absolute glaucoma. This has been referred to above. A probably relevant adult case has come under our notice through the kindness of Professor Ballantyne and Professor Riddell. The patient is a male, aged 25, who had a capillary naevus on the left frontal and temporal regions,

varicosities and aneurysmal dilatations of the conjunctival limbal loops of anterior ciliary veins and of scleral vessels on the left eye. He was admitted to the Tennent Memorial Institute on January 27, 1940, suffering from an attack of congestive glaucoma of the left eye, with steamy cornea, dilated pupil, and a tension of 80. Later, when the cornea was clear deep glaucomatous cupping of the optic disc was found. (And the retinal arteries were almost equal in size to the veins and some of the arteries showed slight expansion of calibre towards the periphery.) The fundus of the other eye was normal.

Any study of those four groups of anomalies (Treacher Collins, von Hippel-Lindau, Bourneville, von Recklinghausen and Sturge-Weber) stimulates the question as to why hydrophthalmia is associated with only the last two of these. Here again the choroid may possibly supply the answer.

The anomalies grouped together by Van der Hoeve are:—

(1) Sturge-Weber's disease (naevus flammeus of the face, meningeal angioma and hydrophthalmia or glaucoma).

(2) Von Recklinghausen's disease (neurofibromatosis, often accompanied by hydrophthalmia or glaucoma).

(3) Treacher Collins—von Hippel-Lindau disease (angiomas of retinae with changes in the cerebellum, medulla and spinal cord as well as in other organs, *e.g.*, the kidneys, pancreas, etc, *not* associated with hydrophthalmia).

(4) Bourneville's disease (tuberoses sclerosis of the brain, chiefly the cerebrum, often accompanied by cysts in the retina, and angiomas of retinae; *not* associated with hydrophthalmia).

Clinically and histologically there is so much overlapping of the conditions found in these four diseases that it is difficult to determine exactly the mode of their origin, and the difficulty is the greater from the fact that when the cases come under observation time has elapsed to permit of this overlapping and of secondary changes in the eye. This applies particularly to the pathological examination of the eye excised many years later. But it would appear that the last two diseases of the above list (Treacher Collins—von Hippel-Lindau and Bourneville) form one division and the first two (von Recklinghausen's and Sturge-Weber) another. In all of them the defect is developmental. In some it is primarily and predominantly in the neural epiblast and in others it is in the mesenchyma, with, in each case, a secondary overflow of the defect and its consequences from the germinal layer primarily affected into the other. Van der Hoeve (1932) says that it is evident that the eye tumours in these phakomatoses originate in one germinal layer only, the Treacher Collins—von Hippel-Lindau in the mesodermal and the Bourneville in the ectodermal; and further that in all these cases we find proliferation of the glial tissue

without knowing whether it is primary or secondary. He sums this up by saying that these phakomatoses are anomalies of congenital origin which do not stick to one germinal layer only, although every one of them has a germinal layer of predilection which it affects mostly, and that they are simply different anomalies belonging to the same group. As a help to understand how these vascular malformations originate Ringland and Anderson commend Streeter's description of five periods in the development of the cranial vascular system. These are (1) The primordial plexus is formed. (2) This slowly resolves itself into arteries veins and capillaries. (It has been suggested that disturbances of development in this stage would result in the anomaly known as Treacher Collins—von Hippel-Lindau Disease). (3) As the meninges and the cranium develop the vascular system breaks up into a superficial (skin) and a deep (meningeal) supply. (Ringland and Anderson suggests that disturbance in this stage would result in vascular naevus on the scalp and on the face, or varices in the dura or to angioma in the pia and its analogue the choroid, or to all of them simultaneously.) (4) A series of changes in the vascular trunks occurs. (5) The histological changes necessary for development of mature arteries and veins are completed.

Thus the blood supply of the face, meninges, and choroid is from the outer vascular system while that of the retina is from the inner. The hydrophthalmia members of the group result from a developmental defect of the former system and the non-hydrophthalmic members from the latter. It is true that an angioma of the choroid may be found in a case belonging to the non-hydrophthalmic group. This has been recorded by A. Loewenstein and Janet F. Steel (1941) in a case of Bourneville's disease. On the other hand there may be extensive involvement of the choroid and yet no hydrophthalmia in a case belonging to the hydrophthalmic group, as in the case of Robson, Blackwood, and Cookson quoted above. Such cases raise an objection to the suggestion that the presence of space occupying new growths in the choroid are factors of major importance in the aetiology of hydrophthalmia. But that is not the only difficulty that one encounters in trying to find some underlying principle to explain all the combinations which are found in this group of anomalies. Nevertheless we think that there is evidence that involvement of the choroid is an important factor in producing hydrophthalmia in an eye which is the seat of even slight developmental defects in the corneo-iridic angle.

V.—Summary

A description is given of a case of monocular hydrophthalmia with calcified angiomata of the choroid. The relation of such a case to the Sturge-Weber syndrome is discussed. It is suggested

that angioma of the choroid may be the connecting link between these two diseases.

Calcification of the ocular tissue (capillaries, angiomata, internal limiting membrane and ganglion cells) was a feature of the case.

Reference is made to the allied anomalies—von Recklinghausen's disease, the Treacher Collins—von Hippel-Lindau disease and Bourneville's disease.

A brief description is given of an angioma of the retina recently found in a case of Bourneville's disease.

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IONTOTHERAPY

(Ionic Medication, Iontophoresis, Ionisation)

AS AN AID IN OPHTHALMIC THERAPEUTICS

BY

NORMAN FLEMING

LONDON

IONTOTHERAPY in ophthalmology is far from being a new form of treatment, but the old methods were somewhat laborious and the results not over encouraging. No doubt there were reasons for this and my experience suggests that too strong currents, too strong solutions and too long applications, were among the causes of disappointment. Furthermore, the very feasibility of the treatment has been doubted and even denied.