EXPERIENCES WITH LIGHT COAGULATION OF FUNDUS LESIONS*

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THREE YEARS AGO, at a meeting of this Society, the first results from our experiments on the effects of high intensity visible light on the retina and choroid were presented. These experiments had been carried out for the Air Force and while our primary concern was with the hazards resulting from the light flashes of atomic explosions, it was at once evident that light coagulation should prove to be a valuable clinical tool. This had already been suggested by Dr. Meyer-Schwickerath of Bonn, Germany, who had used sunlight as a source of energy as early as 1948 in the clinical treatment of various types of fundus lesions. At the International Congress in 1954 in New York, he reported on the treatment of such lesions with a light coagulator in which a high intensity Xenon arc served as light source.

Two years ago we had the good fortune of finding a Von Hippel's angioma of the macula in the right eye of a patient which was successfully treated with our experimental machine. With this apparatus only the macular area could be treated since, in order to carry out coagulation, it was necessary for the patient to look directly into the light. Peripheral lesions could not be treated with this apparatus because of the great difficulty in localizing the area to be treated. This case was reported in the *American Journal of Ophthalmology* for October, 1958.

Following the successful treatment of this case, the potentialities of this form of treatment became even more apparent. Plans were made for developing a clinical instrument when it was learned that Dr. Littman of the Zeiss Company had designed a light coagulator for Dr. Meyer-Schwickerath which would soon be made available commercially. After corresponding with Dr. Littman and Dr. Meyer-Schwickerath and after sending two members of our department to

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Germany, we were able to obtain a light coagulator for the Department of Ophthalmology at the Medical College of Virginia. This instrument was installed and ready for use in May, 1958. This presentation summarizes our results during the past year in employing this instrument, both experimentally and clinically.

Prior to using this instrument clinically, it was calibrated with the same water-flow calorimeter as that used in calibrating our experimental instrument. When this was done, it was found that the Zeiss instrument could develop an irradiance up to 1.9 cal./cm.^{2}/sec. when measured at the cornea (about 30 to 40 percent more energy than that available with the experimental machine). When translated into maximum energy available at the retina, this proved to be 95 cal./cm.^{2}/sec. for an image of 1 mm. size.

After calibrating the instrument, a number of rabbits were burned and it was found that rather severe chorioretinal burns could be obtained with a very short exposure time and with much less intensity than the maximum. It was also found that when maximal or somewhat submaximal intensity was used with even a short exposure time a popping noise could be heard, a noise resembling that heard when corn pops. This was found to be due to a sudden massive build-up of steam within the confines of the choroid and retina which exploded into the vitreous, leaving a crater which could be seen ophthalmoscopically. Minimal burns could be obtained in the rabbit with the least intensity available on the machine and with an exposure time of about ½ sec.

After employing the machine for several weeks on animal experiments, it was felt that enough experience was available for us to tackle our first human case. As might be expected, the first candidate was a doctor. This individual had suffered two previous detachments and had developed a hole in the mid-periphery in an area of old lattice degeneration. He felt that light coagulation was preferable to diathermy and immediately volunteered. A delimiting barrage was laid down surrounding the area of lattice degeneration and the hole itself coagulated; immediately thereafter the patient was able to return to work.

In this case, and in the others that followed, it became apparent that considerably more energy was necessary for a burn of the human choroid and retina than that necessary for a burn of similar severity in the rabbit (about one-half again as much energy). Since this initial case, light coagulation has been carried out on 42 eyes. These fall into several different categories (Table 1).

TABLE 1. LIGHT COAGULATION

	No. of cases	*Result*		
		Good	*Poor*	*Insufficient follow-up*
Retinal tears without or with flat detachment	9	8		1
Delimiting barrage in old detachment	1	1		
Macula holes	7	5	2	
Combined surgery and coagulation	9	7		2
Tumors	4	2		2
Neovascularization of retina	1	1		
Central retinal schisis	2	2		
Choroiditis	4	2	2	
Xanthelasmas	3	3		
Artificial pupil	2		1	1
TOTAL	42	31	5	6

1. *Retinal tears with or without flat detachment.* Retinal tears of traumatic or degenerative origin with no detachment or very early flat detachment lend themselves beautifully to light coagulation therapy (Figures 1, 2). The area of the tear should be sealed off first by a barrage laid down at the periphery of the tear where the retina is absolutely flat and where there is no separation. The area of the tears themselves should then be burned and in such cases the minimal amount of subretinal fluid present absorbs without further therapy. About seven days after exposure a firm pigmented barrage can be

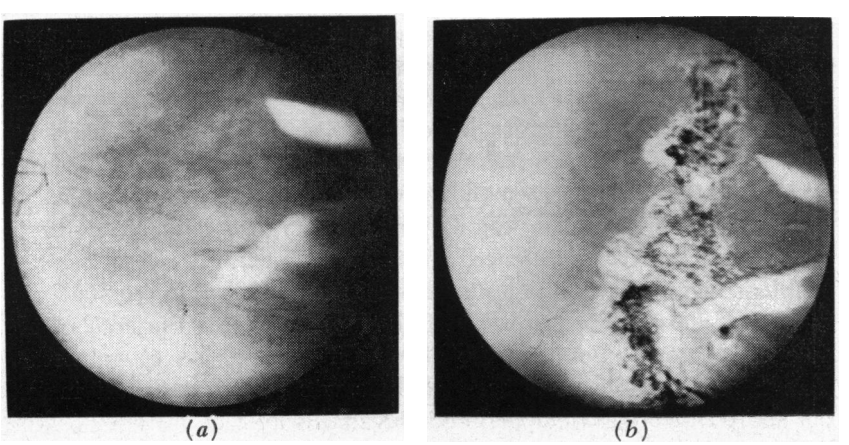


FIGURE 1

(*a*) Peripheral traumatic retinal tears; (*b*) same eye three weeks after light coagulation.

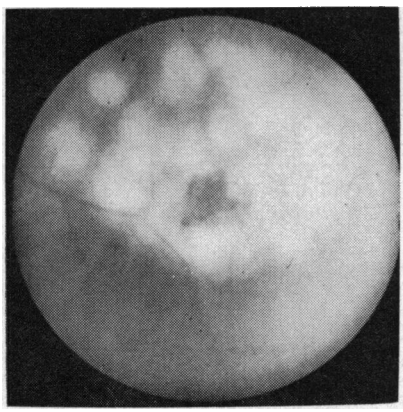


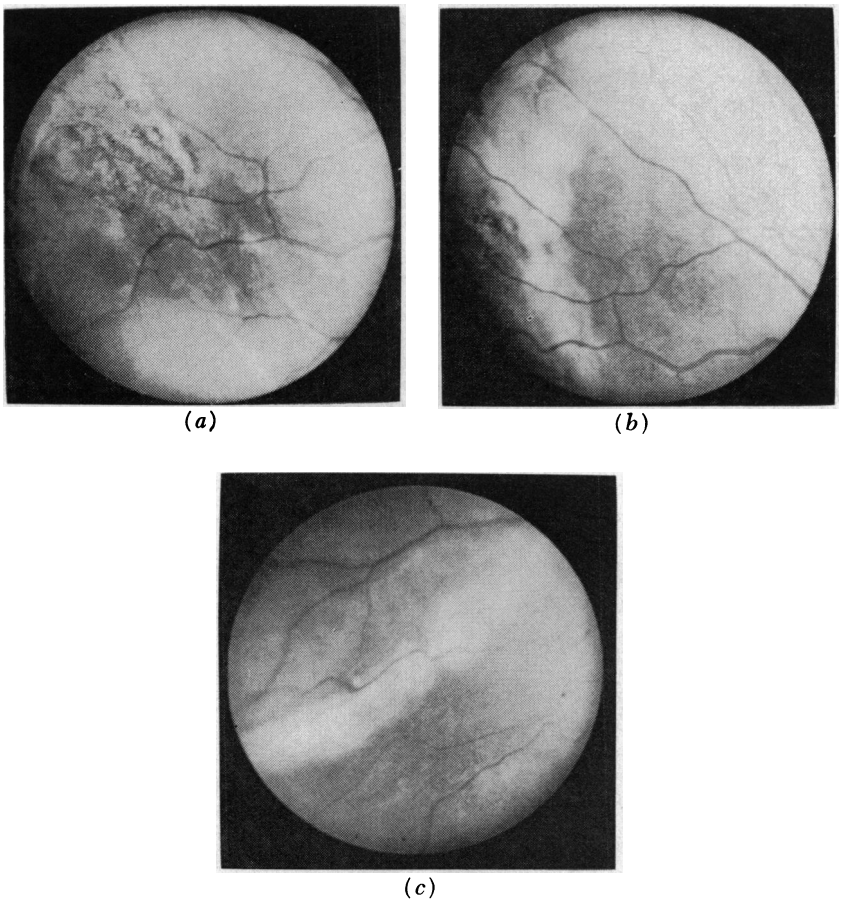
FIGURE 2. SPONTANEOUS RETINAL TEAR IN MID-PERIPHERY TWO DAYS AFTER LIGHT COAGULATION

seen ophthalmoscopically and its appearance differs in no wise from that produced by diathermy. We have so far treated nine cases of this type with excellent results.

2. *Delimiting barrage in old detachments.* One case of a large, moderately elevated, old inferior detachment with encroachment on the macula and with beginning spontaneous demarcation lines was treated successfully in a 16-year-old boy (Figure 3). Central vision was preserved.

3. *Macular holes or cysts.* Macular holes or cysts, of either primary or secondary etiology, are naturals for this type of therapy (Figures 4, 5, 6). It must be emphasized, however, that for light coagulation to be successful the area of the hole must be flat; otherwise coagulation will not occur. It is, therefore, important to treat these lesions early before separation has occurred and, if there is actually a detachment present, fluid must be evacuated before attempting coagulation. In all instances of this type of lesion, visual acuity has long since disappeared and, as a consequence, impairment of central vision is not a problem. Five macular holes or cysts were successfully treated and two cases were treated unsuccessfully. In these cases the area of the hole and a small amount of the surrounding retina was coagulated.

In the first unsuccessful case the hole was of traumatic origin and the entire retina was detached and elevated from 2 to 3 diopters. Mild coagulation did not result in a take, but after coagulation with moderately strong intensity an apparent adhesion resulted. The retina did not remain flat and after several weeks it re-detached. It was



(*a*) (*b*)

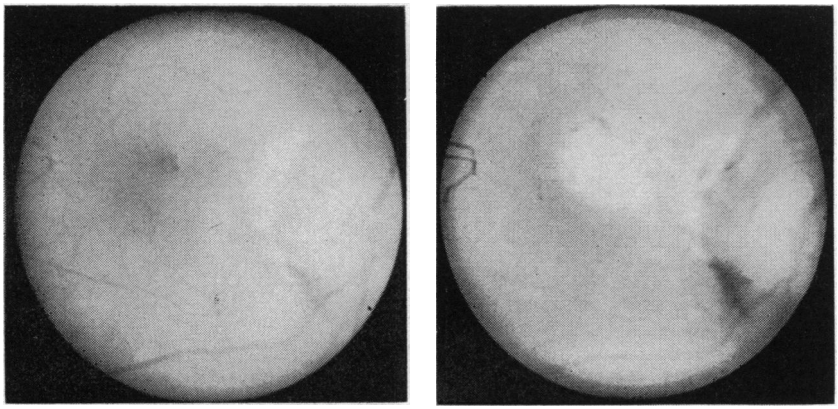
(*c*)

FIGURE 3

(*a*) Long-standing retinal detachment with partial demarcation line; (*b*) same area immediately following a delimiting barrage with light coagulator; (*c*) delimiting barrage in another area of the same patient.

not possible then to carry out coagulation with the light coagulator as the detachment had become bullous. Drainage of subretinal fluid, followed by injection of vitreous, was then tried and when this failed an Arruga type cinching procedure was carried out, but without success. The other case failed because of moderate elevation of the central retina and the patient refused further surgery.

4. *Combined surgery and light coagulation.* In nine cases of retinal detachment, where the retina was bullous or moderately elevated, con-



(*a*) (*b*)

FIGURE 4

(*a*) Macular hole with retinal folds; (*b*) same patient one week after light coagulation.

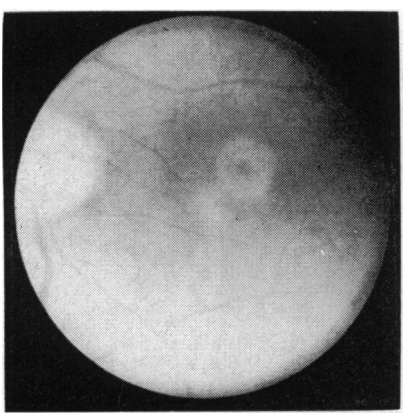


FIGURE 5. MACULAR HOLE IMMEDIATELY AFTER LIGHT COAGULATION

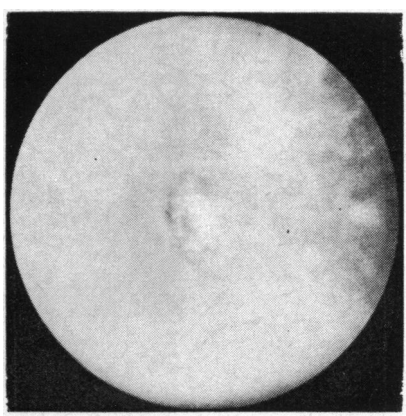


FIGURE 6. ANOTHER MACULAR HOLE TWO WEEKS AFTER LIGHT COAGULATION

ventional diathermy with evacuation of fluid and treatment of the holes with diathermy was carried out and at the end of surgery, or several days postoperative, the light coagulator was used to supplement the diathermy barrage. A preoperative delimiting barrage was employed in four of these cases to prevent possible spread of the detachment to the macular area. In one instance, where there had been two previous detachments in an aphakic eye followed by scleral resection and reattachment, a successful reattachment occurred fol-

lowing a complete circumferential light barrage laid down inside the ring of scleral resection and supplemented by vitreous injection. Vision obtained in this case was the same as that noted prior to the last detachment (20/70).

Another interesting case in this group was that of a 72-year-old male who had undergone a previous detachment operation, a cataract extraction, and a glaucoma operation in the affected eye. When the retina again detached, he was found to have two small holes, one immediately below the disc and another in the 6:00 o'clock meridian just inside the ora. An attempt was made to seal the small hole near the disc with the light coagulator, but it was found that subretinal fluid prevented a take. Subretinal fluid was then evacuated in the lower periphery and at the same time a surface diathermy barrage was laid down over the lower half of the retina 2 to 3 mm. posterior to the ora. The sclera over a degenerated area very close to a vortex vein was coagulated with diathermy. As the fundus was observed following this, a spontaneous choroidal detachment was seen to creep in from this peripheral area and to completely embrace the hole below the disc. When light coagulation was then carried out, the hole was easily sealed off. The area of the hole in the periphery was also treated with ease by the light coagulator. Following this treatment, the patient obtained 20/30 vision with correction which was the same acuity he had prior to detachment (Figure 7).

This very interesting case suggested to us the possibility of draining subretinal fluid and at the same time creating a spontaneous choroidal

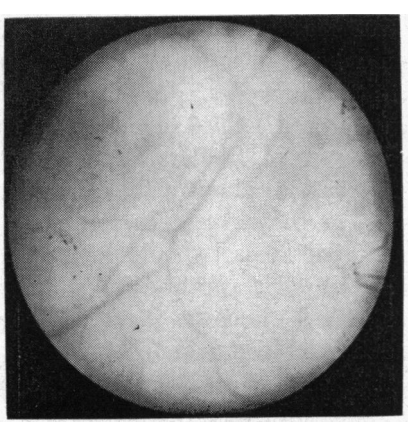


FIGURE 7. SMALL RETINAL HOLE BELOW THE DISC IMMEDIATELY AFTER CLOSURE WITH LIGHT COAGULATION

detachment which would push the choroid against the area of the retina where light coagulation could then be carried out. Such a procedure has been tried on several eye bank eyes with success and will shortly be tried on a suitable detachment case. As yet it is not apparent whether fluid injected into the suprachoroidea will be the most effective method of causing a choroidal detachment, but this at present appears to be the most feasible.

Recently a case referred to us with a recurrent detachment following a Schepens encircling tube was successfully treated. A hole had developed on the surface of the tube and a flat detachment was beginning to spread from this area toward the macula. With the light coagulator the detached area was completely sealed off although the hole itself could not be sealed since the buckled area over the hole would not absorb sufficient heat to cause coagulation. This phenomenon is apparently due to two causes: first, in tubed cases of long standing the choroidal pigment becomes atrophic over the tube; second, the tube itself is transparent. Thus, there is no pigment to absorb the light with resultant coagulation, but instead the light passes through and is dissipated. If one expects to employ the light coagulator in tubing operations of this sort, it would seem advisable to use a darkly pigmented tube, in lieu of a transparent one, as a substitute for the atrophic choroid. If tears then occur on the surface of the tube, coagulation can be carried out, not only in the area of the detachment itself, but in the region of the buckled hole.

5. *Tumors of the retina and choroid.* Lesions of this type lend themselves beautifully to light coagulation. Von Hippel's hemangioma can be easily treated with the light machine, but where the tumor is of massive size it should be eradicated slowly by repeated exposure at intervals of two to three weeks. At the present time a massive hemangioma involving about a third of the retina is undergoing treatment. This patient has been treated at monthly intervals for five months and the tumor now is about a third its original size. It is important to remember in these large tumors that the tremendously dilated and tortuous feeder vessel should be assiduously avoided, for if it is inadvertently burned a rupture may take place either at the time of the burn or later by necrosis. As a result of this the vitreous cavity will be flooded by blood which, of course, precludes further light coagulation, at least until such time as the blood absorbs. We have not yet run into this difficulty, but we were emphatically warned about it by Dr. Meyer-Schwickerath. A hemangioma of the choroid was treated with our light machine for Dr. Angus MacLean by Dr.

Meyer-Schwickerath. This case will be reported at this meeting by Dr. MacLean.

Recently, treatment was begun on a case of Coats's disease associated with numerous aneurysms and neovascularization in the periphery. The large size of the involved retina has necessitated the multiple stage approach and at the present time only three treatments have been carried out. However, rather remarkable shrinkage has already occurred.

We have not yet had a malignant melanoma to treat, but Dr. Meyer-Schwickerath in his report at the recent International Congress in Belgium reported success in 43 out of 63 clinical melanomas which he treated. None of these was larger than 6 or 7 disc diameters in size.

Small retinoblastomas involving less than a quarter of the retina can be treated by light coagulation. We have had experience with only one such tumor which occurred in an 18-month-old child, whose right eye had been enucleated two weeks before because of a massive retinoblastoma, proved histologically. At the time of this surgery the referring doctor had found a small retinoblastoma 2 disc diameters in size about 3 disc diameters above and temporal to the macula. A circumferential barrage was laid down surrounding this tumor and then the tumor itself was coagulated with greater intensity. One week later the tumor itself was again coagulated and three weeks later a large pigmented scar could be seen in the area where the tumor had been, but in the center there was still a small nonpigmented zone. It was felt that to be safe further light coagulation should be carried out and the depigmented zone was again treated with a fairly intense dose. The involved area now is reduced to a large mottled pigmented area such as that seen in areas of old choroiditis and there is no evidence of tumor (Figure 8).

6. *Retinal neovascularization.* One case of retinal neovascularization following venous obstruction has been treated with a good result. This was done prophylactically to prevent repeated hemorrhages (Figure 9).

7. *Central retinal schisis.* Two cases of central retinal schisis following disciform macular degeneration were also treated prophylactically. In the past we have seen on several occasions a complete detachment resulting from lesions of this type and for this reason prophylactic coagulation was carried out. Both of these lesions were successfully walled off.

8. *Solitary or sharply localized areas of acute choroiditis.* It would seem that this type lesion would be most responsive to light coagulation (Figure 10). Four cases were so treated, two apparently with

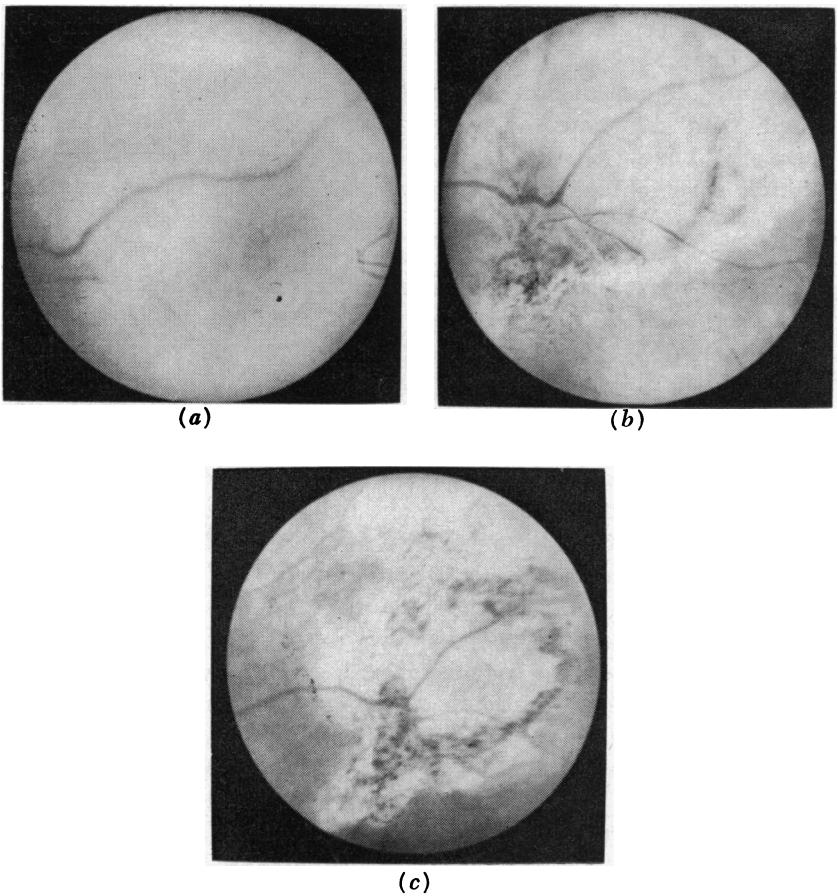


FIGURE 8

(*a*) Small retinoblastoma above the macula; (*b*) one week after light coagulation; (*c*) four weeks after first and one week after second light coagulation.

success and two unsuccessfully. Strangely enough, the two which were apparently successful were of the type thought to be toxoplasmic where daughter lesions constantly recur. In these instances both the old lesions and the fresh were coagulated. In both cases of failure the lesion was a solitary one. In both of these cases there were probably additional peripheral lesions which could not be found.

9. *Light coagulation with the external coagulator.* The adapter for light coagulation of external lesions of the eye has only been in our possession for about three months. During this interval we have

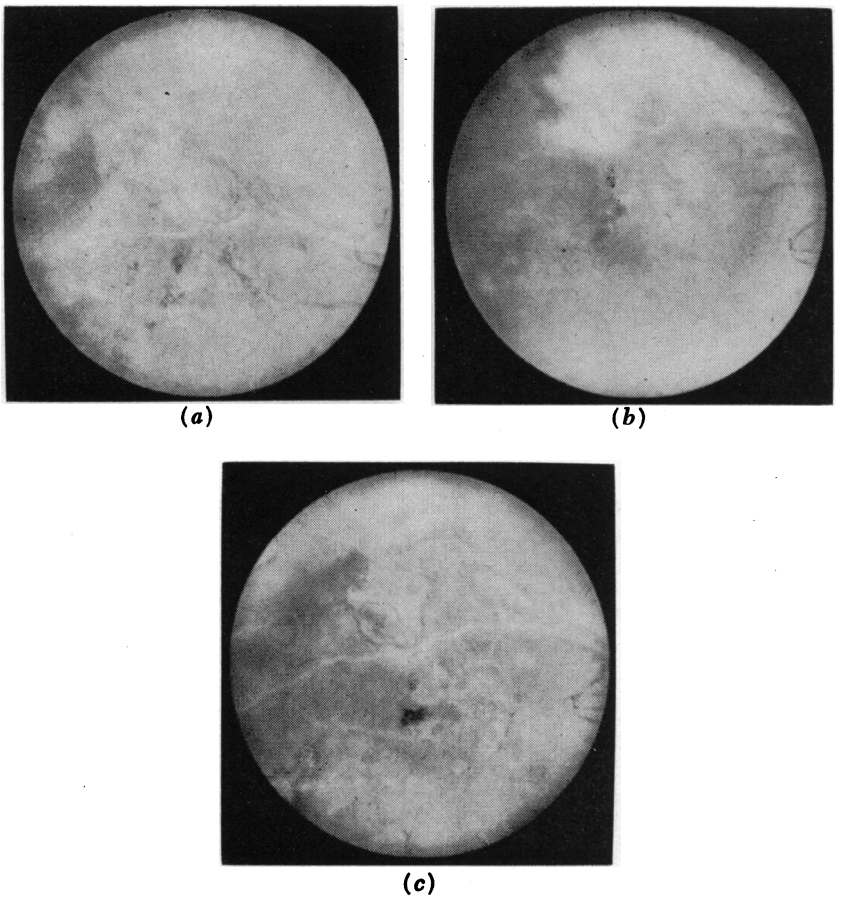
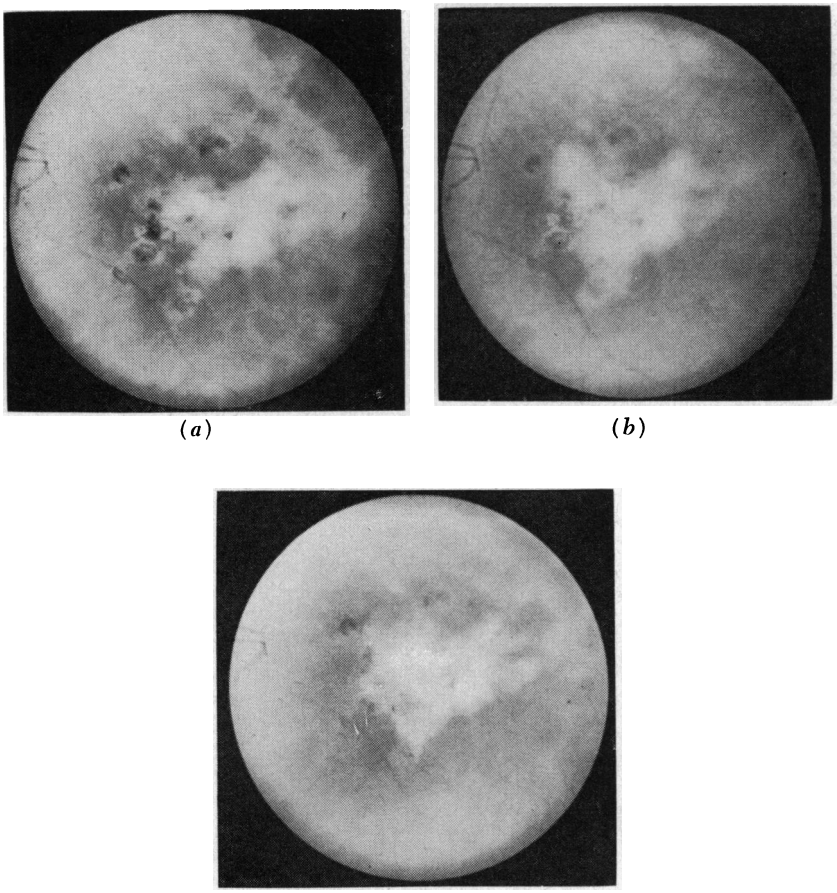


FIGURE 9

(*a*) Retinal neovascularization following central vein occlusion; (*b*) same area immediately after light coagulation; (*c*) same area one month after light coagulation.

burned several xanthelasmas, all with good results. Following light coagulation of the xanthelasmas, the lesions ulcerate and rather marked scab formation takes place. This heals in about two weeks, leaving no scar (Figure 11).

Artificial pupils have been burned in several rabbit eyes (Figure 12), but so far we have only attempted to burn two human cases, both aphakes. In one of these the contact cooling chamber was employed and instead of burning the iris as was expected, coagulation of the



(*a*) (*b*)

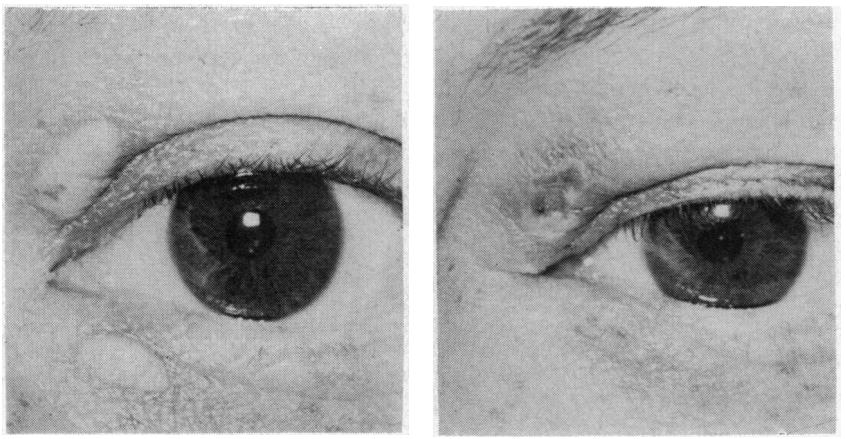
(*c*)

FIGURE 10

(*a*) Recurrent central chorioretinitis with two active lesions; (*b*) same area immediately after light coagulation; (*c*) same area two months after light coagulation.

cornea occurred. This was apparently due to the rather critical focus as a result of using the cooling chamber and the beam was inadvertently focused more on the cornea than on the iris.

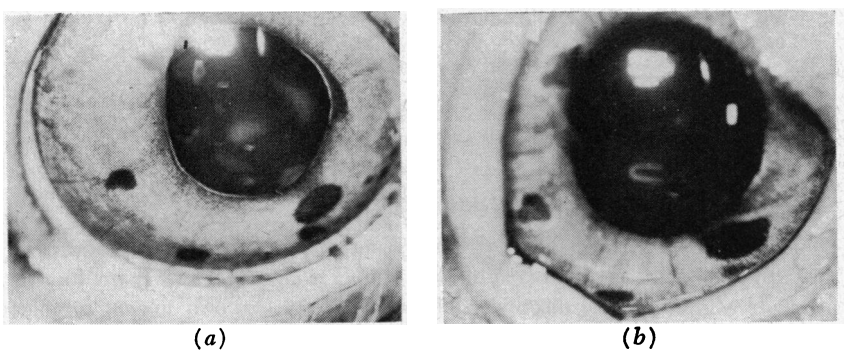
It must be kept in mind that, if iris lesions are to be burned in the non-aphake, spot coagulation of the lens takes place beneath the pigmented iris lesion. If this is far out in the periphery, it will apparently occasion no difficulty. Therefore, if such a lesion is to be treated with the light coagulator, the pupil should be widely dilated,



(*a*) (*b*)

FIGURE 11

(*a*) Xanthelasmas; (*b*) xanthelasmas immediately following treatment with external light coagulator.



(*a*) (*b*)

FIGURE 12

(*a*) Rabbit iris immediately following light coagulation with external light coagulator; (*b*) same iris after one month—in two of the coagulated areas a hole has formed in the iris.

else a central or paracentral coagulation of the lens may result with some loss of visual acuity.

SUMMARY AND CONCLUSION

From our experience with light coagulation, it is our studied opinion that this therapeutic tool is a valuable addition to the armamentarium of the ophthalmologist. Its full potentialities are yet to be realized, but

already it is apparent that such therapy is the method of choice in treating certain lesions. No retinal detachment service can afford to be without a light coagulator.

The importance of predetachment symptoms, such as light flashes and sudden showers of vitreous opacities, must be publicized in order that simple prophylactic light coagulation can be carried out early, before true detachment occurs necessitating surgical intervention.

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DISCUSSION

DR. DOHRMANN K. PISCHEL. Dr. Guerry and his group are the pioneers in the United States on light coagulation, and I want to thank them for the privilege of opening the discussion of their paper. I can only accent some of the things Dr. Guerry said, as he covered the field so well. The experience of my colleagues and myself parallels that of the authors, even to our results in rabbits, in which much less current is used to obtain results comparable to those in human beings. We are lucky to have a series of cases to report, and the results are the same as Dr. Guerry's. We had 31 cases of holes without detachment, with 30 good results and one failure, the latter in a doctor, who has a totally uncured detachment.

It will take years to determine the value of treating degenerated areas of the retina prophylactically before cataract extraction. We really do not know whether we have helped any patients who have degenerated areas at the periphery. Anyone who has been an ophthalmologist for very long has seen dozens of patients whose periphery looks mottled and degenerated, and these patients have gone for years without trouble.

Very dramatic is the curing of patients whose detachment has settled with bedrest. We find 10 percent will settle with bedrest.

Postoperative treatment with light coagulation can be done either immediately, while the patient is still in the operating room or has been brought into the adjacent room in which the light machine is located, or a week or more after the primary operation. Here again, it is difficult to tell whether we have really helped the patient by the addition of light coagulation. We have treated patients immediately afterwards, and five, ten, and twelve days afterwards, sealing holes off where it looked as though they needed more coagulation. This points up one of the great advantages of light coagulation. Formerly when we wanted to reoperate on a patient, we were faced with a very difficult and hemorrhagic operation in which the orientation was difficult. With the light coagulation machines not a drop of blood is shed, and the patient appreciates the lack of discomfort. I will say, on the basis of our clinical judgment of the 32 cases reported, that probably half were saved a second operation. [A slide was shown summarizing Dr. Pischel's cases.]

We have had only a few cases of Von Hippel's disease and the question mark in the Table represents one still under treatment. In contradistinction to diathermy, where we may have massive hemorrhages if we hit a large vessel, this is a very mild procedure, but it is more drawn-out. We can cure very few with one light coagulation; so many months of treatment and observation are needed.

The question marks on aneurysms in the Table again represent two patients still under treatment.

At the time the Table was made, we had treated four cases of retinoblastoma; we now have a fifth which has just been started. The one failure is one that had advanced to form a very large tumor and should not have been treated with light coagulation. However, the parents refused all other treatment; so we did it with a rather guilty feeling because, as has been proven, we could not keep up with the increase in size of the tumor.

Two patients were bleeders into the vitreous and one was a persistent bleeder. They have gone a number of months now with no hemorrhage, where formerly they went only a matter of weeks between hemorrhages. Since this slide was made, we have treated several more of these, and they all seem to work very well.

[Slides were then shown of various lesions before and after treatment. A Von Hippel's tumor at the edge of the disc was shown before and six months after treatment. A malignant melanoma was next shown, first with a ring of coagulations around it, then with treatment of the tumor itself, and finally the five-year cure. A retinoblastoma before and after treatment was also shown. Slides were then shown of treating new-formed vessels as in some form of Eale's disease, with the resulting scars. Finally macular holes before and after light coagulation were shown.]

It is to be noted that in treating Von Hippel's tumors, one must treat them over several months. While this is time consuming, it is safe, as no bad intraocular hemorrhages will occur.

DR. A. EDWARD MAUMENEE. I agree with Dr. Pischel and Dr. Guerry that the light coagulator is a very valuable instrument, and there are many conditions which are very favorable for treatment with this machine. However, are we really justified in treating small pigmented lesions of the fundus, particularly in a patient with two eyes, with light coagulation? Dr. Tamler and I will present a discussion of such small pigmented lesions at the next A.M.A. meeting. We have followed some 30-odd cases from one to ten years and have not noticed any appreciable increase in size of these small lesions. Is it possible that light coagulation of a benign melanoma might stimulate it to become a malignant melanoma? It is thought that thermocoagulation of skin nevi may produce malignant melanomas. On the other hand, if this lesion was a malignant melanoma could one be sure he had destroyed the deepest layer of cells in a lesion elevated 2 to 4 diopters?

DR. ARTHUR J. BEDELL. The authors have operated upon three cases which would have been better without light coagulation.

One was a typical macular hole with dark base and small, white spots about the periphery. This hole never goes on to retinal detachment and the treatment made a much larger scotoma. Another was a well-established compensatory circulation following occlusion of a branch vein. Treatment was of no value, and made the condition worse. The third was an acute choroiditis where the terminal scar was much larger than it would have been if modern treatment of the causative agent had been instituted.

The authors have called attention to some of the advantages of this form of coagulation and also demonstrated several counterindications for its use.

DR. WIESINGER. We should like to thank Dr. Pischel for his kind discussion of our paper. It is very gratifying to learn that his much larger experience parallels our own to a great extent. This certainly justifies our enthusiasm for light coagulation.

I believe that everybody who is working with the light coagulator realizes that we are still in the trial and error period of experimentation and only after more of us gain experience with this type of treatment can one expect to learn all the advantages and pitfalls that almost every new method of treatment carries.

I should like to briefly answer the other discussers. We have had no personal experience in the treatment of pigmented fundus lesions. I fully agree with Dr. Maumenee that one should not tackle benign nevi of the fundus. Meyer-Schwickerath has reported treatment of 63 clinically malignant melanomas and has reported 43 cures which represents a rather remarkable figure. From his description and fundus pictures of the cases that he treated I have no reason to believe that he is treating benign lesions, for they exhibit such signs of malignancy as growth, field defects, etc.

Dr. Bedell's word of caution is well taken and applies especially to prophylactic treatment of retinal detachment as emphasized by Dr. Pischel in his discussion. We are aware of the fact that macular holes do not lead to

destruction of the eye, but we have, however, seen several instances where a complete retinal detachment developed following hole formation with very little chance for a surgical cure. Dr. Meyer-Schwickerath, in a personal communication, has substantiated our experiences. All cases treated by us had a visual acuity of 20/200, Snellen, or less, so that a slightly larger scar than the original hole caused no noticeable diminution of visual acuity.

The cases of neovascularization treated are only such that had undergone repeated retinal and vitreous hemorrhages previously and coagulation was carried out of the vessels thought to be responsible for such bleeding.

The treatment of choroiditis with light coagulation is very experimental. We believe that in one patient this was able to render him free of recurrences; again in this case central vision has long since gone.

This paper was primarily intended to report our limited experiences with light coagulation and to stimulate others to join in this new field of "bloodless" ophthalmic surgery.