THE BRITISH JOURNAL
OF
OPHTHALMOLOGY
NOVEMBER, 1932

COMMUNICATIONS

ANTERIOR DIALYSIS OF THE RETINA:
DISINSERTION OR AVULSION AT
THE ORA SERRATA

BY

J. RINGLAND ANDERSON

MELBOURNE

PART I

"Abreissung der Ora serrata," "désinsertion," "rétino-dialyse."

As the condition about to be described is comparable with iridodialysis, "anterior retinal dialysis" appears to be a suitable title. In each form of dialysis a delicate tissue yields at its weakest point, close to its periphery. The application of the term "posterior dialysis of the retina" to the rare form of separation at the optic disc is a further reason for preferring this term to "disinsertion." Though in practice it may be useful to consider that the retina is inserted at the ora serrata it appears unwise to separate it artificially in this way from the more anterior part of the inner wall of the optic cup. It is unnecessary to introduce a new term into ophthalmology. Probably the separation is not at the ora serrata but immediately behind it. Scheffels appears to use "dialysis" and "detachment at the ora" synonymously.

Gonin found an anterior dialysis in 10 per cent. of his series of 300 retinal detachments and Arruga (1932) in 10 per cent. of 216. Leber in 1908 stated that anterior avulsion of the retina in detachment was frequently seen with the ophthalmoscope.

This paper is a study of examples of anterior dialysis of the retina, more particularly of those the origin of which is as yet unexplained. The application to the latter of the inaccurate title "spontaneous" is due to our ignorance of the productive mechanism. Such a dialysis must be due either to some developmental defect, some trauma, or some process more or less akin, to those which are recognized causes of secondary dialysis. It is wise to study the mechanism of the latter for probably this will throw some light on the search for the less obvious causes of unexplained dialysis.

Let us consider the influences that aid the separation of the retina at the ora serrata under three headings:

- I. Structural characteristics.
- II. Pathology of the zone.
- III. Effects of Trauma.

Characteristics of Incidence

It is necessary to consider several features of anterior retinal dialysis which are almost constant and more or less characteristic of the disorder. They are the preponderance of

- (1) the inferior temporal site
- (2) the male sex
- (3) non-myopic refraction
- (4) a low age of onset.

The inferior temporal quadrant is certainly predisposed to dialysis. The following statistics are based on the study of eight patients of my own and fifteen recorded in the literature. Among these the inferior half of the globe was affected in 96.5 per cent. The only dialysis affecting the upper half occurred after cautery puncture in a highly myopic girl, aged 12 years. Of these cases the inferior temporal quadrant was affected in 17, that is in 74 per cent., the superior temporal in one and the inferior nasal quadrant in three. Once the temporal half and twice the lower half of the globe was affected. So 95 per cent. were situated in the inferior half of the globe, and 85 per cent. were in the temporal half. Löhlein (1930) refers to a young female patient, who was emmetropic, and had a large peripheral rent in the inferior nasal quadrant of each eye. Shapland (1931) found 73 per cent. of dialyses in the lower half and 54 per cent. in the inferior temporal quadrant. This is in striking contrast to the presence of 53 per cent. of round holes in the superior temporal zone and 73 per cent. of arrow-head tears in the upper half of the globe.

If one combines the two series there are 64 separate dialyses.

- 59 per cent. were found in the inferior temporal quadrant.
- 10 per cent. were found in the superior temporal quadrant.
- 11 per cent. were found at the inferior pole. (6 o'clock.)
- 6 per cent. were found at the temporal pole. (Right eye 9 o'clock. Left eye 3 o'clock.)
- 10 per cent. were found in the inferior nasal quadrant.
- 3 per cent. were found in the superior nasal quadrant.
- 1 per cent. were found at the nasal pole. (Right eye 3 o'clock. Left eye 9 o'clock.)
- 84 per cent. were in the temporal half of the globe.
- 86 per cent. were in the inferior half of the globe.
- 14 per cent. were in the superior half of the globe.
- 16 per cent. were in the nasal half of the globe.

Only one of Gonin's series (1930a) of 25 dialyses was not below the horizontal meridian and it was just above the temporal limit of this meridian. He had seen a dialysis of the superior retina only as a result of injury.

In attempting to explain this, it is well to consider first why the neighbourhood of the ora serrata itself is apt to be a line of lowered resistance. It is a zone predisposed to cystoid degeneration, an agent capable of causing rents, and one that develops most markedly and probably earliest in the temporal half. We know

Diagram showing sites of anterior retinal dialyses.

also that not only is the anterior portion of the retina and particularly the temporal area most exposed to direct trauma, but that this area shares with the macular zone the bulk of the damage resulting from indirect trauma. We must remember too the possibility of repeated small contusions on this exposed area producing sufficient damage to start the mechanism that tears the retina at its margin. If this is so any structural defect will greatly increase the risk. Let us therefore consider briefly the structural characteristics of this zone. A fuller description is given in Chapter II. **Detachment of the Retina.**

The anterior margin of the retina—the ora serrata—derives its name from the more or less dentate appearance of its surface. Just short of its margin the retina, apart from the foveola, is thinnest (0.14 mm. compared with the retina above and below disc, 0.4 mm.) Though the retina at the equator appears to be slightly thinner than at the ora, yet the latter contains less actual tissue. This is the area most affected by cystoid degeneration and its development beyond physiological limits. The periphery of the retina is therefore, apart from the macula, its most delicate part. It also contains least supporting tissue such as nerve fibres and vessels. The fact that retinal vessels may run intact across tears is sufficient proof of the resistance they offer to the formation of a tear. Recent literature abounds with illustrations of such a state, *e.g.* see Arruga, Vogt, and Gonin. The peripheral limit of retinal vessels is 1 mm. behind the ora. The nerve fibre layer is thickest (20 to 30 μ) on the upper nasal and lower margins of the optic disc. The nerve fibre and the ganglion cell layers cease 0.5 to 1.0 mm. from the ora. The outermost periphery of the retina contains scattered neuroglia cells in place of ganglion cells and basal cones of Müller's fibres in place of nerve fibres. The membrana limitans interna retinae, like its ciliary counterpart, tends to disappear towards the margin of the retina. The periphery of the retina is also an area of transition and of growth. It is supplied by the end branches of a vascular system.

Along the line of the ora serrata three tissues are attached. (a) The vitreous base is firmly attached at the ora serrata and to a narrow area in front of it. The epithelial cells of the ciliary zone send out prolongations which are continuous with the vitreous fibrillae. This attachment defies the process of separation that causes detachment of the vitreous from the internal limiting membrane. When the vitreous shrinks under the influence of hardening fluids and in morbid conditions, it remains adherent here. When severe trauma tears the vitreous away the ciliary epithelium goes with it and the end of the retina loses its attachment. The anterior and posterior limiting layers of the vitreous are attached in front and behind the vitreous base respectively, and the line of conden-

sation which appears between the secondary and tertiary vitreous remains adherent at the ora serrata throughout life. The attachments of the zonule itself to the ciliary epithelium extend as far posteriorly as the ora serrata. (b) The retina beyond the ora serrata is reduced to a layer one cell thick, which, instead of being insecurely attached, as the retina is, to the retinal pigment epithelium, is firmly attached to the ciliary pigment epithelium. Therefore

Dissection of anterior half of eyeball. A pin is passed through the vitreous base and drawn away to show traction on the adjacent retina and even tearing of the pars ciliaris as a result of its firm attachment there. The margin of the retina is seen midway between the pin and the pigment. A pin inserted through the posterior vitreous did not hold and produced no traction on the retina.

Microphotograph of oblique transverse section of human eyeball, showing fibres of suspensory ligament leaving the pars ciliaris retinae.

the separation of the two retinal layers in retinal detachment tends to end at the ora serrata. (c) As the pigmented epithelium of the ciliary body is attached to the choroid the periphery of the retina

Microphotographs of dissected human eyeball showing the periphery of the retina. The firmly adherent vitreous has been detached and drawn to the right where it is seen lying behind the iris. The pars ciliaris retinae and its pigment has torn away cleanly from the ciliary body.

The second photograph shows the vitreous adherent to the periphery of the retina which shows cystoid degeneration.

The third view shows the manner in which the pigmented epithelium of the ciliary region strips off from the underlying tissues.

may be involved in the action of the outermost part of the ciliary muscle—the tensor of the choroid. Through the firm attachment of the vitreous base to the epithelium of the pars plana and of the latter to the pigmented epithelium of the ciliary body, each tissue finds anchorage to the choroid. To this triple line of union the otherwise loosely adherent inner retinal layer is attached.

It must always be remembered that not only have the protein basis of the vitreous, Müller's fibres and the membrana limitans interna a common origin, but that in life they appear to be connected. This union may be greatly increased by the formation of adhesions, which appear to form so readily. Tissues with a common origin often share the morbid changes of injury and disease. Can an unduly strong attachment of the base of the vitreous play any part in producing anterior dialysis? Fuchs (1920) considered that in his case the anterior boundary membrane of the vitreous predisposed to dialysis. Gonin at the French

Ophthalmological Society's Congress in 1930, said that retinal "désinsertions" were due to a wide adhesion of the vitreous body to the retina. Once the pars ciliaris retinae and the ora serrata itself are torn from the retina by its adherent base, the retina itself lies loosely on the pigment epithelium until fluid collects beneath it, or fluid vitreous passes through the tear and causes its detachment.

Why do the vast majority of anterior dialyses occur in the temporal half of the globe? This portion of the retinal periphery is the earliest to be affected by cystoid degeneration; it is the most exposed to trauma, and it shows certain structural characteristics. The periphery of the retina is thinnest on the temporal side.

The teeth of the ora serrata are most plain where the ciliary body is shortest, that is on the nasal side. The ciliary body is narrowest in the superior nasal quadrant (4.6 to 5.2 mm.). "On the temporal side they often fail completely, and the border is then only finely and irregularly wavy or angular. The teeth correspond in position to the intervals between the ciliary processes and all the irregularities of the development in the corona ciliaris are reflected in the ora serrata." Salzmann (1912*a*). Even in the adult, toothed processes may extend here and there to the ciliary processes, particularly in hypermetropic and malformed eyes. Mann (1928*a*). The teeth are least marked where the ciliary body is broadest. Salzmann and others consider that in hypermetropia the ciliary muscle is narrower than in emmetropia and that it is widest in myopia. The temporal part of the ciliary muscle, resembles the myopic type.

During the fourth month of intra-uterine life the junction between the retina and the ciliary epithelium is just behind the ciliary processes. (Schultze.) This junction constantly moves backwards. More strictly, according to Salzmann (1912*b*), the change is due to the mesodermal walls of the eye growing further forwards over the border of the retina. According to this view, the more the mesoderm grows forwards the greater is the tendency for the teeth to disappear, and so as one would expect, the smallest teeth are found on the temporal side. At birth the orbiculus ciliaris is therefore very short. (1.4 mm. whilst in adults it is 3 to 4 mm.) The ora serrata is 1 mm. further from the limbus on the temporal side of the globe than on the nasal side. This asymmetry is more marked in many of the lower mammals. (Duke-Elder.) About the time of birth the border of the retina tends to become thrown into an artificial fold, which projects into the vitreous and slightly forwards. This, the fold of Lange, still tends to form at the age of 2 years. By the seventh year adult conditions are present on the nasal side. At this age in the child, and nasally in the adult, there is a marked projection of retina over ciliary epithelium.

One is justified in concluding that the wider ciliary body and the absence of teeth in the inferior temporal region of the ciliary body prove it to be more developed than the nasal side. This is the very quadrant in which anterior dialyses are most apt to occur. Cystoid degeneration is more marked also in the temporal half of the globe.

According to Donders the most peripheral portion of the retina is blind. As the nasal field is only 60° wide, it appears that, at least, on the temporal side of the retina, a zone 4 mm. broad is devoid of visual function. Salzmann considers that the histology of the retina does not justify this conclusion. It is strange that this zone is the site in which spontaneous dialyses are most commonly found. This absence of function may explain the little interference with vision in an early dialysis, and also the interval between injury and recognition of visual loss.

Anterior dialysis is most common below the horizontal meridian. Is this fact associated with the phylogenetic youth of the lower in comparison with the senility of the upper retinal area? Ida Mann (1928*b*) has shown that the lower area may be considered as "fluid", and the upper as "stable" in phylogeny. Throughout the vertebrate order the lower area appears earlier and develops further the higher the animal is in the scale. "It appears to be added to the upper area by growth of areas bounding the foetal fissure." Adaptive modifications are most apt to occur in fluid regions. The ontogeny, too, of the various orders shows that this area is younger and more plastic than the upper. In the 5 mm. human embryo the lower area is just recognisable, while the upper is quite advanced. It is not till the 17 mm. stage that nerve fibres are present below and more plastic than the upper. In the 5 mm. human embryo the phylogenetic youth accounts for structural variations in the lower area in different orders, so ontogenetic youth may account for the frequency of congenital defects, and possibly of defects with a relatively early onset, such as anterior dialyses. The majority of retinal holes that are degenerative in origin appear in the older retinal area and almost all dialyses appear in the "fluid" area.

The Male Sex

Amongst 17 patients with anterior retinal dialyses, 15 were male. One of the affected females was a high myope who developed a dialysis after operation—not a spontaneous dialysis. Including this patient 88 per cent. were male whilst in earlier series of all forms of detachment the average percentage of males was over 60 per cent., and this percentage was not affected in Sattler's series in which non-traumatic cases were excluded.

Does the pursuit of sports such as football, boxing, and high diving mean extra trauma in the male sex? The inferior temporal quadrant is certainly the most exposed to injury. In only

one of my eight patients, did injury play any direct and definite rôle. Of the two patients reported by Juler one had done a considerable amount of boxing but none for four years, and the other who had bilateral dialyses, had received two separate blows on the head. Thirty patients in Shapland's series of 134 patients with retinal detachment gave a history of recent local or general trauma. Of these 14 had a dialysis, 5 one or more round holes, 5 horse-shoe shaped holes and 5 irregular rents and 1 a radial slit. Each of the 5 patients who presented an irregular rent gave a history of recent local injury. So 100 per cent. of those with an irregular rent were probably influenced by local trauma, 38 per cent. of those with dialysis, 22 per cent. of those with horse-shoe shaped holes, 20 per cent. of those with a radial slit and only 16.6 per cent. of those with round holes. Of 11 other patients with dialysis only 3 gave a history of recent trauma, so the percentage is probably about 35.

A patient reported by Ballantyne (1931) is of great interest. A man, aged 24 years, noticed that his vision was defective a month after he had received a blow on the left eye when boxing. The upper part of the fundus was of a uniform orange colour and showed no sign of retinal vessels. A small area towards the lower periphery was normal and showed one or two vessels. The large intermediate zone contained a prominent, slightly billowy, veil of tissue, which ended near the lower periphery in a grey, curled and somewhat ragged edge. This tissue was the retina which was torn from the pars ciliaris from 8 o'clock to 2 o'clock. It had fallen down and presented its posterior surface to the observer. No retinal vessels were visible in it but a shadowy suggestion of a vessel near its upper limit and one or two small twigs on the lower curled edge were found. The tissue moved slightly with vertical ocular movements. The patient had central fixation and a field, to a 5/330 white spot, which embraced the fixation point. In the subsequent discussion Juler stated that he had recently seen a boy, with a temporal dialysis, in whose eye the posterior retinal surface was presented. Goulden also had seen a similar case. It is probable that a small dialysis may appear after an injury and may heal spontaneously. Haemorrhage in the periphery of the vitreous may obscure it from view.

Has the preponderance of males amongst patients with this disorder and amongst those with spontaneous retinal haemorrhage of adolescence any connection? Since Eales fully described the latter condition in 1880 and 1882, most bodily disorders have been mentioned as causes and an unending list of therapeutic measures has arisen. Gonin considers that one exciting cause of retinal dialysis is an effusion of blood—a spontaneous haemorrhage of adolescence which he considers is related to tuberculous changes in the retinal veins. There is considerable evidence to show that

the majority of these haemorrhages arise between the equator and the ora serrata. Velhagen (1932) and others hold the view that tuberculosis is not only the most common cause of juvenile vitreous haemorrhages but also of retinal detachments in young emmetropes. It is likely that this explanation does not apply to all countries for the incidence of ocular tuberculosis appears to be very variable.

Non-Myopic Refraction

The majority, that is, over 60 per cent. of patients with detachments are myopic and if anterior dialysis is excluded the percentage is higher. Of 16 patients with dialysis 13 were non-myopic, 2 were slightly and 1 was highly myopic. In the last case the dialysis was not spontaneous and it followed operation. In a small series of 19 patients with detachment excluding dialysis, only one was not myopic and the average degree of myopia was $-11\cdot3$ D. The average error amongst eight patients with dialysis was $+1\cdot3$ D. Shapland found 27 of his patients with dialysis to be emmetropic, 1 to be aphakic, 6 to be low myopes, and 3 to be high myopes. In the combined series of dialysis 77 per cent. occurred in non-myopes, 15·4 per cent. in low myopes, and 7·7 per cent. in high myopes.

Low Age of Onset

In Shapland's series of 100 cases of detachment that were operated on, the average age of onset was 41 years 6 months. This is much lower than the average age in most series, which is just over 60 years. Amongst sixteen patients with dialysis the average age was 27 years. Two were 15 and one was 16 years of age, and the oldest was a sailor of 54 years. All the others were under 40 years.

There appears to be a tendency for detachments of relatively early life to occur in the lower half of the retina, and for those of later life to occur above. In an analysis of 49 patients who were considered by their surgeons to be suitable for operation, 30 showed the initial hole in the upper half of the globe, and 19 in the lower half. The average age of the former group was 47 years and of the latter 28 years. Gonin's series of 25 cases of retinal dialysis can be summarised as follows:

Age	Per cent.	Number	Emme- tropia	Aphakia	Mild Myopia	Marked Myopia
Under 25 years	44	11	7	2	2	—
Between 25 and 35	28	7	6	—	1	—
Between 35 and 45	12	3	1	—	1	1
Between 45 and 55	16	4	2	1	—	1
	—	—	—	—	—	—
Total	—	25	16	3	4	2
	—	—	—	—	—	—
Percentage	—	—	64	12	16	8

Pathology of the Vitreous

The attachment of the posterior limiting membrane of the vitreous to the retina is wide and, according to some observers, extends to the equator. Samuels (1930). It is conceivable that traction, by means of the large radiating lamellae of the vitreous, could produce a dialysis. Once the limiting membrane is detached cellular membranes form on its external surface and they can pull on the retina.

As the vitreous base is so firmly attached in the neighbourhood of the ora serrata, it is wise to consider briefly the causes and results of vitreous detachment. It may be due to the shrinkage of inflammatory products and these are most commonly the result of cyclitis. The vitreous may be detached in retinitis, choroiditis and myopia, and it may be pushed forwards in subhyaloid haemorrhage, or drawn forwards by a shrinking vitreous haemorrhage. The detachment may be complete when it is globular. More frequently, however, it is incomplete and tent-shaped with its apex at the disc, or at the scar round a perforating wound, or an intra-ocular foreign body. Occasionally an antero-lateral detachment is found in which the vitreous is separated from the suspensory ligament.

The Lausanne and the Zürich schools particularly emphasize the frequent appearance in both senile and highly myopic eyes, with and without retinal detachment, of a fine annular opacity in front of the disc which is due to a tearing away of the vitreous. This appearance is one sign of vitreous detachment which is a frequent forerunner of retinal detachment. Vitreous detachment is however more frequently associated with detachments of the upper retina than with dialysis. Yet the alteration in form and position of holes in the "posterior hyaloid" after cauterisation, reveals the influence that vitreous contraction may have on adherent retina.

The influence of less obvious vitreous changes is not yet understood. But the ability of this highly turgescient gel to lose its water content attaches fresh interest to the effects of slight trauma and general disorders and their ability to produce vitreous and retinal detachments.

Pathology of the Ora Serrata and its Neighbourhood

Cystoid degeneration of senile origin affects first and mainly the anterior margin of the retina. It first appears immediately behind the teeth of the ora serrata between the ages of 16 and 20 years. Kuhnt (1881) found that the affected area was of greatest breadth on the temporal side. Zeeman (1912), after examining ten cases came to the same conclusion. The breadth of the affected area varies from 0.5 to 7.0 mm. Leber considered that clinical recognition of this degenerative change was scarcely possible.

Microphotographs of aged chimpanzee's eye to show attachment of vitreous remnants to periphery of the retina and cystoid degeneration. Notice that the artificial detachment ends at the ora serrata. The lower photograph shows complete separation of the retina from its pigmented epithelium. Beyond the ora serrata the pigment has detached with the pars ciliaris.

Cystoid degeneration of periphery of human retina.

Even if it was situated more favourably for ophthalmoscopic recognition he thought that the transparency of the changes would make this difficult. Macroscopically one observes a network of raised gray lines. The extent and complexity of this appearance varies greatly in individuals.

Leber considered that the senile form of cystoid degeneration was purely a regressive change. The absence of venous congestion and of real oedema shows that inflammation plays no part. "As the retinal lymph escapes along the lymph tracks which accompany the vessels a congestion of them will set in earliest at the extreme periphery of the retinal capillary net where the pressure acting on the lymph from behind is smallest—as Iwanoff suggested in 1869." (Leber.) The good state of preservation of the retina and the early age of onset suggest that there is no primary degeneration of cellular tissue.

Dufour and Gonin (1906) found that there is a peripheral restriction of the visual field in old age. Leber considered that the rareness of this finding suggested that the restriction was not due to cystoid degeneration.

When cystoid degeneration occurs as a result of retinal disease, whether due to toxins, trauma or circulatory upset, it is scattered and not confined to the periphery. Leber (1916a) shows it in thrombosis of the central retinal vein, in renal retinitis and in

exudative retinitis. It is also found in all forms of retinal detachments, in glaucoma, in iridocyclitis, in retinitis pigmentosa and choroido-retinitis, and in forms of slow degeneration that produce staphylomatous changes and phthisis bulbi. In such disorders the spaces, which are larger, tend to coalesce forming blisters which contain clear fluid, and project from the external surface of the retina. Lawson (1869) observed eleven such prominences in one globe. They may be 6 to 8 mm. in diameter. When a large area is affected they may simulate a retinal detachment. Occasionally the appearance has aroused suspicions of tumour formation and the globe has been removed. (Treacher Collins, 1890.)

Cystoid degeneration of the retina has been found in association with sarcoma of the choroid. It is apt to occur whenever there is congestion, and either excessive formation of fluid or decrease in the escape of such.

Influence of Cyclitis

In the past anterior dialysis of the retina was more commonly seen by pathologists than by clinicians. This was partly due to the fear of sympathetic inflammation after trauma and old disease

Microphotograph of ciliary region of human eyeball to show the extension of exudate in cyclitis. The routes taken are towards the anterior and posterior chambers, into the vitreous and along the anterior surface of the retina. Later the ciliary body and the periphery of the retina are drawn centrally.

Photograph of Plate VIII, Fig. 1, *Trans. Ophthal. Soc. U.K.*, Vol. XXI, p. 210. Leslie Buchanan. Cyclitis: A study of inflammatory exudations into the vitreous body in cases of cyclitis.

Detachment of the vitreous after an injury. Notice intact attachment at ora serrata.

Detachment of the vitreous from gonorrhoeal ophthalmia and consequent phthisis bulbi.

which was not as great as it is to-day and so the removal of eyes was at times unduly postponed and examples of secondary dialysis developed. It is also due to incomplete clinical examinations.

The ophthalmoscopic picture shows the retina as if drawn backwards. This appearance led to the early belief that posterior traction

DIAGRAM REPRESENTING: 1. Spread of cyclitic exudation.
2. Contraction of cyclitic membranes with tearing away of pars ciliaris retinae and release of retina.
3. Passage of fluid through dialysis.

produced the dialysis. However in most instances the impelling force acts from in front. The ciliary region once again appears as the "cockpit" of ocular disease.

In the early stages of cyclitis an effusion of fluid and later an escape of cells occurs. In acute cyclitis, even a few hours after an injury, leucocytes escape from the ciliary body and pass into the vitreous, both posterior and anterior chambers, and between the epithelial cells of the retina. The spread posteriorly over the retina is of particular interest. The lymph secreted is readily

coagulable and the amount of fibrin varies greatly. The exudate in the posterior chamber is not as readily removed as that in the anterior chamber. Much of it generally remains to become organised. The tendency to organisation is greatest in the spaces in which the fibres of the suspensory ligament lie. Here even as early as the eighth day fibrous organisation may begin to appear. (Buchanan, 1901.)

In later stages a thick transverse membrane is found stretching centrally from the ciliary region on each side. From it processes may be found running to the retina. "During the contraction

Transverse cyclitic membranes projecting from region of ora serrata into vitreous.

which always accompanies consolidation of such tissue the ciliary processes are drawn inwards, and the whole ciliary body is often detached from the sclerotic, except at the spot where the ciliary muscle is inserted into the sclerotic just behind the angle, leaving a large supra-ciliary space traversed by fine, more or less concentric laminae of pigmented stroma. The retina also may be detached by

Perforating wound with connective tissue uniting iris, ciliary body, lens and anterior part of retina and vitreous. A funnel-shaped detachment of the vitreous and a folded retinal detachment end at the ora serrata but the detachment of the anterior choroid and the ciliary body spreads forwards to the base of the iris.

Sympathetic cyclitis with T-shaped membrane formation containing a fragment of new bone. The retina is firmly attached to this membrane and is detached resembling a funnel.

Cyclitis with wedge of dense fibrous tissue filling up space between lens and retina which is detached as far as the ora serrata.

Photographs of plates from the Atlas of Pagenstecher and Genth.

the same process, the globe finally shrinking and entering into the condition known as phthisis bulbi." "The part nearest the ciliary body naturally organises first since it is from this part that the fibroblasts are derived." Parsons (1908a). Parsons in his work "Pathology of the Eye," Fig. 256, shows the manner in which traction, after cyclitic organisation, can retract the periphery of the iris, draw the ciliary processes inwards and detach the retina. (See also Collins and Mayou, 1912.)

The relationship of these findings to anterior retinal dialysis is made clear by a brief survey of two reports made by Leber. Leber's detailed report (1916b) of his histological investigations of a case reported by Nordenson (Nordenson's 4th case) proves that traction from the ciliary region after cyclitis can produce an extensive anterior dialysis. The patient was a woman, aged 52 years, in whose right eye a retinal detachment had suddenly appeared. An extensive avulsion from the ora serrata was observed ophthalmoscopically. Owing to the onset of acute inflammation and diminished tension the eye was removed six weeks after the appearance of the detachment. The retina was obliquely and almost completely torn away close to its anterior limit. Only a short fragment (1 to 1.5 mm. long) was left adherent to the pars ciliaris at which point the latter was detached. A layer of tissue which was attached to the orbiculus ciliaris all round, ran transversely across the globe. This represented the vitreous and was typical of the appearance described by Pagenstecher (1876) as anterior and posterior vitreous detachment. The vitreous which was still attached at the optic disc was drawn

Detachment of vitreous showing transverse cyclitic membrane.

Kerato-iritis with glaucoma and retinal detachment. Notice nasally the shrunken vitreous and the cyclitic membranes which are drawing the detached retina forwards.

Photographs of plates from the Atlas of Pagenstecher and Genth.

forwards into a stalk. The structure of the retina itself was surprisingly normal. A cellular layer which had grown from the pars ciliaris, over the anterior portion of the retina, was obviously similar to the earlier described "pre-retinitis," which was considered by Leber to play so great part in the production of many detachments. This layer appeared as if it could have produced traction on the retina. It was still adherent to the anterior margin of the tear but posteriorly it ended as a free and extended shred. A marked and peculiar hypertrophy of the detached part of the pars ciliaris was present. Anteriorly it was of normal thickness but where it bordered on the retina it was a compact membrane of elongated and proliferated cells and was at least as thick as the retina. The cells were in many layers and anteriorly were formed into clusters between which small gaps were found which were bridged over by fibres which strove to reach one another in arcade-like form. Only the adjacent retina was very irregular in structure. In the presence of vitreous liquefaction and the absence of tissue on the posterior part of the retina which could produce traction, it could be assumed that the ciliary proliferations had caused the dialysis. The origin of the whole process was certainly a chronic cyclitis. The structure of the retina itself was normal. It was the most recent detachment of this kind to be investigated microscopically.

Leber (1916c) reported another of Nordenson's cases. The eye was myopic (8 D.) and was excised fifteen months after the appearance of the detachment. During the first twelve months the retina

went back into position twice. After the final recurrence the retina became widely detached below and a large dialysis could be seen. After enucleation a complete anterior dialysis was found at the transition line into the pars ciliaris, and the retina was pulled far

Spontaneous retinal detachment in myopia. (Case 1, Nordenson.)

Anterior retinal dialysis. The pars ciliaris is detached from the choroid as far as the ciliary processes, and is firmly adherent to the detached vitreous. Its posterior end is torn from the retina which has been drawn back and lies in folds which are adherent to each other. Joining the ends of the pars ciliaris and the retina and represented in the illustration merely as a line there is a layer of newly-formed tissue on the surface of the thickened vitreous.

Photograph of illustration 248 in *Graefe-Saemisch-Hess Handbuch*, 1916.

backwards. The pars ciliaris was widely detached from the ciliary body and pulled perpendicularly inwards. On its anterior or inner surface lay the detached vitreous with serous exudation behind it. A marked proliferation of ciliary cells extended from the posterior end of the pars ciliaris to the anterior surface of the vitreous. From this an offshoot of cellular tissue ran to the retinal folds, uniting them as it spread between them. At first it appeared that this tissue had played some part in the production of the dialysis. Later,

however, it became apparent that this tissue had developed after the retinal tear. Such a proliferation into the scar tissue is common in all types of cyclitis. It may occur from the pars ciliaris retinae or from the retinal epithelium itself. (Parsons.) It was concluded that the traction was from in front, that is from the pars ciliaris. As in the previous case the pars ciliaris was hypertrophied and Leber considered that slight traction produced the initial and transient detachment. The extensive dialysis was produced later when cyclitic membranes had become more powerful.

It is of interest to note that this patient was troubled with exceedingly disturbing subjective light manifestations. These arose fifteen months after the appearance of the detachment, and they persuaded the surgeon to remove the eye when the vision was "fingers at a close range." Leber was inclined to consider that they were due to the presence of a rare retinitis externa. Opposite the site of the tear and towards the posterior pole the outer retinal surface was very uneven and thickened. The outer granular layer and the rods were most affected. As the choroid and the pigmented epithelium were normal this change was considered to be secondary.

The examination of several globes convinced Leber that in purulent cyclitis a proliferation of connective tissue in the anterior vitreous, and of epithelial cells on the retinal surface could produce detachment. One globe was removed two months after a cataract operation. Richly cellular tissue occupied the anterior vitreous. The vitreous was partially detached from the retina and the intervening space filled with serous fluid. A membrane of variable thickness had detached the retina and drawn it into folds. A similar membrane was found on the external surface of the retina. It is conceivable that such a condition may tear the retina away at the ora.

Influence of Trauma

Traumatic cyclitis. It is of value here to emphasize one possible result of contusions and the milder forms of trauma. The ciliary body and particularly its temporal portion is exposed to trauma. Though the typical signs of cyclitis, particularly keratic precipitates are rarely seen after contusions, haziness of aqueous and vitreous, due to exudation from the iris and the ciliary body, are commonly seen. "Precipitates on the cornea are evidence usually of a subacute or chronic process." (Parsons.) However, both exudation from increased capillary permeability and low tension from the reverse state, are early results of cyclitis whether traumatic or not. Probably a slight trauma by producing a bruising effect can start the mechanism that produces anterior dialysis.

Influence of Trauma apart from a Cause of Cyclitis

Direct Injury. The retina may be torn at the ora serrata in one of several ways when the eye is perforated by weapon, instrument or missile. It may be a direct result of the injury, and part of the wound which in turn has affected sclera, choroid and retina. Clinical recognition of such a dialysis is unlikely, as the eye is lost or its opaque media obscure the defect. Histological examination is the means by which this condition has been studied. Treacher Collins (1917) referred to several specimens in the Moorfields Hospital Museum which showed a separation of the retina at the ora serrata as the result of blows. Butler (1917) described an eyeball in which, after a blow from the bough of a tree, he found a dialysis of one third of the ora serrata.

Scheffels reported a man, aged 35 years, whose left eye was ruptured by a thrust from a cow's horn. A rupture at the sclero-corneal junction was found. After enucleation and examination nine weeks later an almost complete dialysis was present and the retina was rolled inwards. There was dialysis and partial prolapse of the iris. There was no trace of lens or vitreous and evidently the expulsion of these tissues had caused traction on the ora serrata. As a result the pars ciliaris retinae was absent except for a small area which corresponded approximately with the locality of the wound. Only at this point did the retina retain its connection with the ora serrata. Elsewhere it was dialysed and detached from the choroid.

Leber (1916d) considered it firmly established that retinal detachment could occur in healthy eyes in consequence of severe contusions which produced serous extravasation. In such cases the contusion always produced a retinal tear which lay usually in the region of the ora. Dufour, Gonin and Wagenmann supported Leber in regarding the tear as the actual cause of the detachment. Many authors considered that a paralysis-like state of the choroidal vessels was produced which permitted the collection of inter-retinal fluid. A similar explanation was advanced for the shallow detachments associated with commotio retinae. Leber referred to twelve cases of detachment following severe contusion. In ten of these one or two tears were present in the anterior part of the retina, and in six an extensive avulsion was found. In two cases Leber considered that tears were present though not found. Concerning the first ten cases Leber wrote that the choroid could be clearly seen, that no blood was seen to pass through into the vitreous and that no diffuse vitreous opacity or vitreous haemorrhage was found. In two of his series Leber observed a choroidal rupture. These

were due to injury from a blunt arrow and a spent grain of shot. The remainder resulted from a blow from a key, a pole, a falling branch, the head of a horse, and a piece of timber. In all the blow was severe, but as a rule it left no objective signs behind.

Scheffels (1891) reported two patients who developed anterior retinal dialysis after trauma which did not produce any abrasion or scar on the eye. The first was a man, aged 35 years, who was examined two days after an injury with a stick. Only the upper lid showed signs of injury and they were slight. Two months later, when the blood and the vitreous opacities had cleared, the fundus was found to be normal, except at the inferior periphery where the retina was hazy. A corresponding defect in the upper field was found. The upper lid was injured and an upper iridodialysis was present, but it was the lower part of the retina that had probably separated from the ora. Thirteen years later, when the patient returned for a "follow up" examination, a hypermature cataract prevented a fundus view. The second patient was a woman, aged 38 years. She, whilst pruning a vine, was struck in the left eye by a flying twig. Ten days later a greyish white wavy mass of folds and coils was seen through the pupil. No retinal vessels were seen, for a complete dialysis had occurred, and it was the rod and cone surface that was exposed. The choroid in all its details could be clearly seen. Scheffels stated that these two instances of dialysis, with intact zonula and lens in its normal position, were unique in the literature.

A slight injury may be sufficient to cause dialysis in predisposed eyes. In one of Leber's series, predisposition was suggested by the existence of blindness in the second eye from a probable detachment. In another the eye was myopic and the trauma slight. In Scheffels' last case a knock from a twig when pruning vines was sufficient to produce dialysis. It appears likely that in a predisposed or myopic eye a severe bodily injury may produce a dialysis. Baquis' patient was thrown from a horse. He had 14 dioptries of myopia and it was possible that contusion produced a retinal dialysis. No detachment appeared at first but, later, vitreous passing through the opening pushed forwards the retina. Knapp (1931) found an inferior dialysis from 6 to 8 D. D. in length, in a woman's eye which had been struck by her child. After cauterisation it recurred but on conservative treatment it largely re-attached. H. Müller (1931) reported a patient who, by falling seven feet, had fractured his skull and produced a long tear of the extreme periphery with a detachment. In Fuchs' patient (1920) the retina was completely detached and the dialysis was just in front of the ora serrata. In places the tear extended to the posterior edge of the corona ciliaris. Fuchs considered that the membrane of proliferated tissue that was present did not supply the traction that

produced the dialysis, but that this was due to trauma and unusual strength of the anterior border layer of the vitreous. The patient was a boy, aged 11 years, who, during the three months prior to enucleation, received two injuries to his left eye which was congenitally myopic. Haitz (1931) wrote concerning a man, aged 49 years, who fell on his back and developed an anterior dialysis. Haitz considered that the fall had jerked the vitreous backwards and torn it and the adjacent ciliary epithelium from their ciliary attachments and so released the retina. A number of cases have been reported of extensive anterior dialysis with haemorrhage into the vitreous. A branch of a tree caused the injury in Baurlein's case (1871), and broken glass in a patient of Vossius (1901). The haemorrhage may obscure the actual retinal rupture especially if the choroid is torn away too. When the anterior part of the choroid as well as the retina is torn by a severe contusion, the tear is found in the vicinity of the ora serrata.

Leber considered that detachments, which appeared during the first two months after an injury, were probably due to a peripheral tear. Such a tear, especially if small, is easily missed as long as the retina is flat and undetached. The persistence of small tears without detachment is considered by Leber (1916*e*). Even large tears may remain for some weeks before producing a retinal separation. A patient reported by Cramer (1905) illustrates this point. He was aged 59 years and he received a severe blow on his only useful eye with a threshing flail. There was no disturbance of vision for five weeks, when, preceded by a period of considerable visual vibration, blindness rapidly developed. An extensive detachment was found with an irregular tear in the extreme temporal periphery.

Influence of Indirect Trauma

Rupture of the various ocular tissues at their weakest spot may result from indirect trauma. The typical scleral rupture is concentric with and just outside the limbus. A partial or complete iridodialysis with aniridia or retroflexion may occur. The characteristic rupture of the ciliary body is a separation of the circular fibres from the longitudinal or of both from the sclera. [L. Buchanan (1903). Treacher Collins (1892)]. The suspensory ligament may rupture and occasionally so slightly that no dislocation of the lens occurs. The most common choroidal rupture nearly always occurs between the macula and the optic disc and is concentric with the margin of the latter. Choroidal ruptures, unlike the main retinal damage, are not situated at the macula; possibly the presence of the disc is a determining factor. Hughes found that 84 per cent. of choroidal ruptures developed temporal to the disc which in most cases meant

nasal to the visual axis. The retinal effects of indirect trauma are mainly found at the macula where oedema and later a hole are frequent results. If a tear is found peripherally, it is as a rule at the ora serrata but such a rupture is not common apart from perforating wounds.

Dialysis at the ora therefore appears, after indirect trauma, as one of a series of ruptures at the weakest spots of different tissues. The occurrence of a rupture of a more anteriorly situated tissue probably lessens the risk of rupture of a more posterior layer. In a globe described by L. Müller the only part of the ciliary body not detached from the sclera was that at the site of iris rupture. (Parsons, 1908b.) Similarly in Nordenson's fourth case the only part of the pars ciliaris retinae, which was not torn from the ora serrata, was detached.

Traction Scarwards with Dialysis of Antipodes

A perforating wound may alternately produce a dialysis by cicatricial contraction towards the scar. The part of the ora serrata that is diametrically opposite the scar is that which is usually

Partial anterior dialysis six weeks after a perforating wound on the opposite side of the globe.

Anterior dialysis after perforating wound. All contents of eye including temporal half of retina and the lens are drawn towards scar in the nasal sclera.

Photographs of plates from the Atlas of Pagenstecher and Genth.

affected. It has been seen that the traction in cyclitis was inwards and forwards. After a perforating wound a new direction—scarwards—is added to the lines of traction.

Martin (1929) reported a globe which had been injured by a knife in the lower nasal part of the sclera. The contraction of cyclitic membranes had torn the temporal retina away at the ora.

The lens too was drawn nasally. Poos (1928) reported a boy, aged 7 years, who was struck in the left eye with a knife. Five weeks later the eye was injured when playing football and three months later it was removed. The lens was found to be drawn towards the scar. The ciliary processes near the wound were embedded in cicatricial tissue and folds of detached retina. Posteriorly the ciliary epithelium was drawn into long thin cords of cells. The completely detached retina had even been torn from its attachment at the ora serrata. This dialysis was diametrically opposite the scar. "Attached as the vitreous is, not only to the lens anteriorly but to the retina behind, it is easily seen how a blow upon the eye would precipitate retinal detachment" and dialysis. Wintersteiner (1901) reported a child, aged 7 years, who developed irido-cyclitis after an injury. The retina was separated at the ora serrata on the opposite side of the globe to that where the scleral scar was found. He considered that direct traction had not caused the dialysis as the retina was in loose folds and not stretched. Probably the vitreous base had drawn the pars ciliaris retinae forwards until it separated from the retina and the latter was released.

Lawson (1917) reported the story of a lieutenant, aged 23 years, who at the Dardanelles was struck on the left side of his face. His vision was 6/24, and the fundus appeared normal but the vitreous was clouded and showed a large grey mobile opacity. Three months later his vision failed suddenly. "A fine lace-like veiling was found hanging detached over the lower two-thirds of the picture, leaving a gap above it through which the choroid and its vessels were plainly seen." X-rays revealed a minute foreign body near the ciliary body temporally. After rest the lower visual field improved but the upper field remained very defective. Four weeks later the retina was found to have largely re-attached and a foreign body was found high on the temporal side. Treacher Collins reported the pathological findings. The vitreous was almost absent, only a small area lay posteriorly. The retina was detached and formed a puckered membrane in the centre of the globe. After the removal of a grey gelatinous coagulum, which completely filled the space between the retina and choroid, it was found that the retina and a portion of the pars ciliaris had been torn from the ciliary body, both above and below. The only portion of the peripheral retina to retain its attachment was on the temporal side. The entire pars ciliaris and the suspensory ligament were drawn towards the centre and the temporal side of the globe. A conical projection joined the outer surface of the retina to an atrophic area of the choroid on the temporal side. The foreign body was found between the lower margin of the lens and the detached pars ciliaris. The contraction along the track of the foreign body in the anterior vitreous, had probably dragged the posterior part of the pars

ciliaris and the adjacent retina inwards towards the centre of the globe. It appears therefore as if a scar lying behind the ora may lead to sufficient cicatrisation to tear the retina at the ora. In Constantin's case (1904), four weeks after a puncture wound in the inferior temporal quadrant of the equatorial zone, the upper half of the retina was torn away and flapped over the lower half.

Supertraction of the Retina over the Ciliary Body

The retina may be drawn forwards over the ciliary body by contracting scar tissue following lens injuries or spontaneous hyalitis. The anterior edge of the retina may even reach the axis of the eye. Delicate membranous extensions appear to extend towards the lens. These draw the retina forwards. The pars ciliaris retinae at times may be affected so that it is separated from the orbiculus ciliaris. It and the ora serrata too may be drawn forwards. Leber described this form of retinal supertraction in eyes which were injured by a knife, perforated by an ulcer or affected by a metastatic vitreous abscess during an exanthem. In another eye the injury was a corneal perforation due to a peck from the beak of a cock. Newly formed tissue surrounded the lens and was connected with the ciliary body and the retina. The cells of the pars ciliaris retinae were drawn out into long fibres. Here the traction had been so great that the retina was torn at the ora serrata. The anterior margin of the retinal tear was caught forwards in tissue near the ciliary body, whilst the posterior margin was entangled in newly formed tissue near the lens margin.

Supertraction of the retina and pars ciliaris over the ciliary body from the contraction of fibrous tissue behind the lens.

Photograph from *Graefe-Saemisch-Hess Handbuch*.

Römer (1901) wrote that only one case of complete retinal separation at the ora serrata had been described histologically. This had been reported by Velhagen (1900). The patient was aged 17 years, and when 5 years of age his left eye had been injured by a shoemaker's punch. On microscopical examination the corneal scar was not found. The entire pars ciliaris was detached and folded. The retina was a shrunken mass resembling a spherical tumour on the optic disc. It was separated from the pars ciliaris by a space filled with serous fluid. Leber afterwards studied the specimens and stated that it was only the second case of dialysis from supertraction that he had seen. He considered at first that the separation of the retina was due to traction from the posterior part of the globe. However as neither connective tissue in the retina, nor any other substance to cause traction in this direction, was found, he concluded that connective tissue which was present in the neighbourhood of the shrunken lens had drawn forwards the pars ciliaris until it completely separated from the real retinal tissue which then contracted posteriorly. A similar condition is shown in Pagenstecher and Genth's Atlas (1875). Unfortunately no history accompanies the report.

Hernia

Leber (1916f) reported the globe of a child, aged 2 years, which had become ectatic after discission of a congenital cataract. After an iridectomy a slight vitreous loss occurred and on the following day a white mass of tissue was found in the wound. 16 days later

Hernia of infected contents through perforating wound.
Retina is torn from the ora serrata and the optic disc.

Photograph of plate from the Atlas of
Pagenstecher and Genth.

the eye was removed. Examination of this eye showed extensive choroidal detachment, and the vitreous space, which was markedly reduced, was filled by the retina which had become folded over many times. If a more extensive hernia occurs a dialysis may ensue.

The retina may be prolapsed into a wound, but this is much rarer than vitreous prolapse. Leber reported an eye with such a prolapse after injury. It was excised three weeks later. A gaping wound affected the whole of the cornea. The nasal half of the retina was missing. The lens and most of the vitreous had escaped at the time of the injury and the completely detached retina was separated at the ora on the nasal side. Its anterior end replaced the missing iris and was caught into the scar.

Stellwag in his "Ophthalmologie" reported instances of detachment at the ora following penetrating wounds of the globe and perforating corneal ulcers in which the lens and vitreous had been extruded. (Scheffels.) Evidently in Berger's case (1887) dialysis followed a blow from a pitchfork when the retina was prolapsed into the anterior chamber.

A similar result may complicate an iridectomy or a cataract operation. If conditions are suitable merely the escape of aqueous may be sufficient to excite an expulsive haemorrhage. Such a catastrophe is most apt to occur in ectatic globes and in the presence of vascular degeneration. Beer points out that dialysis may follow operative interference in glaucoma if due to a choroidal tumour. (Scheffels.) In Pagenstecher's collection there were two globes in which an iridectomy for this form of glaucoma had been followed by choroidal haemorrhage, inclusion of the retina in the wound and dialysis at the ora serrata. This cause of dialysis must be separated from instances due to prolonged traction from long-standing scars without prolapse. See Römer's (1901), Vossius' (1901), and Wintersteiner's (1901) cases.

Needling

If the membrane that has formed after a cataract extraction is firmly adherent to the retina near the ora serrata, a tear in this neighbourhood may occur during a needling operation. Fuchs (1877) described such a case. It followed an attempt at discission and reclinatio. The dialysis was visible through the coloboma. Leber stated that he had seen an almost similar case.

Contrecoup

A rare type of dialysis is that which is due to contrecoup when an explosive force causes the trauma. Then the retina may suffer far in excess of the choroid and sclera. In a classical case which

will be briefly referred to, to the tear at the ora, which was complete, was associated with a small rupture of the globe. The scleral wound was above the limbus and due to an explosion. Römer (1901) who reported the condition, considered that the remainder of the retina was separated at the ora by contrecoup. Clinically the iris and lens were invisible having been driven through the scleral rupture. A cord of tissue, which ran towards the scleral wound, consisted of the retina which was torn completely away at the ora. Here and there a vessel was visible as one studied the outer surface of this cord. The pigmented retinal epithelium was exposed lying intact on the choroid. At the time Römer's case was clinically unique.

Anterior dialysis is comparable with posterior dialysis which however must not be confused with avulsion of the optic nerve. In Paul's case (1905) of posterior dialysis, a fall on the face occurred

Complete posterior dialysis of the retina. Penetrating foreign body produced dense connective tissue behind lens which united ciliary body and detached the retina.

Complete anterior dialysis of the retina. The rolled up retina resembles a tumour lying on the optic disc.

Photographs of plates from the Atlas of Pagenstecher and Genth.

in which the eye was struck by a stake. This caused tearing of the retina, and its vessels from the disc. In Dahrenstadt's case (1892) a similar injury produced a steep but local detachment around the disc but no dialysis.

(To be continued)