Communications

Treatment of proliferative diabetic retinopathy by repeated light coagulation

A 7-year review

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In 1968 the results of treating 42 eyes from 35 patients suffering from proliferative diabetic retinopathy were presented at the Airlie House Symposium on Diabetic Retinopathy. We have now treated 174 eyes from 126 consecutive cases and present the results of the series which has now been running for over 7 years.

Clinical data (Table I)

The series includes 33 out of the original 35 patients reported in 1968 at the time of the Airlie House Symposium, and consists of 78 men and 48 women, whose present ages range from 21 to 72 years. For comparison with these cases we have 59 'control' eyes from 42 patients previously documented in the proceedings of the symposium.* These controls were cases studied before the light coagulator was available, and are comparable in terms of sex ratio, age at onset of diabetes, and the length of time they have been observed (Tables I, III, IV).

Table I *Clinical data in cases and controls*

<i>Series</i>	<i>Age at onset of diabetes (yrs)</i>	<i>No. of cases</i>	<i>Per cent. of total</i>
Cases	Over 40	39 (18)	30.9
	15-40	49 (33)	38.9
	Under 15	38 (27)	30.2
	Total	126 (78)	100
Controls	Over 40	17 (11)	40.5
	15-40	13 (9)	30.9
	Under 15	12 (7)	28.6
	Total	42 (27)	100

Numbers in brackets = Males

All affected eyes had true new-formed vessels as distinct from dilatations of pre-existing capillary channels, and in all cases these had given rise to subhyaloid or vitreous haemorrhages or occasionally to loss of vision due to cicatricial changes. The fact that the great majority of these cases were referred by other ophthalmologists probably ensures that we are dealing with a series of cases of at least average severity.

Assessment of patient

(a) General assessment

It is of paramount importance to have a diabetes specialist's assessment. The cardio-

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*The evolution of the changes in proliferative diabetic retinopathy and a description of Stages I, II and III, are described by Dobree (1969) and Dobree and Taylor (1968), and the photocoagulation technique by Dobree and Taylor (1968).

vascular system is examined with particular reference to hypertension, cardiac ischaemia, and the state of the arteries of the extremities, the renal system for evidence of nephropathy, and the peripheral nervous system for evidence of neuropathy.

(b) *Ocular assessment*

(1) VISUAL ACUITY

The corrected visual acuity is recorded at each visit.

(2) FUNDUS PHOTOGRAPHY, MAPPING OF LESIONS

Fundus photography of the disc and retina, approximately as far as the equator, is carried out, and in addition sketch-drawings are made.

(3) THE STATE OF THE RETINAL VESSELS

The state of the anatomical retinal vessels is particularly noted. The most striking abnormalities are usually on the venous side of the circulation, and generalized distension, with sectors of beading, sheathing, and displacement of vessels by traction bands are noted. The signs on the arterial side of the circulation are even more ominous and arteriolar narrowing and obliteration by connective tissue (the so-called "white line" appearance) is often present in the third or fourth order branchings and is indicative of retinal ischaemia.

(4) CAPILLARY ANGIOPATHY AND EXUDATIVE MACULOPATHY

Foci of capillary pathology, manifested by microaneurysms, varicose capillaries, haemorrhages, retinal oedema, and hard exudates, are indications of capillary angiopathy. They occur principally at the posterior pole, and are especially numerous just lateral to the macula. These lesions, often termed "background retinopathy", are important as they are a frequent cause of visual deterioration, but have been excluded from the series in which the main target of attack has been the proliferative lesions.

(5) HAEMORRHAGES

Subhyaloid haemorrhages are of the greatest significance in the ocular assessment in that they betray the presence of actual bleeding sites, the eradication of which is the cardinal aim of this method of treatment. Multiple subhyaloid haemorrhages indicate that several groups of new vessels have ruptured at the same time and this invariably means that the patient had undergone some physical strain.

Vitreous haemorrhages present greater difficulties, but the quadrant from which bleeding occurred can often be found from the history of how it originally appeared to the patient, or by noting the area of greater density of the haemorrhage. Small recurrent vitreous haemorrhages have been a frequent problem. These are often due to a quite insignificant group of new vessels attached to a retracted vitreous face, and painstaking examinations are required to reveal them.

(6) CONNECTIVE TISSUE FORMATIONS

These form particularly in the cicatricial stage of evolution and result either from connective tissue condensations around new vessels on the disc or retina or from thickenings of the posterior vitreous face. These may form a barrier to vision, or cause traction effects on the retina, such as schisis, detachment, or displacement of the macula or blood vessels.

The ocular condition was reviewed regularly at intervals of 3 to 4 months and serial fundus photography was used extensively to record pre- and postoperative changes.

Method

There were two major aspects to treatment:

(1) All patients, both cases and controls, were advised to modify their mode of life to eliminate as far as possible all situations leading to raised venous pressure in the head and neck. These included lifting and all forms of physical strain, straining at stool, coughing,

vomiting, etc. In addition, specific rest in hospital was advised in particular cases in which a vitreous haemorrhage was slow to show signs of absorption, especially if it was the first major haemorrhage.

(2) All patients were treated with photocoagulation on at least one occasion, but the majority had repeated light coagulation as further groups of new vessels developed. So far 63 eyes have required only one light coagulation session, and one eye has had as many as nine treatments; the average number given to the 174 eyes was 2.2 sessions. The indications for treatment were:

- (i) All flat areas of neovascularization, either Stage I or Stage II, which were not on the disc or related to the macula.
- (ii) Pre-retinal ("forward") groups of vessels, either Stage I or Stage II. However, pre-retinal Stage II vessels were not treated if associated with bands or if it was thought that traction effects on the macula might follow.
- (iii) Disc vessels were not considered suitable for direct treatment by light coagulation but in some instances regression of disc vessels followed remote peripheral coagulation. This has previously been reported (Taylor, 1970).
- (iv) Coagulations were used sparingly in cases in which the "white-line" appearance of the arterioles indicated retinal ischaemia.
- (v) Stage III lesions were not treated.*

A total of 174 eyes were treated by photocoagulation in the series of 126 patients, 48 having treatment in both eyes and 78 in one only. In 59 of these 78 patients, the second eye was untreatable when first seen because of retinal detachment, dense vitreous haemorrhage, or terminal Stage III retinopathy. Since the initial photocoagulation eleven eyes have been under observation for more than 5 years and sixteen eyes for less than 6 months (Table II, overleaf).

Results

(1) *Effect of rest in bed*

23 patients, 13 male and 10 female, were admitted to hospital for rest in bed and limitation of all physical activity. Five of these patients had bilateral vitreous haemorrhages, so that 28 eyes were under observation. After periods of rest varying from 2 weeks to several months in one case, fifteen eyes showed complete clearing of vitreous haemorrhages, although in four there was associated advanced retinopathy so there could be no improvement in visual acuity. In twelve eyes there was no real change in the density of the vitreous haemorrhage either objective or subjective, and one eye had a further vitreous haemorrhage while the patient was in hospital.

(2) *Effect of light coagulation*

Of the many possible parameters by which the effect of treatment can be gauged, the length of time that the original visual acuity is preserved is probably the most satisfactory.

(A) RETENTION OF ORIGINAL VISUAL ACUITY

174 eyes are under observation and of these 107 (62 per cent.) have retained the same visual acuity or have a better acuity than before treatment. If the eyes are divided into groups with respect to length of time under review as shown in Table III, the number of eyes maintaining the original visual acuity is greater than 50 per cent. in all periods except the 4 to 5-year period. In twelve of the 67 eyes in which there is a loss in vision, the loss is due to factors other than progression of proliferative retinopathy: increasing lens opacity (4), concurrent maculopathy (7), and paramacular photocoagulation burn (1).

Table II *Duration of observation after treatment*

Duration (yrs)	No. of eyes
> 5	11
4-5	8
3-4	31
2-3	42
1-2	35
0-1	47

Table III *Retention of visual acuity in treated and control eyes, by duration of follow-up*

Duration of observation (yrs)	Treated			Controls		
	Total no.	Eyes retaining same visual acuity		Total no.	Eyes retaining same visual acuity	
		No.	Per cent.		No.	Per cent.
> 5	11	6	55	16	4	25
4-5	8	2	25	6	2	33
3-4	31	17	55	12	3	25
2-3	42	28	67	3	2	66
1-2	35	18	51	15	10	66
0-1	47	36	77	7	2	29
Total	174	107	62	59	23	39

These results may be compared with our control series of 59 eyes, of which only 23 (39 per cent.) retained the original visual acuity.

In groups of eyes observed for 3 years or less, the numbers retaining the same level of vision were very similar, namely 66 per cent. of treated and 56 per cent. of control untreated eyes. In contrast, in those groups under observation for more than 3 years, 50 per cent. of treated eyes as opposed to only 27 per cent. of untreated eyes retained the same visual acuity.

A further comparison can be made between these two groups by considering the number of eyes retaining the same level of vision which have been under observation for more than 1 year, more than 2 years, and so on up to 5 years, instead of considering them in each separate yearly grouping. The results are shown in Table IV (opposite) and are represented graphically in the Figure. It is seen that at all stages the treated eyes had a much better retention of vision than the controls and that an unexpectedly high number retained the original visual acuity for over 5 years. In both series most failures to maintain the original visual acuity occurred in the first 2 years.

FIGURE *Retention of original visual acuity in a series of 174 treated eyes and 59 control eyes***(B) LEVELS OF VISUAL RETENTION**

The level of visual retention in the 174 treated eyes was assessed by subdividing the final visual acuity into four groups (Table V).

There were 85 eyes (49 per cent.) in Group I, 30 (17 per cent.) in Group II, 25 (14 per cent.) in Group III, and 34 (20 per cent.) in Group IV, the last falling into the category of the legally blind. Table V shows the number of eyes in each group related to the duration

Table IV Retention of visual acuity in treated and control eyes, duration of follow-up being shown cumulatively

Duration of observation (yrs)	Treated			Control		
	Total no.	Eyes retaining same visual acuity		Total no.	Eyes retaining same visual acuity	
		No.	Per cent.		No.	Per cent.
> 5	11	6	55	16	4	25
> 4	19	8	42	22	6	27
> 3	50	25	50	34	9	27
> 2	92	53	58	37	11	30
> 1	127	71	56	52	21	40
< 1	174	107	62	59	23	39

of treatment. Although there is no significant direct relationship, there is a trend towards either retention of good visual acuity or to blindness, fewer eyes falling into the intermediate categories as each year passes.

Table V Number of eyes in each group related to duration of treatment

Duration of treatment (yrs)	Visual acuity			
	Group I > 6/9	Group II 6/9-6/18	Group III 6/24-6/60	Group IV < 6/60
> 5	5	—	1	5
4-5	3	1	1	3
3-4	14	6	2	9
2-3	21	7	7	7
1-2	13	5	9	8
0-1	29	11	5	2

In addition, each group of levels of retention of visual acuity can be related to age at onset and duration of diabetes as shown in Table VI. In each range the highest number of eyes is that in Group I (*i.e.* minimum visual acuity 6/9), but if this number is taken as a percentage of the total number of eyes in each age group, a higher proportion of patients with diabetes of juvenile onset (63 per cent.) retained 6/9 vision than of those with diabetes of mature onset (35 per cent.). Moreover, there is a trend towards a more rapid loss of vision with late onset diabetes than with early onset diabetes—so that those with a visual acuity of less than 6/60 have 30 years' average duration of diabetes with onset at less than 16 years in contrast to 8 years' average duration with onset at 40 years or over.

Table VI Level of visual acuity retained related to age at onset and duration of diabetes

Group	Visual acuity retained	No. of eyes	Age at onset (yrs) < 16	Duration of disease (yrs)	Age at onset (yrs) 16-40	Duration of disease (yrs)	Age at onset (yrs) > 40	Duration of disease (yrs)
I	> 6/9	85	32	26	35	21	18	11
II	6/9-6/18	30	6	26	11	22	13	11
III	6/24-6/60	25	5	29	9	14	11	8
IV	< 6/60	34	8	30	17	22	9	12

(C) EFFECT OF DISC NEOVASCULARIZATION (Table VII)

Of the 174 eyes, 99 (60 per cent.) had new vessels on the disc, but the retention of the original visual acuity is much the same in these eyes as in those without disc vessels even though a higher proportion of the former has been under observation for more than 3 years.

Table VII *Eyes retaining vision with and without optic disc neovascularization*

Group	Visual acuity retained	No. of eyes	
		With disc vessels	Without disc vessels
I	> 6/9	47 (20)	38 (10)
II	6/12-6/18	12 (2)	18 (6)
III	6/24-6/60	13 (3)	12 (1)
IV	< 6/60	27 (21)	7 (7)

The numbers in brackets refer to numbers of eyes under observation for more than 3 years.

Thus 47 eyes (47 per cent.) with new vessels on the optic disc and 38 eyes (51 per cent.) without disc vessels fell into Group I. In contrast, in Group IV (*i.e.* eyes which are legally blind), there are 27 eyes (27 per cent.) with and only seven eyes (9 per cent.) without disc vessels—in both cases more than three-quarters of the eyes have been under observation for more than 3 years. While many eyes with disc vessels pass into the cicatricial Stage III without bleeding, the occurrence of disc haemorrhage may gravely and permanently influence the prognosis.

(D) VISUAL RETENTION IN TREATED “ONLY EYES”

This is a particularly interesting group of cases in which the eye treated had a potentially bad prognosis, the fellow eye having either been previously blinded by proliferative diabetic retinopathy or considered to be untreatable. There are 42 of these pairs of eyes for study and they have been under observation for from 15 months to 5 years since the first treatment by photocoagulation. Of the 42 untreatable eyes, the vision was less than 6/60 in 34, 6/24 in four, and 6/36 in the remaining four. All these eyes had terminal Stage III proliferative diabetic retinopathy or retinoschisis. The retention of vision in the treated group of “only eyes” is remarkably good; 27 eyes (64 per cent.) retained the original level of vision and 22 of these (52 per cent.) have a visual acuity of 6/9 or better. Only eleven eyes (26 per cent.) fell into the category of the legally blind with a visual acuity of less than 6/60. This compares very favourably with an untreated series of Patz and Berkow (1968), who found that in 89 per cent. of patients the vision in the second and better eye deteriorated to less than 20/200 in a 5-year period, and moreover that in 59 per cent. the visual loss actually occurred in the first 12 months.

(3) *Retinal effects of photocoagulation*

(a) As is well documented, groups of flat retinal new vessels directly treated by photocoagulation are obliterated, some small vessels appearing to close immediately and the remainder within a few weeks. In addition, regression has been observed of small groups of new vessels lying nearer to the optic disc than the coagulated areas, as well as regression of some flat unsupported new vessels on the disc itself.

- (b) Areas of preretinal "forward" neovascularization do not respond in the same complete manner, but there is frequently an attenuation of the new vessels and they become tenuous and atrophic although still maintaining a circulation.
- (c) Photocoagulation interrupts the normal sequence of events in proliferative diabetic retinopathy. Areas of neovascularization associated with the upper and lower temporal vessels are often followed by the formation of a scimitar band. However, if these areas of neovascularization are obliterated by photocoagulation, no connective tissue or scimitar band develops, thus preventing many traction complications.
- (d) In contrast, there may be acceleration of the natural development of proliferative diabetic retinopathy after extensive photocoagulation. This is exemplified by the rapid progression of disc vessels from Stage I to III in a few months after coagulation to multiple separate retinal areas. This change can be equally beneficial, as haemorrhage is very uncommon from the resulting relatively avascular tissue.
- (e) Pooled subhyaloid haemorrhage appeared to clear more rapidly after light coagulation to the group of new vessels which had bled. It therefore seems possible that there are recurrent small haemorrhages from the same area of neovascularization and that once the area is obliterated haemorrhage is absorbed with relative rapidity.
- (f) Direct photocoagulation of subhyaloid haemorrhages results in rapid absorption in a few days. This practice is to be advocated for persistent subhyaloid haemorrhages rather than allowing posterior vitreous face thickening to develop over the haemorrhage. Care is taken to ensure that there are no major vessels deep to the haemorrhage.
- (g) A generalized reduction in venous calibre was often observed after extensive light coagulation, but no reversal to a uniform calibre occurred in beaded veins. A reduction in the number of small retinal haemorrhages was associated with this generalized reduction in venous calibre.

Discussion

The prognosis for vision in proliferative diabetic retinopathy has been estimated in several studies. Deckert, Simonsen, and Poulsen (1967) and Caird, Burditt, and Draper (1968) found that 50 per cent. of patients became blind within 5 years, and data from Beetham (1963), as calculated by Caird, Pirie, and Ramsell (1969), showed that 43 per cent. of those with juvenile onset and 61 per cent of those with mature onset became blind within 5 years.

In this series 20 per cent. of the total number of treated eyes fell into the category of legal blindness, with an increase to 24 per cent. if only those eyes under treatment for more than 3 years are considered. Moreover, 49 per cent. of this series retained full vision, *i.e.* visual acuity better than 6/9. Even in the small series of "only eyes", over 50 per cent. retained a visual acuity of 6/9 or better, and only 26 per cent. had a visual acuity of less than 6/60. This result agrees with the findings of Krill, Archer, Newell, and Chisti (1971), who found that 35 per cent. of second, better eyes, became blind in their series of eyes treated by photocoagulation. It is probable, therefore, that photocoagulation may enable more patients to retain good vision for longer than has been indicated in untreated series previously published.

Caird and others (1968) showed that the prognosis for vision in proliferative diabetic retinopathy is worse with increasing age and this is confirmed by the findings of Patz and Berkow (1968, 1969) and Miki, Fukuda, Kuzaya, Kosaka, and Nakao (1969). In our

treated series we also found that patients with diabetes of mature onset lost vision in a shorter time than the younger patients, but in both types the best results were obtained from the early treatment of groups of new vessels, although coagulation is necessarily more limited in older patients in the presence of ischaemic changes.

It seems, therefore, that photocoagulation has a definite place in delaying or preventing the onset of blindness in patients with proliferative diabetic retinopathy. It should, however, be emphasized that in this series the results have been obtained by meticulous observations coupled with precise photocoagulation by the same two ophthalmologists, with adequate resources for in-patient treatment.

Summary

- (1) 174 eyes from 126 consecutive cases of proliferative diabetic retinopathy have been treated by repeated light coagulations and restriction of certain forms of physical activity. The results are compared with those in 59 "control" eyes from 42 patients previously documented.
- (2) Using the parameter of the retention of the original visual acuity, the treated cases fared better than the controls, especially those eyes which were under observation for more than 3 years.
- (3) In a group of 42 treated "only eyes" which had a potentially poor prognosis, being the surviving eyes of patients in whom the fellow eye was blind or was untreatable because of proliferative diabetic retinopathy, the retention of vision was considerably better than in an untreated series previously reported.
- (4) A more rapid loss of vision occurred in patients with diabetes of mature onset than in patients with diabetes of juvenile onset.

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