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MICROWAVE DIATHERMY IN OPHTHALMOLOGY: CLINICAL EVALUATION

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I HAVE no doubt that most ophthalmologists in this audience have had the same experience that I have had in the management of many disease conditions in the posterior ocular segment. My own experience has been, in general, extremely discouraging. For that reason I have been inclined, as I suppose you have, to welcome any new method that seemed to promise better results. I am afraid that I have also been inclined, at least until experience taught me otherwise, to grasp at any improvement observed, without too much critical evaluation. We all seem to be avoiding that particular error in microwave diathermy. Careful animal experimentation has preceded clinical testing. The physiologic implications of the experimental results have been carefully studied. Finally, there has been an admirable degree of restraint in the attribution of clinical successes to this method. I am sure, therefore, that I need not emphasize to this audience that the experiences which I am about to relate constitute merely a clinical report, and a preliminary one at that, and that nothing more than that should be read into them.

PREVIOUS METHODS

My interest in treating diseases of the posterior ocular segment by elevation of the regional temperature goes back to the late 1930's, when I attended an instructional conference at one of the Academy meetings and heard the late Dr. Clifford Walker recommend conventional diathermy for the management of early secondary senile macular degeneration (which I shall, for convenience, refer to henceforth merely as senile macular degeneration). His recommendation was made on the ground that dilatation of the choroidal blood vessels might conceivably be helpful. Although we followed Walker's technic in every detail, our personal results with this method were no better than results with methods which we had already discarded as ineffective.

Our next approach to the problem was prompted by the observation that many patients with early senile macular degeneration also presented mild to moderate secondary anemia. The observation was made often enough to warrant the assumption that a nutritional deficiency in the macular region, which is the presumptive cause of this disease, might be explained by anoxia, which might be explained, in its turn, by a red blood cell deficit. Acting on this assumption, we employed all the standard therapeutic measures for anemia, including transfusions of whole blood and of red blood cells, but again the results were disappointing. Macular degeneration was not influenced even when the red blood cell values were elevated above normal, and even when the patients were seen early.

We then turned to the use of vasodilators. The nitrates and nicotinic acid proved too fleeting in their action to be useful. Various mercurial drugs were equally ineffective. Priscoline proved unsafe; its generalized vasodilator ac-

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tion caused visceral bleeding in several cases. Depropanex was the most satisfactory of all the therapeutic agents employed, and, as I shall point out shortly, we have continued to use it as an adjunct measure, no matter what other methods of therapy we have employed.

MICROWAVE THERAPY

As soon as microwave diathermy became available, late in 1947, we began to study it, first experimentally, and then by cautious clinical use. On the whole, our results have been promising, and, what seems quite as important in a method still undergoing clinical testing, we are quite certain that we have not done any harm in any case in which it has been used.

The approximately 75 cases upon which this communication is based include senile macular degeneration, retrobulbar neuritis, central serous retinopathy, thrombosis of the central retinal vein and its branches, traumatic hemorrhage, and postoperative uveitis. All of these patients were treated by a standardized technic. We have excluded from consideration all of our early cases, in which we were working out dosages and methods, though it seems worthwhile to say that we are quite certain that we did no damage in any of them either. It also should be noted that all of the cases in this series are instances of a single disease condition; we have not included in this evaluation any case complicated by multiple diseases.

Technic

Unless otherwise stated, all the patients in this series were treated by a technic which we are still employing and which we have worked out by a process of evolution. The triangular applicator of the Raytheon Microtherm is used at a distance of 3 inches from the temple, with the output directed to the region of the choroid. With this technic the heat is concentrated within an area of 1 to 2 inches. Each treatment lasts for fifteen minutes and utilizes 20 per cent of the output of the machine. As long as the patient is under treatment he takes nicotinic acid and thiamine chloride by mouth, the former in 50-mg. doses four times daily and the latter in 25-mg. doses by the same scheme. He receives Depropanex (2 cc.) intramuscularly before each treatment.

The first course of microwave diathermy consists of three treatments weekly for three weeks. At the end of this period the visual acuity and central fields are checked against the pretreatment record. If there has been no improvement in vision or if, as sometimes happens, there has been a deterioration, it is usually concluded that microwave diathermy will not be effective in the special case and it is discontinued. If the visual acuity has been maintained at the original level or has improved, the same regimen of therapy is repeated for another three weeks, after which another re-evaluation is carried out. Our experience has been that if treatment is to be successful, maximal benefits will usually be observed by the end of the six-week period. However, in some instances additional improvement in visual acuity may be observed to take place over a longer period of time.

We have found that patients vary in their response to treatment. The length of remissions differs from case to case, and so does the amount of treatment required to maintain whatever benefit may have been received. When maximal benefit has been achieved, therefore, the procedure is adapted to the reaction of the individual patient. Until this can be determined, we reduce the number of treatments by a fixed routine. They are reduced from three to two a week for six weeks, and then to one a week for the same period of time. Visual acuity and central fields are checked at the end

of each six-week period. The patient is then dismissed, with instructions to return for examination at the end of six weeks unless he notices any decrease in visual acuity earlier; if he does, he must return at once. We have learned that some patients, in order to maintain whatever benefits they have received, must be treated at weekly intervals. Others require even more frequent treatments, while still others can go for longer periods. The essential thing is to learn the pattern of the individual response to therapy and to treat the patient accordingly.

One thing we have learned from our experience with diseases of the posterior ocular segment is that we must alter our criteria of success. In senile macular degeneration restoration of vision does not seem to be an attainable objective. We have found that we cannot help any patient who comes to us with vision of less than 20/40. This is the poorest vision with which ordinary print can be read without the aid of a magnifying glass or telescopic lens. We therefore regard the maintenance of vision at a useful level, that is, 20/40 or better, as the criterion of successful treatment in senile macular degeneration and other diseases which we have treated with microwave therapy. To express it differently, our objective is the prevention of further regression, and we feel that we have accomplished a good result when we have brought the disease to a standstill.

CLINICAL RESULTS

Senile Macular Degeneration

Our first, and widest, experience with microwave diathermy has been in the treatment of senile macular degeneration. By the criterion which I have just described, I think it fair to say that our results have been encouraging. They are the more encouraging when one realizes that almost without exception the patients who experienced no improvement came to us with vision below 20/40, that is, with vision that had already sustained an irreversible decrease.

If I have arrived at any important conclusion from this clinical experience, it is that as ophthalmologists it is our duty to try to do something for patients with secondary senile macular degeneration, all of whom are elderly, before their vision reaches the point at which we can do nothing for them. We ought to remind ourselves, and we ought to teach our students, that it is simply not enough to tell a patient who complains of a drop in visual acuity that cannot be improved by refraction that he has an incipient cataract. We all know that presenile changes in the lens, such as cuneiform and coronary opacities, lamellar separations, and water clefts in the suture lines do not produce marked decrease in visual acuity. We all know that patients with so-called incipient or presenile cataracts can be kept with 20/20 vision for years merely by changing their glasses as the refractive index of the media changes. In short, a patient whose fundus can be seen clearly with an ophthalmoscope and whose vision cannot be improved to normal with refraction deserves a central field examination.

Retrobulbar Neuritis

I hope that some day, and that in the not too distant future, the neuro-ophthalmologist will present us with some perimetric method of making the differential diagnosis between early senile macular degeneration and retrobulbar neuritis. By present methods the field defect, a small central scotoma, seems the same in both. The most intensive study provides no differential help. In our own clinic we use the binocular ophthalmoscope with Hildreth ultraviolet light and filters, the Friedenwald ophthalmoscope, and the Goldmann corneal microscope with Rhuby lens. It may be that

electroretinography and flicker-fusion fields, which we have not yet tested, will provide the diagnostic aid required.

Since this diagnostic confusion exists, it was natural that on some occasions when we thought we were treating retrobulbar neuritis, we found later that we had been dealing with early senile macular degeneration. Some patients with presumptive retrobulbar neuritis, whose vision had been greatly benefited by microwave diathermy, failed to return for examination at the intervals set. When they did return, months later, they presented frank degeneration of the macula with pigment changes and irreversible loss of vision. These cases prove the difficulty of making the differential diagnosis between the two conditions.

In spite of that confusion, our results with retrobulbar neuritis treated by microwave diathermy have been encouraging on the whole when they are analyzed by the criterion of maintenance of visual acuity at a useful level.

Central Serous Retinopathy

Although central serous retinopathy is a disease which can be picked up by objective examination, all of us know that no effective treatment for it has yet been devised. It seemed logical to treat it by microwave diathermy, on the ground that the pathologic process is a hydrops of the macular area, resulting from local failure of circulation. Our results in the 8 cases in which we have used this method have been extremely encouraging. The condition tends to recur, but patients tend to be most cooperative about reporting for treatment, because they know that after one or two weeks of microwave diathermy any loss of vision within the compensable range is likely to be corrected.

Thrombotic and Hemorrhagic Conditions

We have used microwave diathermy in a small number of cases of branch thrombosis of the retinal vein, with what can fairly be described as outstanding success. The absorption of hemorrhage, the recanalization of the vessels, and the return of function to the affected eye have been nothing less than spectacular. Unfortunately, in thromboses of the central retinal vein, in which we had expected our results to be equally good, they were just as spectacularly bad. For this we have no explanation.

The good results observed in branch thromboses of the retinal vein were, however, repeated in a few cases of traumatic vitreous hemorrhage. I am quite certain that by using this method we have saved the vision of more than one eye in which the outlook was initially poor. We began to use microwave therapy in traumatic vitreous hemorrhage with full awareness of the risk of causing more bleeding. Our feeling, however, was that this is a desperate condition, for which a desperate remedy is warranted, and the risk proved worthwhile. If the method is to be successful, it must be used early. It is not effective after organized clot formation has occurred.

Postoperative Uveitis

In the 7 cases in which we have used microwave diathermy for postoperative uveitis we have had very good results. Almost always there has been prompt relief of ciliary pain and a sense of generalized well-being, while redness and inflammation have disappeared even more rapidly than in the cases treated with topical cortisone alone. Our technic in this disease is to use 30 per cent of the output of the machine and reduce the length of the treatments, which are given daily, to ten minutes. Applica-

tions are continued until the eye is quiet, which is usually five to ten days after treatment is started.

COMMENT

The obvious advantage of microwave therapy is that with it it is possible to heat the deeper tissues without undue heating of the more superficial tissues. With the modern equipment now available it is possible to localize the heat to the special area to be treated, and to control and measure the dosage. The technic of application is simple and the patient is comfortable and free from apprehension while he is undergoing treatment.

Animal experiments and clinical results both indicate that the temperature of the vitreous can be raised to a therapeutic degree (103° F.) when microwave diathermy is used correctly. We had planned to continue our own experimental studies on cadaveric and enucleated eyes but abandoned the idea when we reflected that the loss of normal body temperature would inevitably alter the results. No harm could result from determining the temperature elevation in an eye hopelessly destroyed and about to be enucleated, but we have not yet found a patient willing to volunteer for the experiment. The thought of the introduction of the thermocouple into the eye, which would require opening the globe, and the sight of the equipment effectively discouraged the few patients who had originally shown any interest in the matter.

With the method we use, which utilizes 20 per cent of the output for fifteen minutes at a time, we have never observed any damage to the crystalline lens, although many of our patients receive very large numbers of treatments. This is a most important consideration. As you know, most animal experiments in which serious lens damage was reported were conducted with dosages considerably heavier than those used clinically. The only case of our own in which any output larger than 30 per cent was used furnishes an interesting contrast to the experimental results.

This patient, a 36-year-old woman with optic atrophy, had vision limited to hand motion. The crystalline lens was clear when she was first treated, January 23, 1950. The schedule of treatment, which was entirely for testing purposes, was as follows:

From January 23 through July 27 she received 36 treatments utilizing 20 per cent of the output of the machine. In these and all succeeding treatments the triangular applicator was directed through the dilated pupil. Between the latter date and August 24 she had six treatments utilizing 30 per cent of the output and three utilizing 45 per cent. Between the latter date and August 30 she had three treatments utilizing 60 per cent of the output.

At this time she complained of discomfort from the heat and treatment was discontinued until September 27. Between that date and October 30 she received eleven more treatments utilizing 45 per cent of the output of the machine. At this time, because of intercurrent illness, treatment was discontinued permanently.

Careful examination at regular intervals during the course of treatment, when it was concluded, and again in July 1951, eighteen months after treatment had been begun and nine months after it had been stopped, always showed the lens to be perfectly clear. Curiously, this patient's vision, which had been limited to hand motion when she was first seen, was 20/200 when treatment was discontinued and has remained at that level. We regard this improvement as entirely unrelated to microwave diathermy. We regard it as extremely significant, however, that this patient, who could be tested clinically without fear of damage because her sight was irretrievably lost, could receive 59 treatments over a nine-month period with no harm at all to the crystalline lens, and with an incidental slight improvement in vision, although 23 treatments utilized a considerably higher output of the machine than we are accustomed to use therapeutically.

SUMMARY

Microwave diathermy seems to offer a simple and rational method of treating diseases of the posterior ocular segment if maintenance of visual acuity at

a useful level (20/40) is used as a criterion of success. It has been employed with generally encouraging results in secondary senile macular degeneration, retrobulbar neuritis, central serous retinopathy, certain thrombotic and hemorrhagic conditions, and postoperative uveitis. It is also significant that with the use of what is accepted as a therapeutic amount of the output of the diathermy machine, no lens damage has been observed in any of the cases treated by this method.

DISCUSSION

DR. R. H. DAVIES, Detroit, Mich.: Dr. Clark's paper presents a very definite and rational method of treatment pertaining to diseases of the posterior ocular segment and one which most ophthalmologists will welcome as a useful tool in the realm of ocular therapeutics. The results of the cases which he has presented offer definite encouragement in the restoration of useful vision in eyes which, in many instances, have generally progressed to complete destruction. As described by Dr. Clark this form of therapy should be included as a further adjunct in the therapeutic measures employed for these ocular conditions.

In reporting his results in this series of cases it is encouraging to note that the essayist has used a standard technic in this form of therapy, and, he is to be congratulated upon employing such great effort in his methods for evaluation pertaining to the success of the treatment with microwave diathermy. It was a difficult matter for me to properly evaluate a series of 100 cases of ocular diseases recently in which microwave diathermy was employed. These cases included retrobulbar neuritis, thrombosis of the central retinal vein and/or its branches, postoperative uveitis, acute iritis, chronic uveitis, Berlin's edema, traumatic hemorrhage, postoperative hyphema, acute congestive glaucoma, infections of the lids, herpes zoster, corneal ulcers and corneal lacerations. In most instances the diathermy was used in conjunction with the local instillation of mydriatics or miotics as indicated. On the whole the results were promising and encouraging as they were in Dr. Clark's cases. Similarly, we are certain that no harm was done in any case in which diathermy was used.

In 1940 Ruedemann and Zeiter reported a series of 60 cases treated with electromagnetic diathermy. Nineteen ocular conditions were treated including central venous thrombosis, corneal ulcers, tarsitis, herpes zoster, uveitis, malignant exophthalmos, vitreous degeneration, postoperative inflammation, and acute inflammatory glaucoma. As in Dr. Clark's series the results were encouraging.

It has been shown by careful animal experimentation that exposure of the eye to microwaves when using 60 to 70 per cent of the maximal output of the Raytheon microwave generator, with the C Director (corner director) at a distance of 2 inches from the skin and exposure for twenty minutes, the temperature of the vitreous was raised to an average of 105° F. It is felt that care must be taken to employ dosages which will not exceed this temperature elevation and a technic which will not damage ocular or adnexal tissue. Experimentally using 75 per cent output with the director 3 inches from the skin for twenty minutes, the average increase in temperature of the vitreous was 2.5° C., that of the retrobulbar tissue was 1° C. and that of the aqueous was 2.4°.

Cataracts have been produced experimentally in animals using the same apparatus at an output of 94 watts at a distance of 2 inches for a ten-minute exposure. This has been done by Daily et al, at the Mayo Foundation and has been used to study the experimental production of cataracts. It is to be noted that the Raytheon Microtherm operates at a wave length of 12.2 centimeters and has a maximum output of 125 watts. Hence, the upper limits of maximal output are used in the above instance. In Dr. Clark's series of cases, and in our series of cases, 20 per cent and 40 per cent of the output of the machine were utilized respectively. In analyzing the clinical results of these cases, no lens damage has been observed. Also to be considered in this analysis and already pointed out by the essayist, the type C Director of the microwave machine was used in his series. This allows a maximum of heat at the center of the heated area. In our series of cases type A Director, a 4-inch hemisphere type, was used. With this director the temperature at the center of the heated area of the skin is 50 per cent of that at peak levels. Thus, in the use of microwave diathermy it is of value to be acquainted with the capabilities and output of your microwave apparatus and to carefully observe the response and reaction of the individual to this form of therapy. It is important to stay within the point of tolerance of the patient and not to proceed beyond the point of comfort.

DR. GRAHAM CLARK, New York, N.Y., (by invitation). As physicians we have inherited a basic right in the field of electricity, for you will remember that it was the personal physician of Queen Elizabeth of England who coined the term "electricity." He derived that from the Greek "elektros", meaning amber, which was the substance used to produce early electrical phenomena. We neglected this birthright of ours and have contented ourselves too often to gain our knowledge of the electrical equipment which we are using from the pamphlets which come with the apparatus as it is delivered to us.

Dr. Thorpe has given us an excellent summary of what is a rather complex field, and he has introduced it in simple terms. I should like to re-emphasize one point which Dr. Thorpe has brought up in order to illustrate a need for basic knowledge of the fundamentals of electricity. There are two instruments on the market today, both of which are accompanied by brochures highly recommending them for use in treatment of retinal detachment. Examination of the machines and the circuits, if one is wont to do so, will show very little dissimilarity. The only detectible dissimilarity is the fact that the voltage-amperage ratio is reversed, the first machine producing what we call the fulgurating or desiccating current and the second machine producing what we call the coagulating current, the one that we require in the treatment of retinal detachment. The first machine is excellent for removing warts or for doing transurethral resections of the prostate but it is not for cases of retinal detachment.

Dr. Clark's paper is certainly interesting in that it gives us another insight into the important field of electricity in medicine. The field of high frequency current is practically limitless in its variations and effects and this type of microwave therapy will be investigated further as it certainly deserves.

Question may well be raised, of course, in the cases presented in Dr. Clark's paper as to whether the improvement was derived from the microwave therapy or from the vasodilating and nerve stimulating drugs that were used in conjunction with it. However, the previously disappointing results with the chemotherapeutic agents alone I think speak rather loudly in favor of the microwave as the effective agent in the miprovement.

At the Institute of Ophthalmology, of the Presbyterian Hospital in New York, we began our experiments with the microwave about the same time that Dr. Clark did but with a completely different purpose in mind. Our objective was to use the microwave to reproduce the temperatures derived from foreign protein shock therapy and to use it in the form of a control in studies of the mechanism of foreign protein therapy on diseases of the eye. We began by animal experimentation, using anesthetized rabbits. Our object was primarily to find out if we could reproduce the intraocular temperatures of generalized fever; second, what the treatment doses would be to produce and sustain those fevers for the time interval required; and third, and, of course, most important, if there was any harmful effect on the tissues of the eye produced by the microwave therapy.

As the experiments were carried out, we found that it was very simple to produce temperatures from 103° to 105° F. in the vitreous chamber by the use of microwave radiation, the temperatures being taken by a thermocouple attached to the potentiometer in the routine fashion. The factors which I will give later, are the same as those we used in the treatment of the human eye. We then carried out a series of experiments in which we exposed the eyes of animals to a standard treatment of exposure for twenty minutes daily for five days under these same temperature factors. At the end of this period one series was sacrificed and immediate sections made: the second at a three-month interval, and the third at a six-month interval. The treatments used were higher than any that have been mentioned by either Dr. Clark or Dr. Thorpe because we were trying to reproduce the temperatures we experienced in sustained foreign protein therapy; therefore, we were using 60 per cent output instead of 20 to 30. There was, however, no damage shown in any ocular tissue in any of the animals immediately, at three months or six months thereafter. I think it is important to stress this because there have been a number of papers recently describing cataract formation due to microwave therapy. I think it is misleading because if you will notice carefully the temperatures producing the cataracts ranged from a low of 146 to an actual high of 158 degrees. That is beyond the therapeutic range and it is beyond the tolerance of a patient.

Following our animal experimentation clinical evaluation began in which we compared our results on patients treated with the microwave as opposed to those treated with foreign protein therapy. We have a series of 95 cases under each in which we confined ourselves to

iridocyclitis, retained cortex, and postoperative uveitis. Our standard dose was given with 60 per cent of the output, using the Director C, which is the angular director described by Dr. Thorpe, at a distance of four inches from the closed eyelid and perpendicular to it. The treatment was carried out every other day for twenty minutes at each treatment. In this series we can also report there were no harmful effects noted at or since that time in any of the patients treated. The subjective reactions of the patients were noted, and they varied from a very soothing sense of warmth during the treatment to a very marked and welcome relief of symptoms. The actual result, objectively checked on the patients, showed that it was not as good a reaction as we gain in the use of foreign protein therapy but, it did, in every case, reduce the expected course of the disease.

Dr. Clark's further studies may give us a great deal of interesting information, and certainly he has cast a ray of hope in a field badly in need of a new ray of hope. We will be most interested in his further reports.

BINOCULAR INDIRECT OPHTHALMOSCOPES

The Trotterscope and the Heedscope

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BY INVITATION

WHILE I was at the Massachusetts Eye and Ear Infirmary in Boston on the Heed Fellowship, Dr. Robert Trotter generously and informally demonstrated his partially constructed arrangement for binocular indirect ophthalmoscopy. Schepens[3,4] had shown that his method of fundus examination had certain advantages. It was Dr. Trotter's idea that the housing and rhomboid prism unit of a Bausch and Lomb Binocular Magnifier without magnifying lenses would satisfy the optical requirements. During the remainder of the Heed Fellowship many individuals* who observed the further development of this idea made valuable suggestions. Several constructed their own instruments, and the instruments vary with the maker. All of these instruments are variations of the 1861 Giraud-Teulon[1,2] binocular indirect ophthalmoscope modified by the attachment of an electric light to the double reflecting system.

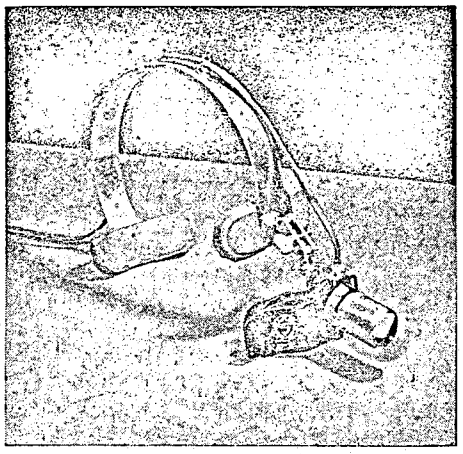

FIG. 1—Trotterscope, made by attaching rhomboid prism unit of Bausch and Lomb Binocular Magnifier to headband by swivel. Headlight attached by second swivel.

The only requirement for a binocular view of the indirect fundus image is that the two visual lines be brought near the axis of the light source. A pair of rhomboid prisms will do this by producing an artificially narrow P.D. of 15 to 20 mm.

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