TIFFANY (F.B.) Compliments of the author

Dr B. Joy Jeffries

GLAUCOMA.

BY

Flavel B. Tiffany, M. D.,
of Kansas City, Mo.

A paper read before the Missouri State Medical Society, at Jefferson City, May, 16, 1883

SAINT LOUIS.
Reprinted from the
SAINT LOUIS MEDICAL AND SURGICAL JOURNAL
September, 1883.

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ST. LOUIS:
MEDICAL JOURNAL PUBLISHING COMPANY.
2622 WASHINGTON AVENUE.
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Glaucoma.* By Flavel B. Tiffany, M. D., Kansas City, Mo.

Gentlemen: In considering the subject of glaucoma, that we may better understand the pathology and etiology of the disease, I would first call your attention to the anatomy and physiology of the organ in which this dire disease is located; more especially to the ciliary region, and the parts in close proximity. Cursorily glancing at the globe, we find that it consists of a certain number of tunics and refracting media, with numerous vessels and nerves. The structures to which I particularly wish to call your attention are Schlemm's canal, and those

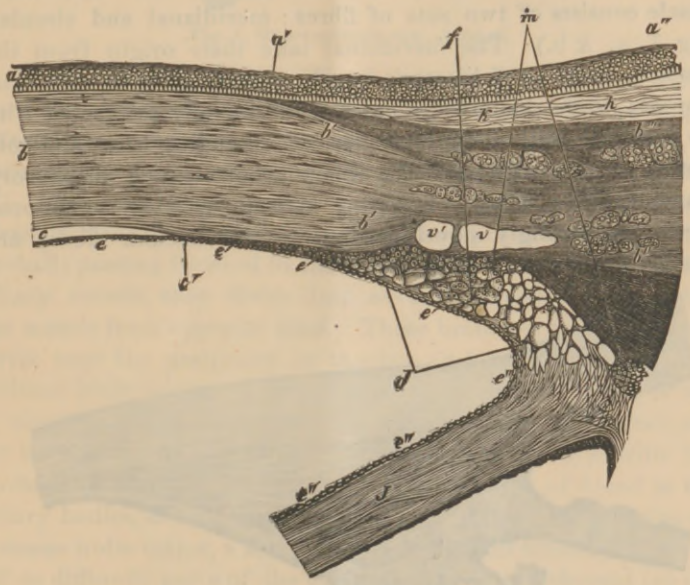

Fig. 5, Section of normal eye through the ciliary region —Williams.

in near proximity. Schlemm's canal is the circular canal sit-

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uated at the junction of the cornea with the sclera, in front of the ciliary attachment of the iris. (Fig. 5, v. v'.) Internally and posteriorly it is bounded by the ligamentum pectinatum iridis and the ciliary muscle; anteriorly and externally, by fibres of the cornea and the sclerotic. The iris or diaphragm of the eye (J), consists of two sets of fibres, radiating and circular, with blood vessels; nerves, etc. Anteriorly the iris is attached to the cornea by the ligamentum pectinatum iridis; in fact, this ligament is a continuation of the endothelium of the cornea (Desemet's membrane, d). The radiating fibres of the iris become continuous with those of the ciliary muscle, and ciliary processes (Fig. 7), which muscle and processes are principally formed by folds or plaitings of the middle and internal layers of the choroid.

The canal of Fontona is the triangular space enclosed by the ligamentum pectinatum, cornea, ciliary muscle, and iris. (Fig. 5, f. m.) It is crossed by bands of fibres, and is a loose cellular net-work which connects with Schlemm's canal. The ciliary muscle consists of two sets of fibres: meridianal and circular. (Fig. 7, a. & b.) The meridianal take their origin from the posterior wall of Schlemm's canal, extending back upon the choroid; while the circular are more intimately connected with the posterior wall of Fontona's spaces, extending back, and connecting with the fibres of the ciliary processes and suspensory ligament. (Fig. 7, a.) In highly myopic eyes the meridional fibres are strongly developed, while the circular fibres are scarcely to be seen. (Fig. 6.)

Fig. 6, Section of a myopic eye.—Ivonof.

In the hypermetropic eye the opposite conditions prevail.

The meridional fibres are short, while the circular are highly developed. (Figs. 7 & 14.) Immediately posterior to the iris we have the crystalline lens in its capsule, supported by the suspensory ligament, the vitrious body, and ciliary processes.

Fig. 7, Hypermetropic eye.—Ivonof.

Blood vessels of the eye (Fig. 8.) according to Lieber, represents the distribution of blood vessels to the eye. The principal arterial blood supply to the anterior portion of the eye, is through the long posterior (c) and the anterior ciliary arteries (f). The posterior penetrate the sclera in a very oblique course about midway between the equatorial and posterior parts of the eyeball; passing forward in the outer layer of the choroid to the ciliary muscle, they divide into several branches, penetrating the muscle from opposite sides. These branches uniting, form a circle near the periphery of the iris (g & h). the circulus arteriosus iridis major. The anterior ciliary arteries, eight or ten in number, arising from muscular branches of the opthalmic, enter the eye in the region of the ciliary muscle, unite with the circle just described, assisting in the distribution of blood to the ciliary bodies, ciliary ligament, and iris. From the circulus arteriosus iridis major, a series of very important branches is given off to different parts of the eye ball, viz.: to the choroid (*n*) ciliary processes (l) and iris (i). The recurrent branches passing back into the ciliary muscle (m) are very numerous, forming a perfect meshwork throughout the muscle. The arterial twigs to the ciliary processes are short tubes, which enter these bodies from the circulus arterious iridis major. After they have trav-

ersed the ciliary muscle, each, of the seventy or eighty processes receives two or three twigs; in each process itself, the arterial vessels split up rapidly, and subdivide into a considerable num-

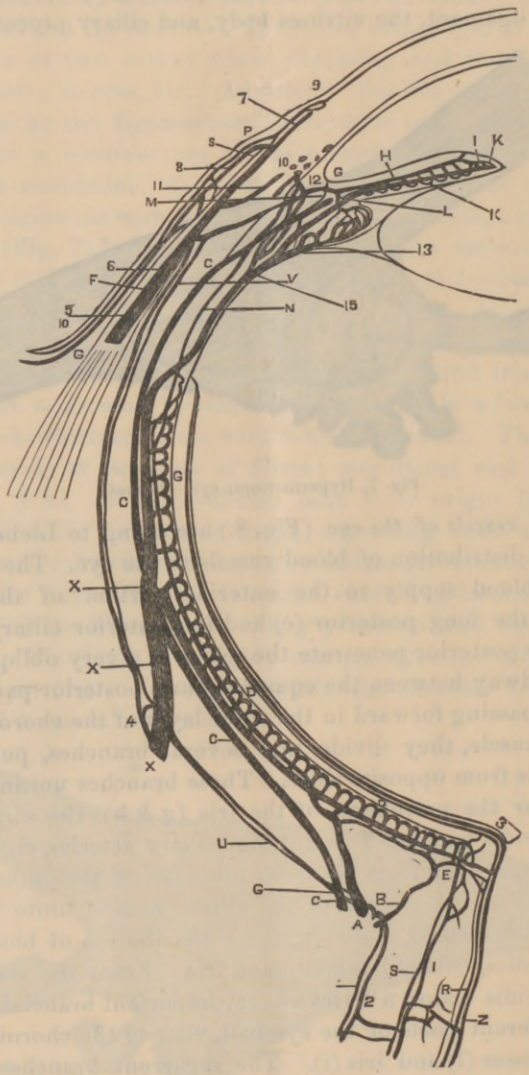

Fig. 8, Section representing the bloodvessels of the eye.—Frey.

ber of finer tubes, which form a perfect net-work of blood vessels in this region. From the latter arterioles spring the venous

radicals of the parts (18), which finally empty into the venæ vorticosæ (x), which veins pierce the sclerotic near the equatorial part of the eyeball. The vessels supplying the iris are all derived from the circulus arteriosus iridis major. They form a wide vascular net-work through the stroma of the iris, converging toward the pupil near its margin they form a new vascular circle,(the circulus arteriosus iridis minor) (i). From this, branches are still further, given off which supply the sphincter of the pupil (k), and finally merge into venous radicals. The veins of this part of the eye are nearly as numerous as the arteries; crowded close together, they unite at very acute angles to form larger branches; some of which finally empty into the venæ vorticosæ (x); others take their exit through Schlemm's canal (19). Some twenty-five or more quite large branches, mostly from the ciliary muscle (12), leave the eye at this point, where they pierce the sclera quite obliquely, and upon its surface empty into the ciliary veins (17). Hence we see, gentlemen, that this portion of the eye is highly vascular, that the blood vessels are closely packed, requiring but a slight disturbance in the anatomical parts to produce a disturbance in the circulation. Accompanying the blood vessels we find an equally complex structure of nerves ramifying and traversing these structures of the eye. The ciliary nerves, which supply the cornea, pass through the ciliary bodies, ciliary muscle, and iris, via Schlemm's canal to the cornea, about sixty in number, terminating as filaments void of their medullary sheath, they finally end, according to Cohnheim, in the nucleoli of the epithelial cells of the cornea.

PHYSIOLOGY.

The office of the crystalline lens, together with the other refracting media,is to cause luminous rays to be focused upon the rodsand cones of the retina. Now, in the emmetropic or typical eye, the

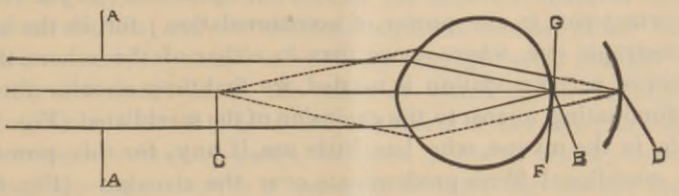

Fig. 9.

refracting media is such that parallel rays, AA or rays coming from

distant objects, are brought exactly to a focus upon the rods and cones of the retina (Fig. 9, f g). For all other rays, viz.: those coming from near objects, which are divergent rays (Fig. 9 c), there must be some change in the refracting media. In hypermetropia, on the other hand, this change must take place for *all* rays—rays coming from distant as well as those from near objects. The refracting power of the hypermetropic eye being too low to focus parallel rays upon the retina, much less

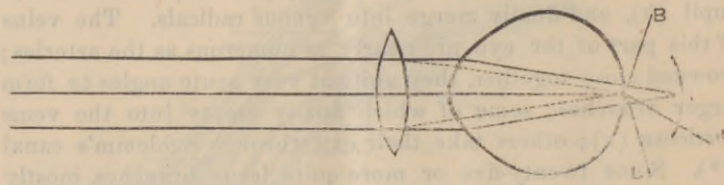

Fig. 10.

can it focus divergent rays. (Fig. 10.) This altering power, then, plays constantly in the hypermetropic eye. In the myope the eye is adjusted for divergent rays; these, only, it focuses upon the retina, and hence; for distant objects, it must make use

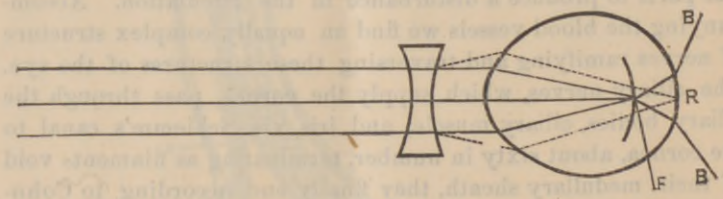

Fig. 11.

of some external power, as concave glasses. (Fig. 11.) This power *in* the *eye* is called the power of accommodation. And this power is located in the ciliary muscle; but just what its *modus operandi* is, science has not yet determined; it is evident, however, that the *circular fibres* of the ciliary muscle play a very important part in the power of accommodation; for, in the hypermetropic eye, where more than in either of the others, this power of accommodation is needed. we find these circular fibres predominating, almost to the exclusion of the meridianal (Fig. 7), while, in the myope, who has little use, if any, for this power, the meridional fibres predominate over the circular. (Fig. 6.) In the emmetrope the two sets are more nearly equal. This reasoning concerning the use of the accomodation power, depends

upon the fact that, as a rule, people are more engaged with near objects than with distant.

ETIOLOGY.

This brings us to the etiology of glaucoma, for I wish to take the position, gentlemen, that hypermetropia, and its first cousin, presbyopia, if not the original causes of glaucoma, are at least *largely*, almost *infinitely* concerned in its development. Let me emphasize, gentlemen, byrepeating the structure of the hypermetropic eye. In hypermetropia, as we said, the refractive power of the eye is too low or the antero-posterior axis of the eyeball is too short, so that when the eye is in a state of rest, parallel rays are not united upon the retina, but behind it. (Fig. 10.) To remedy this condition, in order that the hypermetrope may be able to get a clear image of the object, the eye undergoes a change in its power of refraction sufficient to unite the rays upon the retina.

"The less the power of refraction of the hypermetropic eye, the greater must be this effort of accommodation and it must increase, of course, proportionately, as the object is brought nearer to the eye." Hence, we see that the hypermetrope is using his power of accommodation all the time, whether he is looking at near objects or at those at a distance; there is, then, a *constant strain* of accommodation. The ciliary muscle and processes are constantly at work, so long as the individual is regarding *any* object, be it *near* or *distant*. Hence the reason of the circular fibres and ciliary processes of the hypermetropic eye being so much more developed than those of either the emmetropic or myopic eye. Let us notice what takes place in the act of accommodation. The pupilary margin of the iris moves forward, while the ciliary margin is drawn outwards towards Schlemm's canal, the anterior surface of the lens becomes more convex and advances toward the cornea, the anterior chamber becomes more shallow, and its contents (aqueous humor) either become more dense, or escape more freely through some channel, probably Schlemm's canal, the office of which canal, doubtless, is to transmit the fluids of the chambers of the eye; thereby allowing a constant change in these fluids of which, reasoning from analogy, there is a necessity in order that the eye may remain in a healthy condition. We are led to this belief by the fact that, under special conditions, there is a very copious secre-

tion of the aqeuous humor as, for instance, after the operation of paracentesis of the cornea and of iridectomy in which the chambers are evacuated, and the cornea collapses; in a few seconds the humor is re-established, and the cornea resumes its normal curvature. This copious flow presupposes a secreting membrane (Descemet's membrane) which, to be in a healthy condition, must be active, and the supply constant. Consequently, the drain must also be constant. This drain must be either by the process of exosmosis, or through some canal or duct. The sclera and cornea are both dense structures, and the exosmosis through them would be slight. Just at their junction, as we have seen, is Schlemm's canal, opportunely situated for this very work of draining, hence we are *presumably logical* in *concluding* that *this is* its *function*. Presbyopia is not an anomaly of refraction, but, of accommodation. It is a condition which appears in every emmetropic and hypermetropic eye after a certain period of life. In the emmeotropic eye it appears at the age of forty-five years; in the hypermetropic it may appear much earlier.

What is presbyopia? It is simply an arrest of the power of accommodation; an insufficiency upon the part of the ciliary muscle to perform its function. For a certain number of years we are able to see near objects as well as those at a distance. Whenever we want to look at a near object, the little ciliary muscle, springs into action, renders the lens more convex, adjusting it so as rightly to focus divergent rays upon the retina, and we get a clear image of the object; but, after a certain number of years this muscle, which is almost constantly called into use in the emmetrope, because as a rule we are largely employed with near objects, and in the hypermetrope is used *without* cessation, becomes tired (in common parlance), and refuses to perform its function, and the individual experiences a corresponding dimness of vision. You may readily see, gentlemen, that if this condition is allowed to go on without being corrected by the proper glasses adjusted, some lesion is almost sure to arise. As a further evidence that this condition is due to weariness of the ciliary muscle, I would call attention to an occasional phenomenon termed by the laity "second sight." By the use of glasses the muscle is relieved of its work, and after resting for a period of time, (several years) its power is re-established, and the person is able to read even the finest print with the naked eye. An instance of which I had a few days ago in the testimony of a patient nearly eighty years of age. He had used glasses for nearly twenty years, when he was able to lay them aside, and read fine print with the naked eye.

This lesion, the direct result of the strain of the power of accommodation induced by hypermetropia and presbyopia, at least sets with a wonderful impetus toward glaucoma. And here allow me to suggest, gentlemen, the importance of every

physician being able to recognize these anomalies, and to correct, or have them corrected before the complications arise.

What is glaucoma? Glaucoma, as I believe, is a disease in which there is an obstruction of Schlemm's canal with some lesion in the ciliary region, which is peculiarly liable to be disturbed here on account of the very complicated net-work of blood vessel and nerves entering and leaving the eye at this point.

SYMPTOMS OF GLAUCOMA.

1. Increased tension of the globe.
2. Rapid increase of any pre-existing presbyopia.
3. Venous hyperæmia.
4. Dilatation and sluggishness of the pupil.
5. Cloudiness of the aqueous and vitreous bodies.
6. Periodic dimness of sight.
7. Appearance of a halo of prismatic colors about a light.
8. Contraction of the field of vision.
9. Ciliary neuralgia.
10. Anæsthesia of the cornea.
11. Scotomata.
12. Arterial pulsation at the fundus of the eye and cupped disk.

Von Graefe has divided glaucoma into four stages :

I. Premonitory—Glaucoma imminens, where many, or even all of the above symptoms may appear, though with intermissions, and in a less marked degree than in the second stage.

II. A fully developed stage—Glaucoma evolutum.

III. The third stage he terms Glaucoma Consummatum, a stage in which quantitative perception of light has been completely lost for some time.

IV. The fourth stage is where the eye undergoes glaucomatous degeneration, and instead of the eyeball being over tense, the tension often falls much below the normal.

Considering the different symptoms as given, we shall endeavor to show clearly the relation between cause and effect.

Taking them in the order given :

First symptom—The patient complains of a fullness of the eye ball, as though the globe was too large for the orbit, and upon examination we find that the tension is considerably increased ; the pressure made upon the globe with the eye closed and directed downwards, reveals the eye as hard, varying from a slightly perceptible increase to that of stony hardness, according to whether the disease has reached the first, second, or third stage. Now to

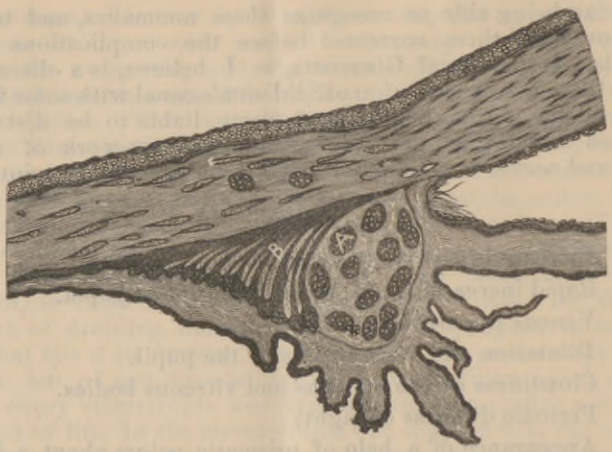

Fig. 14. Section of a glaucomatous eye in ciliary region.—Tiffany.

what is this increase of intra-ocular tension due? In the physiological eye we know that there is a constant escape of the aqueous fluid; probably through the canal of Schlemm. In the glaucomatous eye (Fig. 14) we find the following conditions, viz.: swelling of the ciliary processes, hypertrophy of the ciliary muscle, adhesions of the iris to the cornea, obliteration of Fontona's spaces, and consequently obstruction of Schlemm's canal; as a result of which we have an accumulation of fluids, or intra-ocular tension; and upon *this*, gentlemen, hang all the other symptoms.

Second symptom—Rapid increase of any pre-existing presbyopia. The patient finds it necessary to change his glasses very frequently for stronger ones What does this mean? It means that the ciliary muscle is becoming involved, and is *rapidly loosing* its power of accommodation.

Third symptom—Venous hyperæmia. The anterior ciliary veins become engorged and tortuous, which is simply due to the intra-ocular tension which impedes the circulation.

Fourth symptom—Dilatation and sluggishness of the pupil. Upon examination we find that the pupil is more or less dilated, according to the stage of disease, and does not respond readily to the stimulus of light.

To what are these conditions due? In our anatomical review we found that the motor nerves supplying the circular fibres of the iris, viz.: branches of the *third* pass through the ciliary regions; hence, with the other structures, they become involved, and consequently lose their functional power, leaving those which supply the radial fibres, viz.: sympathetic, to gain a preponderanceof power and thus produce dilatation and inactivity of the pupil.

Fifth symptom—Cloudiness of the aqueous and vitreous humors. The aqueous humor is found to contain leucocytes, epithelial cells with more or less granules of pigment. The patient complains of seeing specks or cobwebs floating before his eyes. Upon examination, the vitrious is found to contain pigment, corpuscles, and striæ floating about, showing that some dissolution of the ciliary processes or choroid, or both, has taken place; originally due to the lesion in the power of accommodation and obstruction of Schlemm's canal.

Sixth symptom—Periodic dimness of sight. The patient in the premonitory stage, often complains of periodic dimness of sight. This is probably due to temporary disturbance of the intra-ocular circulation. This dimness can be easily produced by merely pressing upon the globe (thus) showing that a very slight disturbance of the intra-ocular circulation will affect the vision.

Seventh symptom—The halo of prismatic colors around the light. This is one of the most constant symptoms of glaucoma, especially in the earlier stages. The outer part of the ring is red, the inner bluish green. "This halo is only seen when the pupil is dilated, and it is probably due to a diffraction of the rays of light owing to a change in the refracting power of the lens," especially at the periphery, or that portion nearest the ciliary region or seat of the disease. Hence, we refer this symptom to the lesion of the ciliary muscle.

Eighth symptom—Contraction of the field of vision. The field of vision is usually greatly limited. The contraction usually beginning in the equatorial portion of the globe, going on to such an extent that the patient will describe his limitation of vision as if he were looking through a tube. The most probable reason of this limitation of the field of vision beginning in the equatorial region *is*, that this is the portion of the retina nearest to the seat of the disease (ciliary region), and also that the venæ vorticosæ leave the eye at this part.

Ninth symptom—Ciliary neuralgia. This symptom in the accute form of glaucoma is *always present* throughout *all* the different stages. The patient complains of a *sense* of aching and a tightness of the globe, with pain extending toward the right orbit over the brow, through the temples and down the nose. "The pain is *most severe*. Sometimes of an almost madning character; but the most *intense* agony is often felt in the back of the head;" this is usually accompanied with severe vomiting, assuming the character of a bilious attack, for which by the superficial observer, it might be taken. This ciliary neuralgia is undoubtedly due to the pressure upon the ciliary, and branches of the trigeminal nerves as they pass into the eye and through the ciliary region.

Tenth symptom—Anæsthesia of the cornea. This is quite a frequent symptom of glaucoma, especially in the chronic form.

The cornea becomes so anæsthetic that it can be touched with the finger or brush without occasioning the slightest pain. We have seen that the nerves supplying the cornea pass through the ciliary region, a sufficient explanation for this phenomenon.

Eleventh sympton—Scotomata, or blind spots, of which the patient occasionally complains, is usually due to hemorrhagic patches upon the retina, referable to the intra-ocular tension.

Twelfth symptom—Arterial pulsation at the fundus of the eye and cupped disk. These symptoms, which the opthalmo-

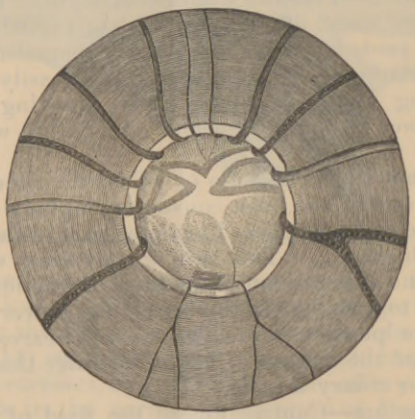

Fig. 12. Glaucomatous cup.—Noyes.

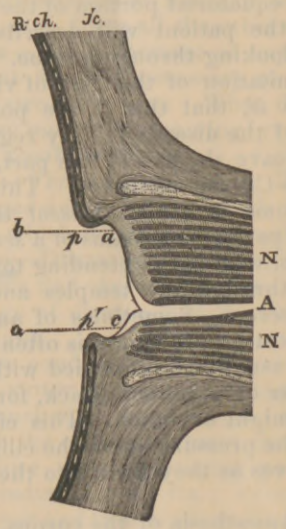

Fig. 13. Profile view of Glaucomatous cup.—Noyes.

scope may reveal, provided there is not too much cloudiness of the refracting media of the eye, are quite pathognomonic of glaucoma. The glaucomatous cup involves the whole optic disk (Fig. 12 & 13), while the physiological cup is simply a shallow depression confined to the center of the optic disk. In the glaucomatous cup the margin is abrupt, sharp, and often excavated, and as the vessels curl over its edge, they appear interrupted or distorted. (Fig. 12.) The optic disk is usually encircled by a light colored band, which is due to the sclerotic shining through the atrophied choroid. At the margin of the disk, where the blood vessels wind up over, a distinct arterial pulsation may be seen either spontaneous or caused by a slight pressure upon the globe, which is synchronous with the heart's beat. The cause of these symptoms is evidently intra-ocular tension, and the reason of their location may be explained by the fact that the foramen-opticum is located at the fundus of the eye.

THE COURSE OF GLAUCOMA.

If it is of the acute form, the course is often rapid, destroying the vision in a few hours.

"In the chronic form the course of the disease is slower, and may extend over a period of years, but it is steadily onward, and if not relieved by timely treatment, sooner or later dooms the eye to irremediable blindness."

Before proceeding to the treatment of glaucoma, I would note the fact that primary glaucoma sometimes attacks the myopic eye. This I believe to be due to the *same cause* as in *hypermetropic* and *presbyopic*, easily explainable in the fact that the myope frequently uses his glasses adjusted for distant objects, in reading, thereby necessitating a demand upon the accommodative power, which, as we have seen is, by nature, weak in the myopic eye, and easily overworked.

TREATMENT OF GLAUCOMA.

In glaucoma imminens, or earlier, a prophylactic treatment is often effectual.. The anomaly of refraction or accommodation is to be corrected by the proper adjustment of glasses. *Eserine* I have found, also, very useful. Its preventative action is as follows:

It contracts the pupil, and thereby draws the iris away from Schlemm's canal, and permits again the free escape of the aqueous humor, and so relieves the intra-ocular tension.

All use of mydriatics should be avoided, as their action is diametrically opposed to the desired results. They dilate the pupil and thereby draw the iris back more completely, closing the canal. Indeed, the use of mydriatics, from this very action, may induce glaucoma. When the disease is once established, as in glaucoma evolutum, there is but one treatment which offers any assurance of permanent cure or relief; and that is iridectomy or sclerotomy. The results of these operations in acute

glaucoma have been most brilliant. In the chronic form they will arrest the progress of the disease. And if made in the earlier stage, will often restore a portion, if not the entire amount of sight lost. In the acute form the operation should be made as soon as possible after the *prodromal* stage has set in; for every hour delayed is most valuable time lost; for, as we have seen, this form of the disease often runs its course in a few hours, reaching the form of glaucoma absolutum, a stage in which quantitative perception of light is comletely lost. Paracentesis, and other operations, have been recommended for glaucoma, but their effect is only temporary or transient, as they do not remove the cause of the intra-ocular tension. Iridectomy, or sclerotomy, is efficient in doing this, as in either operation the incision is made through the sclera at or in close proximity to Schlemm's canal. The wound, uniting, acts as a filter for the fluids, for a time at least, until the canal has fully regained its function. Of the two operations, iridectomy and sclerotomy, I prefer sclerotomy, for the following reasons, viz.: It accomplishes the desired results with a greater degree of certainty. It is less dangerous to the iris and crystalline lens; it does not disfigure the pupil, causes much less pain, takes less time and instruments, and is easier made. The steps for making this operation, are as follows:

1. A few drops of a solution of one grain of sulphate of eserine to an ounce of distilled water must be droped in the eye before the operation.

2. The operation, if possible, should be made without narcrosis.

3. Section, may be made upwards or downwards.

4. Enter the sclera with Von Graefe's knife at one m. m. from the edge of the cornea, as if about to make a scleral flap. (Fig. 15.)

5. When the knife has made the counter puncture, it is to be pushed slowly forward, and the operation ended if possible by the withdrawal of the knife, which should be done very slowly.

6. Flap is not to be completed, but the apex is to be left. (Fig. 16.)

Fig. 15.

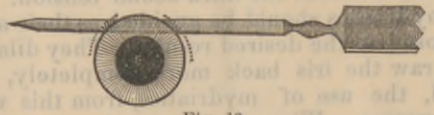

Fig. 16.

7. Eserine must again be dropped into the eye and a bandage applied.

The authorities consulted in writing this article are Frey, Satterthwaite, Wells, Lawson, Noyes and Abadie.