SAMELSOHN (J.)

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OF THE

CENTRAL ARTERY OF THE RETINA.

By DR. J. SAMELSOHN, of Cologne.

(Translated by Dr. Hasket Derby, Boston.)

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EMBOLISM OF THE CENTRAL ARTERY OF THE RETINA.

By Dr. J. SAMELSOHN, of Cologne.

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A case of blindness occurring in connection with the chain of symptoms which characterize embolism of the central artery of the retina, is still entitled to be regarded with more interest than a single observation in most instances is capable to elicit. For the hope expressed by Virchow,* in closing his classical researches on thrombosis and embolism, that—"if a chance should be offered of making an ophthalmoscopic examination in cases of very recent embolism of the larger retinal arteries, it might be possible, during life, to distinguish the occluded portions by their whiteness and trace directly the progress of secondary derangements, all of which would have a most valuable bearing on the theory of metastasis"—this hope has been only partially realized. It is true that we are at present in possession of a satisfactory though not very large number of observations in which the diagnosis of obstruction of retinal vessels by embolism is well made out, though unsupported by anatomical proof.† It is true that Knapp has

* Gesammelte Abhandlungen, p. 723.

† Cf. Stellwag v. Carion, Lehrbuch der Augenheilkunde, 1867, p. 791. Roth, Ueber Netzhautaffectionen bei Wundfieber. Deutsche Zeitschrift f. Chirurgie, Bd. I. Heft 5, p. 471.

recently described* a hemorrhagic infarctus as the keystone, so to speak, to the picture of derangements in the circulation of the retina caused by embolism; but the analysis and the history of all these observations are, in many respects, so varying and even contradictory, both in the apparently similar mechanical conditions and in the consecutive, nutritive and functional derangements, that a general description of the disease under consideration can only be given with the utmost caution, and a diagrammatical explanation of the secondary derangements, or an elucidation of the process of metastasis, has, from this part at least, hitherto been out of the question.† It is only since Cohnheim's‡ recent luminous investigations have cleared up the subject of mechanical derangements of the circulation succeeding arterial embolism, and especially since the vague conception of collateral fluxion has been reduced to its proper proportions, that it will perhaps be possible to marshal the numerous variations of the observations on record, in obedience to an ordered system, to subject the published cases to a more rigid criticism, and to find a surer foundation for diagnosis.

Before, however, I discuss previous observations with reference to the results gained by the experiments of Cohnheim, I would crave permission to report an original observation, which excited me all the more to this investigation by its coincidence with the appearance of Cohnheim's work.

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* Archives of Ophthalmology and Otology, Vol. I., 1, 1869, 64–84.

† Steffan, Ueber Embolische Retinalveränderungen, Graefe's Archiv, XII., 1., p. 42.

‡ Cohnheim. Untersuchungen über die embolischen Processe, 1872.

Maria P., a woman of no especial vigor, 62 years of age, came to me, August 2d of this year, complaining that fourteen days ago, after passing a quiet night, she remarked in the morning entire blindness of the left eye, although she was perfectly certain of having seen well with it the evening before. On awaking, she had a feeling as though this eye were shut, and consequently asked her husband to take a look and ascertain why she could not open it.* Being informed by him that it was open, she experimented on the acuteness of vision of each eye, and found that with the left she could not even distinguish light from darkness. She at once consulted an oculist, who told her there was nothing to be done for the eye, that it was lost. Alarmed at this opinion, she went to another, who ordered her iodide of iron, but said nothing about her condition; and it was at the end of fourteen days that she came to me to obtain my opinion concerning the disease.

The objective examination showed the following:

The *right* eye, emmetropic, has S = 1, and the amount of accommodation corresponding to the age of the patient. In spite of the normal acuteness of vision the patient insists that all objects seem *smaller* to her than formerly. As no comparison with the appreciation of magnitude by the left eye could be made, I was unable to estimate at its proper value the correctness of her statement. This seeing things smaller, however, inspired her with much apprehension for the future. Ophthalmoscopic appearances normal.

In the left eye there is a dull quantitative perception of light in the eccentric portion of the field lying upwards and inwards; a large lamp being distinguished when held close before the eye, while in the central and remaining portions of the field entire blindness prevails. The cornea and iris are unaltered; the pupil is

* Steffan's patient experienced the same feeling. L. c., p. 36.

moderately enlarged, as in cases of paralysis of the oculomotorius, and reacts with extreme sluggishness when exposed to light; still, this reaction is independent of the movements of the other iris, and is incontestably present. The intra-ocular pressure is perceptibly heightened, albeit to no great extent.

Ophthalmoscopic Examination. — The transparent media are entirely clear, the refraction of the eye emmetropic. On bringing the fundus into focus the attention is at once arrested by the threadlike appearance of the retinal vessels, it being at first sight impossible to distinguish between the arteries and the veins, the reflex due to the tubular form of the arteries being wholly wanting. On closer examination it is seen that the papilla has clean-cut edges, *is surrounded by no retinal cloudiness*, and is tolerably pale, but still by no means exhibits the dazzling whiteness of atrophy. The paleness here described is all the more marked by the sharp contrast it offers to the *normal redness of the fundus*. The veins emerge with narrowed channel from the vascular centre of the papilla, and gradually increase in diameter as they approach the periphery, but even at the equator attain to scarcely half the thickness of the veins seen in the other eye. They convey blood throughout their whole course, and exhibit no portions free from blood with oscillating movements. The arteries depart from the point of entrance of the vessels as thin, bright-red threads, and become in part brighter, but less visible, as soon as they pass beyond the edge of the papilla, owing to the lessened contrast between them and the red fundus oculi. One artery proceeds,

in the inverted image, downwards and inwards, is accompanied for a certain distance by a vessel readily made out to be a vein, and gives forth a dark-colored, spindle-shaped swelling, starting off from the thread-like vessel at a distance of about one and a half diameters of the papilla from the edge of the optic disk; just behind this enlargement the vascular canal entirely escapes recognition. The most rigid investigation in the upright image fails to detect any oscillating movement in the contents of this vessel. The vein corresponding to this arterial division is the fullest of any of the fundus, and tapers but slightly as it approaches the point of entrance of the vessels. The whole extent of the macula lutea has a bloody tinge, is not surrounded by any whitish opacity, does not look like the seat of an extravasation, but, on the contrary, seems, in spite of its redness, to preserve a uniform granular appearance, and keeps its normal line of demarcation from the vicinity (it being remembered that the boundaries, at an age like that of the patient, are not particularly marked or circumscribed); it is, however, remarkable that the vessels, so thin throughout the remainder of the fundus, assume such prominence in the region of the macula. The strongest pressure on the eyeball excites no arterial pulsation; the phosphenes are perfect.

Of the significance of the ophthalmoscopic symptoms there could be no question. The sudden advent of blindness, the striking diminution in size of the vessels, especially of the arteries, the enlargement of the veins towards the periphery, the impossibility of exciting arterial pulsation by pressure, all pointed to a cutting off of

the arterial circulation. In what portion of its course the principal artery was obstructed could hardly be ascertained after a lapse of fourteen days, inasmuch as collateral circulation had probably been set up. It appeared, however, certain that the occluding clot could not be in the ophthalmic artery, inasmuch as the choroidal circulation was not only unimpaired, but seemed even more vivid than in the other eye, to judge from the existing increase of intra-ocular pressure. As has been stated, a spindle-shaped swelling could be made out in one artery, on either side of which the vessel was extremely narrowed. The whole region gave the impression that we had here to do with a small embolus, which had obstructed a single branch of the central artery. This observation agrees entirely with that of Cohnheim, according to which *the channel of the vessel is more or less dilated at the point of obstruction, but appears decidedly contracted both in front of and behind it.**

The second and principal embolus must, of course, be situated in the trunk of the *arteria centralis retinæ*, at what point will be discussed further on. The source of the embolus was the next question. The most thorough examination of the heart and the large vessels revealed nothing in the least abnormal to either percussion or auscultation ; the radial arteries, however, especially the left, showed hard atheromatous deposits in the middle coat, yielding to the finger the familiar sensation of a bird's trachea. Inasmuch as an atheromatous condition of the cerebral arteries is frequently present with-

* Loc. cit., p. 11.

out any manifestation of atheroma in the remaining arteries of the body, while conversely atheroma of the arteries of the body seldom fails to implicate those of the brain, it became necessary to assume some process within the internal carotid or ophthalmic arteries, from which diseased vascular region the current of the circulation swept particles of tissue or thrombic clots into the central artery and one of its branches.* The inducement to believe in some such disease of the cerebral vessels and the consequent derangement of nutrition of the organ itself became all the greater when it was considered that the woman had previously been both cheerful and lively, but of late had grown melancholy, lachrymose, and had come to be haunted by impressions of impending misfortune; the veins of the face, moreover, exhibited unmistakable symptoms of stagnation of the circulation. Urine normal. I venture only to hint at the possibility of a connection between the micropsia of the right eye and the above-described derangement of nutrition.† The following points bore on the question of therapeutics:

1. The mobility of the pupil when exposed to light, and the perception of light, slight though it was, in a limited portion of the visual field;

2. Phosphenes responding to pressure;

3. Absence of any striking alteration of tissue in the retina;

4. Absence of any cardiac disease.

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* Cf. Steffan, loc. cit., p. 39. Liebreich, Deutsche Klinik, 1861, No. 50, p. 476.

† Cf. Panum. The apparent Size of Visible Objects. Graefe's Archiv, Bd. V., 1, p. 16.

The slight but still uniform and equal fulness of the arteries and veins giving good grounds for belief that the collateral circulation proceeded from the ciliary vascular plexus, the first indication seemed to be, by stimulating this, to cause an afflux of blood towards the retina that should not only prove a source of nutrition to its tissue, but also enable it to resume its functions. For thus must we theorize with regard to the apparently singular fact that a failure of nutritive supply may not cause the destruction of a tissue, while leading to a limitation or entire suspension of its functions; the collateral circulation following directly on the obstruction being sufficient to prevent the necrosis of retinal tissue, but unequal to the task of maintaining an exercise of functions that are necessarily accompanied by a large consumption of material; a view of the case amply justified by analogy in other organs. This view, too, harmonizes very well with the fact of the good preservation of the phosphenes. For inasmuch as the *larger* retinal arteries ramify in the inner, *conducting*, layers of the retina, irritation of which originates the phosphenes, these layers, though their vessels be but partially filled, must retain a certain limited activity beyond that enjoyed by the external, *perceptive*, retinal layers, which are permeated only by the finer subdivisions of the central artery, and must hence remain more empty when the circulation is impeded.*

* Cf. Steffan, l. c., p. 62, whose view of the *exclusive* supply of the external retinal layers by the chorio-capillaris is hardly tenable. I would simply refer, in this connection, to the preservation of the functions of a retina overlying choroidal ruptures, etc.; Knapp, Archives of Ophthalmology and Otology, I., 1., p. 169.

The question, of course, arose whether a stimulation of the retinal circulation, provided we could bring this about, might not drive the embolus still deeper into the central artery, and thus gravely compromise the collateral circulation, so recently established. This doubt, upon which the treatment of Schneller's* single successful case was based, appeared to have no bearing on the present one. In the first place, the embolus having remained fourteen days in one place, which it entirely filled, could hardly be assumed to be sufficiently movable to yield before the *dash* of the blood; in the second place, we had a right to argue that the current would follow, by preference, the already open channels of the collateral circulation, a thing proved by experiment, inasmuch as clots generally extend to the *next higher* anastomosis.

Among the means of bringing about an increase of force in the circulation towards the retina, iridectomy occupied the first rank, an additional inducement to its performance being the indubitable increase of intra-ocular pressure. This increase of intra-ocular pressure is a phenomenon both significant and interesting; significant in regard to its results, which impeded the rapid accomplishment of a collateral circulation; interesting with reference to its development, which allows us an insight into the peculiar derangements of circulation that accompany retinal embolism. These derangements of circulation in an eyeball closed on all sides, and provided with two nearly independent vascular systems,

* Graefe's Archiv, VIII., 1, p. 274.

must run a course very different to that observed in the tongue of the frog, the object studied by Cohnheim. In this latter case the single requisite for the formation of a collateral circulation is the presence of anastomoses, and the tissue interposes no obstacle to the re-establishment of a vascular current, while in the former the greater or less rigidity of the sclero-corneal capsule, the tension of which is maintained by the vitreous, offers a very appreciable resistance. The normal retinal circulation is an indubitable adjunct to the amount of the intra-ocular pressure, through the quantity of blood contained in the retinal vessels; still it is now beyond disputation that the choroid and ciliary body are the real source of the fluids that create the intra-ocular pressure. When now an embolic closure eliminates the retinal circulation, how is the intra-ocular pressure affected? At the very first it will undoubtedly decrease in direct proportion to the amount of blood circulating in the retina; this decrease, however, is partially neutralized, and finally reduced to a minimum by the elastic contraction of the envelope of the globe. The situation, however, almost immediately changes. The obstruction of the central artery drives the blood into one or several of the preceding lateral branches of the ophthalmic, and causes it to flow with increased rapidity into these, *i.e.*, the ciliary arteries; "with the same increased rapidity the blood traverses the capillaries supplied by the said lateral branches, and runs all the more quickly into the veins that carry it off. This acceleration of the circulation in these arteries, capillaries, and veins remains for a longer or shorter time at the same height,

without causing a rupture and hemorrhage, until finally a gradual and equable distribution of the superfluous current is made over several of the preceding neighboring branches, and an equilibrium thus established." *

I have almost literally transcribed this passage from Cohnheim's article, because this observation, based on experiment, seems to me to furnish the key to a proper conception of the mechanical conditions that ensue on vascular obstruction due to embolism. At a later period we shall more clearly perceive the neglect that has been bestowed on, and the faulty conclusions that have been derived from, this state of things. If these experimental results be applied to the present case, it will be seen that the circulation will be affected as follows: The blood will flow with increased rapidity through the ciliary arteries to the chorio-capillaris and ciliary veins; the process of filtration is thus hastened and the intra-ocular pressure increased; this temporary increase of the inner pressure of the eye hinders again the quick completion of the collateral junction in the region of the optic papilla, and the blood hence rushes with a constantly growing rapidity into the posteriorly situated ciliary arteries. As the intra-ocular pressure increases, the activity of the increased rapidity is converted into an increased lateral pressure, and the filtration pressure of the chorio-capillaris thus increased, so that as a final result of the dilemma we note an increase in the intra-ocular pressure and an impeded current in the direction of the collateral optic vessels, and this in spite of the

* Cohnheim, l. c., p. 9.

vascular distribution at the extremity of the optic nerve that seems so favorable to the quick development of a collateral circulation.

Guided by this reasoning, I decided at once to perform iridectomy, the influence of which to diminish pressure in a similar case had already been tested by v. Graefe.* On the very next day I made a broad coloboma upwards, and took pains to let the aqueous humor escape somewhat rapidly. The day following I could not refrain from a cautious examination of the vision and the fundus, the absence of all reaction rendering this apparently devoid of danger. There could be no doubt of an increased perception of light, extending over a large portion of the visual field; it was, however, in no degree qualitative. Ophthalmoscopic examination revealed a considerable alteration in the state of the vessels; the arteries were much fuller, and distinguishable from the veins by their color as well as by a certain reflex, this distinction being most marked in the arterial branch containing the swelling that has been characterized as an embolus. The central contraction in calibre of the vessel had now disappeared, and with it the spindle-shaped enlargement, but it was, as before, impossible to trace the vessel at its peripheric continuation beyond the embolus. The latter, however, had not changed its position. The result of the following and more comprehensive examination, which was made three days after the operation, was the astounding fact that the patient could count fingers with tolerable cor-

* Cf. Graefe's Archiv, V. 1, p. 151. Knapp, Ueber Verstopfung der Blutgefässe des Auges, Graefe's Archiv, XIV., 1, p. 219.

rectness, not, it is true, centrally, but with a portion of the retina closely bordering on the centre; only below and inwards no trace of a perception of light had returned, corresponding entirely to the spindle-shaped swelling which lay in the inverted image, below and inwards. Ophthalmoscopic appearances the same as two days before. During the next few days the improvement somewhat progressed; large objects like a watch, key, knife, etc., being made out, and the power of vision gradually approached the centre. A change, too, in the ophthalmoscopic appearance of the macula lutea could now be observed. The blood-red color gradually disappeared from without inwards (inverted image), and gave way to a brownish yellow, without, however, the development of any opacity at this point. I must advert here to one very strange symptom. While the patient, in a darkened room, had an accurate perception of fingers and other objects gently illuminated by a gas-jet at her side, except over that portion of the visual field that has been already repeatedly alluded to, she was yet unable to recognize or state the position of the full jet of gas when carried directly before her eyes. A curious analogy exists between this and cutaneous analgesia, and has been already several times adverted to in cases of amblyopia following a large loss of blood.* It seems to me more an evasion than an explanation of this phenomenon, to say that the retina, long disabled functionally, responds to a slight, but is exhausted by a strong, stimulus, and I simply here note

* Vikentscher, Graefe's Archiv, VIII., 1, p. 213. Colsman, Klinische Monatsbl., VII., p. 13.

the fact. Not till ten days after the operation did this symptom disappear and the patient accurately localize the largest flame.

I expected now that the improvement in the power of vision would steadily progress. My hope was, however, disappointed, and soon gave way to the fear that what had already been gained might yet be lost. In this apprehension I was by no means guided by the perception of light, which persisted over the whole surface described, but by the ophthalmoscopic appearance of the retinal vessels; for these began again to exhibit a diminished calibre, especially the branch with the embolus, which latter clearly displayed again a spindle-shaped swelling, on either side of which the vessel was contracted, just as before the operation. It was clear that the diminution of intra-ocular pressure, due to the operation, had begun to lose ground, and that the process of cicatrization was offering a fresh obstacle to the collateral circulation that had been excited.

Under these circumstances the patient was dismissed from the hospital, but has remained under surveillance up to the present time. The ophthalmoscope reveals now the last-described state of things, the vessels being moderately contracted, the spindle-shaped swelling present, the veins less attenuated at their point of emergence, and the macula lutea yellowish brown. The white discoloration of the papilla has not increased, and neither has any alteration in the visual power of the left eye taken place since the examination last described. Nor is the right eye at all changed, and, according to the patient's account, the micropsia remains the same.

I cannot, at present, find any reason for this either in the accommodation or the retina.

On reviewing now the single elements which went to make up the diagnosis of our case, we are struck first of all with the absence of that loss of transparency of the tissue which, with hardly an exception, has characterized every case of embolism of the central artery that has hitherto been described. The objection might indeed hold that this was present during the days that first elapsed after the formation of the embolus, and had already disappeared without leaving a trace behind, when I made my first observation, fourteen days after the advent of blindness. A glance at the best known of the hitherto published cases will most quickly inform us with reference to the admissibility of such a theory.

The table opposite shows that the commencement of opacity of the tissue is ordinarily noted during the days that immediately succeed the embolic obstruction, and that, while the opacity in many cases takes more than fourteen days to disappear, shorter periods are not uncommon. Under these circumstances we are not called upon to decide on the absence of opacity in our case, and are at liberty to rank it with Schneller's, which he observed the twelfth day after blindness occurred, and noted *no opacity of the tissue whatever.* These two observations, however, open the discussion as to whether the early or late occurrence of opacity of the tissues is a necessary consequence of the embolic occlusion of the central artery.

TABLE I.

No.	Name of observer.	Situation and extent of the opacity.	Day it appeared after the attack.	Day it disappeared.	Where recorded.
1	v. Graefe.	Macula lutea and a portion of the papilla.	14	30	Graefe's Archiv, V., 1, pp. 149–152.
2	Blessig.	Macula lutea, papilla and retina below the papilla.	Some hours.	Thirty days later still present.	Graefe's Archiv, V. III., 1, p. 219.
3	Schneller.	Vicinity of papilla slightly veiled.	....	....	Graefe's Archiv, VIII., 1, p. 272.*
4	Liebreich.	Macula lutea.	....	....	Graefe's Archiv, V., 2, p. 263.†
5	Liebreich.	In each of six cases opacity of the macula and the papilla.	1—6	6—?	Deutsche Klinik, 1861, No. 50, p. 476. Atlas of Ophthalmoscopy, Pl. 8, Fig. 4. ‡
6	Steffan.	Macula and papilla.	4	40	Graefe's Archiv, XII., 1, pp. 37–38.
7	Saemisch.	Lower portion of retina.	2	5	Klin. Monatsbl., 1866, p. 34.
8	Schirmer.	Retina and papilla, no opacity around macula.	2	30	Klin. Mon., VI., 41.
9	Knapp. The last of the 5 cases can hardly be included.	1 } Macula and papilla.	5	19	Graefe's Archiv, XIV., 1, pp. 210–220.
		2 }	1	....	
		3 }	2	20	
		4 No opacity.	....	....	
10	Knapp.	Retina, macula around the infarctus.	Observed 3 weeks after the attack of blindness.		Archives of Ophthal. and Otol. I., 1, p. 64.

* Schneller's case, distinguished beyond nearly all others by a considerable restoration of vision, came under his observation the twelfth day after the advent of the blindness.

† The case is described with much brevity, and hence allows no appreciation of its circumstances.

‡ The opacity constantly occurred, sometimes early, sometimes late, disappearing in like manner. Liebreich gives no further particulars.

A proper estimation of the derangements in the tissues that ensue on the occlusion of an artery is based wholly and entirely on "whether behind the coagulum, between it and the dependent capillary tract, there is given off an arterial branch that directly inosculates with any other artery, or whether such an anastomosis is wanting." * If the latter be the case, that is, if the occluded artery be a terminal one, its embolic occlusion may give rise to a double series of derangements, entirely independent of each other. "First, necrosis, the natural consequence of the cessation of circulation in an animal organ; secondly, engorgement, due to the reversed action of the current of the neighboring vein, a current impeded in the retina by no venous valves. The combination of both chains of deranged symptoms is the infarctus." †

This being the fundamental law, it is a source of surprise that the embolic infarctus of the retina should have been accurately noted in but a single case, while, on the other hand, it adds considerable force to the observation that this infarctus took place in connection with an embolism of a *branch* of the central artery, a branch of whose significance as a *terminal artery* there can be, according to Cohnheim's construction, no doubt. On reading the critical remarks appended by Knapp to his case, we gladly admit that he fell but little short of a solution of the whole process, the final theoretical verdict being reached by Cohnheim's experimental observation.

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* Cohnheim, l. c., p. 16.

† Cohnheim, l. c., p. 61.

To bring about an opacity of the tissue, which must be regarded as an optical evidence of necrosis, it is essentially necessary that the artery supplying the tissue concerned should be terminal, the occluded vascular region being, in any other event, simply eliminated from the circulation. If this be the stand-point from which we proceed in our consideration of the retinal circulation, we find at once that the authorities are at variance. While Cohnheim denominates the central retinal artery, at its point of departure from the papilla, distinctly terminal, referring to a point beyond the slight connections between it and the ciliary arteries that here traverse the optic nerve,* Leber says, "The small arteries which proceed from the plexus surrounding the optic nerve go in part inwards, to that portion of the nerve that lies before the lamina cribrosa, in part run more posteriorly into its trunk. Their connections with the branches of the central artery seem generally pretty minute. *Very minute branches are continued also into the retina in the immediate vicinity of the papilla.* It is therefore an established fact that the ciliary vessels contribute to the nutrition of the papilla and the adjoining portions of the optic nerve and the retina. Considering this appreciable vascular connection at the point of entrance of the optic nerve, it is astonishing that, after a complete embolism of the central retinal artery, no more considerable collateral circulation should be established."†

In accordance with these investigations of Leber,

* Cohnheim, l. c., p. 72. † Graefe's Archiv, XI., 1, pp. 6 and 7.

and as long as they are not controverted, must we base our faith, and hence allow the possibility of an undoubtedly imperfect supply of the retina from these ciliary connections, after an embolic occlusion of the central artery on the further side of the minute connections with the ciliary arteries, and regard only the branches of the central artery as terminal arteries in the full sense of Cohnheim's views. At all events, these direct connections between the ciliary arteries and the retina are so slight as to seriously compromise the nutrition of the latter when supplied from this sole source; and when we note the considerable amount of opacity that accompanies the closure of a branch of the central artery, the assumption will not seem forced that appreciable necrotic opacities of the retina, and consequent incurable destruction of its functional capacity, must result from an occlusion of the central artery at a point beyond the giving off of the ciliary connections. It is both theoretically probable and practically established that, in a necrosis of this kind, the primary impairment will be in the region of the macula lutea, a spot which in the normal state is particularly devoid of vessels. Should the necrosis recede as rapidly as it advanced, it is to be assumed that the embolus is situated at a point particularly favorable to the development of the ciliary collateral current, which collateral current may, as has already been indicated, be sufficient to arrest the necrosis and remedy the opacities that have already been induced, without being sufficiently ample to bring about a resumption of function. The period of occurrence of necrotic opacity of the tissue (aside from sp-

cific, infected embolisms) may thus become a valuable means of diagnosis for us in determining the locality of the vascular obstruction, and the clearing up of the opacity as accurate an index of the time and extent of the collateral connection.

A second point, about which authors exhibit many discrepancies, and which I am apparently allowed by the experiments of Cohnheim to view under a single aspect, is the form and contents of the occluded vessels. The following table (p. 64) bears thereupon.

This table exhibits wide variations in the abnormal state of the vessels, both as regards contents and shape. Although, in the majority of cases noted, the arteries appear appreciably narrowed, and exhibit from the centre towards the periphery a diminution in calibre, there are yet two cases that show a directly opposite state of things (Cases 2 and 7), the arteries being decidedly fuller at their peripheric distributions than at their centre. These two cases, that seem decidedly without the pale of typical embolism of the retina, are capable, on closer examination, not only of entire explanation, but furnish at the same time a clue to the occurrence of extravasations that we have to allude to farther on. For on comparing Case No. 2 with Figure No. 7 in Cohnheim's article,* we see that the whole affair amounts to a replenishing of the occluded artery by means of an arterial anastomosis from the ciliary plexus of the optic nerve, an explanation harmonizing fully with Blessig's remark that the greater fulness of the very contracted

* L. c., p. 16, and plate.

TABLE 2.

No.	Name of author.	Arteries.	Veins.
1	v. Graefe.	Extremely narrow lines.	Thin; their unequal fulness increasing towards the equator.
2	Blessig.	Small red lines; they contain a certain amount of blood some distance from the papilla; in most of them this amount of blood and their diameter *diminish* as the papilla is approached.	Narrowed and best filled towards the periphery; unequal fulness throughout their whole course.
3	Schneller.	Thin, red streaks confined within two *white* lines.	Narrow, growing *thicker* towards the papilla.
4	Liebreich.	*Wholly void of blood.*	Thin, becoming thick in the direction of the periphery.
5	Liebreich.	Thin.	Thin, tapering towards the point of emergence.
6	Steffan.	Thin.	Thin, tapering towards the point of emergence.
7	Saemisch.	Thin and quite *white*, at one place some blood is retained; above the white coloration an enlargement. On the tenth day after the advent of blindness some blood could be proved to be contained in the *peripheric* portions of the occluded arterial branch; the current advancing towards the centre, but still showing an interruption.	The corresponding vein is somewhat enlarged, especially towards the papilla.
8	Schirmer.	Very thin, the column of blood being nowhere interrupted.	On the papilla very thin, at some distance from it abnormally large, tortuous, exhibiting a type of stagnation.
9	Knapp.	1. Very thin and threadlike, quite rapidly decreasing in diameter in the direction of the periphery. 2. Threadlike, single in contour, not to be traced far beyond the papilla. 3. Very thin. 4. Thin, with a slight enlargement on the papilla.	1. On the papilla most narrow and very dark; thicker towards the periphery. 2. Very thin, larger towards the equator. Fulness equal. 3. Well filled, with shifting interruptions. 4. Rather thinner than normal.
10	Knapp.	Thin, like a fine red thread, that becomes suddenly transformed again into a ribbon with a double contour.	The corresponding vein enlarged and tortuous.

arteries began immediately beyond their passage over the edge of the papilla, that is, at the point where, according to Leber, branches of the ciliary arteries directly enter the retina. There results hence the extreme probability that the embolus had been carried down to a great depth in the central artery.

Case No. 7 possesses an entirely different significance. The phenomenon of decided arterial engorgement at the periphery is here presented, not at the commencement of the blindness, but as late as the tenth day. It is probably an instance of a retrogressive movement from the neighboring vein. "It begins at the point of union of the passive with the flowing vein, the latter emptying the greater portion of its contents in the normal direction of the heart, but passing, too, a certain quantity into the immovable venous branch, in a directly contrary direction.* In the case referred to, the vein corresponding to the branch containing the embolus was somewhat swollen, especially in the direction of the point of emergence from the papilla; the fulness of the occluded arterial branch began at the periphery and advanced gradually forward in the direction of the central extremity, *without, however, causing the interruption of fulness* to disappear. A similar explanation may be offered regarding the phenomenon of unequal fulness of the veins, with intermitting motion of their contents, observed in some cases (1, 2, 9, 3), inasmuch as Cohnheim has observed and described a similar intermitting movement, a going and coming, first occur-

* Cohnheim, l. c., p. 18. Fig. 6.

ring when the fulness of the veins has attained a certain height by means of the retrogressive current.*

We find, moreover, laid down in the table that the arteries at times appear thin, or like a fine red streak, or, again, like a fine red line bounded on either side by two fine white lines, or finally, like entirely white bands. As is well known, this utterly varying description on the part of single observers has led Stellwag von Carion in especial to express the doubt as to whether we have not, in the observations in question, to do rather with a perivascular inflammation than with an embolism. But the observations of Cohnheim allow us even here to array all the types described under the head of a general and final cause. A glance at his figures, 4, 5, 6 and 7, gives us the explanatory clue to the possibilities described. The explanatory text teaches us that the different types are simply due to the *rapidity* with which the occlusion takes place; according as the embolus suddenly obstructs the whole trunk of the vessel, or gradually increases from partial to total, so do we remark on either side of it now a tranquil column of red blood, again a tranquil red column behind, and a colorless column of plasma before the obstruction, and yet again a pale, colorless vascular trunk as a consequence of the embolism. And that a process of embolism may occur that *gradually* leads to an entire closure of the canal of the vessel, we find sufficient proof in the records of cases that treat of the obscurations preceding the attack of actual blindness.

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* Cohnheim, l. c., p. 19.

TABLE 3.

No.	Observer.	Number and form of extravasations.	Position of extravasations.	Day of occurrence after the attack.	Form of red spot at the macula lutea.
1	v. Graefe.	None.	None.	....	Cherry-red spot in the immediate vicinity of the foramen centrale.
2	Blessig.	Two ecchymoses, the one on, the other near, a retinal vein.	Around the macula lutea.	10	A red spot in the foramen centrale.
3	Schneller.	None.	None.	....	None.
4	Liebreich.	Small ecchymoses on the veins.	Around the macula lutea.	....	....
5	Liebreich.	Ecchymoses in all six cases.	Around the macula and papilla.	....	In all six cases without any detailed information, except that they were situated in the opacity of the macula.
6	Steffan.	Two small extravasations.	At the edge of the papilla, the one below, the other outwards	9	In the centre of the milk-white opacity.
7	Saemisch.	....	....	....	....
8	Schirmer.	....	....	....	At the macula a red spot, easily distinguishable from an extravasation.
9	Knapp.	1. Numerous, striped and spotted.	In the opaque retina, around the macula, extending to the papilla.	5	....
		2.	....	....	A cherry-red place around the yellow spot.
		3. One hemorrhage.	Close in the vicinity of the upper edge of the papilla.	2	A small dark-red spot on the macula.
		4.	....	....	....

We have yet to consider a symptom by no means constant, namely, that of *extravasation*, with which we

will connect a discussion of the much-argued question as to the red coloration of the favea centralis. Let us then seek to derive from a table some information as to the frequency of extravasation. (See page 67.)

With these cases must be ranked Knapp's observation of the infarctus, made three weeks after the advent of blindness, and in which the numerous hemorrhages *were situated around small venous branches.* The red spot at the macula is recognizable, it is true, on the colored plate, still is markedly different from other descriptions and representations. Of its significance as an ecchymosis there is in this case no doubt.

In the above 28 cases the table exhibits to us 12 instances of ecchymosis, which vary not inconsiderably in number and in size. Their site is generally about the macula lutea, sometimes in the neighborhood of the papilla. On comparing the last table with table No. 1, it becomes evident that, in all cases in which ecchymoses are noted, their sites exhibit proof of necrotic changes of tissue. In 3 cases the hemorrhage is expressly described as proceeding from the retinal veins. As regards, finally, the period of occurrence, we unfortunately find no details given in the most cases; according, however, to the positive observations made in some cases, it happens generally several days after the embolic obstruction. In but a single case (Knapp, No. 3) do we find allusion to an extravasation close to the papilla the day succeeding the sudden advent of blindness.

On collating now these several data and comparing them with the results of the experiments of Cohnheim,

I think we shall find no difficulty in passing judgment on them from a single point of view. It has already been stated that no theory of an arterial hemorrhage in consequence of the collateral fluxion, succeeding the occlusion of the principal branch, can obtain, all the less, indeed, because this collateral fluxion would have to be greatest after the occlusion, and diminish or entirely disappear in proportion as time went on.* The case must be one, therefore, of extravasation from the veins or capillaries, described by Cohnheim as the result of venous accumulation, combined with necrosis of the tissue or vascular walls, and to be regarded as paving the way to an infarctus. A properly typical picture of this infarctus has been furnished us by Knapp, and it is certainly to be regarded as a triumph of ophthalmoscopic observation that the embolic infarctus should be, in this case, pointed out to be a venous extravasation, in entire opposition to the views previously obtaining. This observation has in itself fulfilled the second portion of the hope expressed by Virchow, and cited in the introduction to this article, and the experimental investigations of Cohnheim have rendered possible the pathogenetic elucidation of its mechanical details. Blessig, too, was on the scent of the right solution. "The extravasations occurred subsequently to the dissolution of the retinal elements. This later appearance, as well as the circumstance that hemorrhages into the parenchyma took place only on those portions of the retina that were opaque, and hence liable to be more

* Cohnheim, l. c., p. 88.

thoroughly and quickly affected by the derangement of nutrition, go to prove that the dissolution of the tissue must have been a primary, and the hemorrhage into the degenerated and softened retinal tissue a secondary, symptom. I lay great stress upon this circumstance, because the occurrence of hemorrhagic processes in the vicinity of arteries occluded by embolism is generally explained on the theory that collateral fluxion causes the blood to collect in the region of the occluded arteries, and ultimately brings about a rupture of the vessels." * Although this theory nearly approaches the one of Cohnheim adopted by us, we still see from the sentence immediately following this explanation how slight a conception Blessig had of the *mechanical* concomitants of extravasation, and how this depended on the lack of experimental microscopical observations. For he goes on to say: "It is perhaps a consequence of the sparse collateral communications in the vascular tract of the central artery of the retina, that more pronounced and extensive parenchymatous hemorrhages have not been noted in embolism of the same." The picture drawn by Knapp of retinal infarctus may be considered typical according to the views of Cohnheim, and in the critical analysis of the case there is nothing wanting except the retrogressive venous current from the neighboring vein, a knowledge of which indeed could hardly be theoretically attained. If, on the other hand, it is demanded why extravasations are not met with in all cases in which necrosis of the retinal tissue

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* Graefe's Archiv, VIII., 1, p. 224.

is found, I would refer to the frequently cited article of Cohnheim,* which contains an exhaustive discussion of the circumstances in question.

We have still to discuss the inquiry as to whether the red spot at the macula lutea, that has grown to be an almost pathognomonic indication of embolism of the central artery of the retina, is to be interpreted as a phenomenon of contrast or a hemorrhage. We find it noted thirteen times in the eighteen cases of the table, and are justified in distinguishing between it and the infarctus, an indubitable hemorrhage into the retina. Among these remaining twelve cases we find the red spot associated eleven times with a white discoloration of the macula lutea. The only time that the red spot existed, without opacity of the macula lutea, we find expressly stated that "a reddened place is met with on the macula lutea, *between which and an extravasation there is a distinct difference.*" (Case 8, Schirmer.) In another of these cases (9, Knapp's third case), an ecchymosis at the upper edge of the papilla is described, and then a small, dark-red spot on the macula lutea alluded to; a similar coincidence occurs, moreover, in Blessig's case: one would think that the question of likeness or dissimilarity would be easily decided, owing to such an immediate juxtaposition of two red spots. In considering Steffan's discussion of the present question,† it is presently discovered that this is based on a false mechanical principle, that of arterial collateral fluxion, and, with its result, the formation of extravasation

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* L. c., pp. 85-88 † Graefe's Archiv, XII., 1, pp. 39-47.

in the choroid, must be held erroneous; hemorrhages from arterial fluxion having been proved by Cohnheim untenable. Looking now at the table with a view of ascertaining the form of development of this red spot in the several cases, we find the description to present no inconsiderable variations. At one time there is a cherry-red spot in the immediate vicinity of the foramen centrale, at another situated on the foramen centrale itself; sometimes it is described as on the macula, and sometimes indeed as around it. In the case I myself observed I found it red, with a granular surface, indistinct boundaries, entirely unlike an extravasation, with no parallax to be made out between it and the neighboring retinal veins.* The red coloration was most intensive in the middle, corresponding to the fovea centralis, and passed through a succession of less brilliant shades till it merged in the normal fundus. Its disappearance was gradual and equal on all sides, the red color slowly melting into the ordinary yellow-brown. The impression made on me by the red patch, I have already described as entirely dissimilar to that produced by an extravasation, and I am very well able to conceive how, when a whitish coloration occupies all of the yellow spot but the fovea centralis, the intensely red centre must appear as a hemorrhage. Inasmuch now as I find no anatomical foundation for a venous hemorrhage in the region, and especially the centre of the macula lutea; inasmuch, moreover, as no veins quit the

* It seems almost incredible that the binocular ophthalmoscope should be neglected, as a means of diagnosis, in such cases, and a "parallax" gravely alluded to in determining differences of level.—TRANSLATOR.

choroid at the portion posterior to the macula lutea; *inasmuch, however, as the most numerous and vigorous twigs of the short posterior ciliary arteries enter the choroid exactly at the posterior pole,** it is easily seen that the collateral fluxion succeeding the embolism may attract especial notice by its deep-red color, exactly at the point where the vessels are still closely packed together, since this fluxion consists in an acceleration of the current of blood through arteries dilated under an increased pressure, *without any extravasation through the arterial walls being yet brought about.* Inasmuch now as the middle of the yellow spot is colorless, nearly wholly transparent, and at the same time the thinnest portion of the retina,† the normal appearance of the fovea centralis is that of a dark-red spot; if now, on the other hand, an increased redness of the choroidal polar region occurs, the color of the fovea centralis must naturally increase. When, as in my case, this red color embraces the whole macula lutea, in gradually decreasing intensity indeed, and without sharply-defined boundaries, I find in exactly this circumstance an increased support of the theory advanced: for in the first place the thickness of the remainder of the macula lutea is more considerable than that of the fovea centralis, and in the second place the boundaries of the yellow spot are never as sharply defined in old

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* Leber. Investigations concerning the course and connections of the vessels in the human eye. Graefe's Archiv, XI., 1, p. 14.

† H. Müller. Anatomic-physiological investigations concerning the retina of men and vertebrates. Zeitschrift für Wissensch. Zoolog., VIII., p. 1–122. Gesammelte Abhandlungen, p. 303.

people as in children; from the last circumstance it necessarily results that the superjacent retinal pigment must cause the circumscribed hyperæmia of the choroid to appear somewhat diffuse. This explanation is favored, too, by the gradual and equable disappearance of the red color, without the occurrence of any perceptible change of tissue.

COLOGNE, November, 1872.