charge varies with the polarity of the applied current. These findings add a new dimension to the accumulated evidence that horizontal cells modulate the transmission of visual information through the distal retina.

After the frustrating uncertainties of the fifties and the dramatic strides of the mid-sixties, research on the function of the distal cells of the retina is now proceeding at a brisk pace. Within this decade, we may reasonably expect to see the intracellular approach increase our insight into the roots of the psychophysics and electrophysiology of human vision, strengthen the correlation between retinal structure and function, sharpen our perspective of central neural networks, and begin to unravel the ionic mechanisms of transduction and synaptic transmission in the retina.

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Laser treatment for glaucoma

Lasers (light amplification by stimulated emission radiation) have been available for the last 10 years. A laser works by stimulating electrons into orbit so that their emissions are simultaneously released and amplified in a resonating chamber or crystal.[1] The solid-state lasers depend upon polished surfaces on either end to resonate back and forth. The gas lasers use an ionized gas within a chamber and mirrors, one of which is incompletely silvered that allows a small per cent of the lased light to continuously leave through it. The duration of a gas laser such as an argon laser can be controlled by a shutter or by pulsing the tube with repetitive strobe flashes. The solid-state lasers such as the ruby or neodymium are pulsed or pumped with a strobe unit and can be Q-switched (quality switched). In this process, a mirror, dye, or other method of stopping the resonation is placed within the unit such that a very high intensity builds up until the switch is released and the quality of the pulse is changed from a longer duration (microsecond) pulse of a few watts to an ultra short (nanosecond) pulse of very high wattage (megawatts).

The use of lasers in the treatment of retinal diseases has received much attention. Any specific advantages of laser over regular light (xenon) photocoagulation is currently under study. In the last five years there has been interest in the use of lasers for the treatment of glaucoma. The techniques are basically three in number: peripheral iridotomy, alteration of the trabecular meshwork, and destruction of the ciliary body. All three have their counterpart in established surgical techniques, including cryocyclotherapy. There is not yet enough information nor enough experience to know if any of these three modalities would be safe enough or effective enough to replace existing therapeutic techniques.

Peripheral ruby laser iridotomy has recently been reported by Perkins and Brown.[2] In this technique they used a pulsed ruby laser in a series of 49 patients with an overall 76 per cent success rate. Twenty per cent were considered failures and 4 per cent had insufficient follow-ups. In five out of 22 cases of angle-closure glaucoma, laser iridotomy failed to relieve the glaucoma.

Laser treatment of the angle has been variously termed laseropuncture,[3] laser trabecular puncture,[4] and laser trabeculotomy.[5] All of these terms assume that an opening is made in the trabeculum. Krasnov[3] reported the treatment of 10 patients using a Q-switched ruby laser and, in an unpublished report, has now expanded his series to close to 100 cases. He used the Q-switched laser on the advice of Professor Prokhorov, the Russian Nobel Prize-winning physicist, who suggested the Q-switched ruby laser would give maximum vaporizing effects and minimum thermal effects. Krasnov stated he had earlier tried the argon laser but found the thermal effects too great. Hager,[4] in Berlin, has reported a series of 28 cases with a four-month follow-up, treated with the argon laser, both to the trabeculum and the iris base. In the former cases, 68 per cent had a pressure reduction, in 11 per cent there was no change, and in 21 per cent there was an increase in pressure. In the treatment of the iris base, 47 per cent had a pressure reduction, 50 per cent no change, and 3 per cent had an increase. In his article, Hager suggested that "trabeculo puncture" could be improved by decreasing the beam size and the exposure time, while increasing the wattage of the treating beam. Worthen and Wickham[5] have reported laser trabeculotomy in monkeys and have recently presented[6] the results of treatments in a series of 23 human eyes. They noted a drop in intraocular pressure of between 8 and 10 mm. Hg. The effect seems to last about three months. All three authors noted a drop in intraocular pressure which seems to be temporary.

Treatment of the ciliary body has been approached from two standpoints. Lee and Pomerantyeff[7] reported the use of a ruby laser to photocoagulate rabbit ciliary processes transcorneally with some success. Recently, Zimmerman, Worthen, and Wickham[8] have reported a failure of such treatment in four cases wherein the pressure would drop transiently but then return to the previous levels. Both Lee and Beckman (personal communication) have tried transcorneal laser photocoagulation in a total of six cases which have had a similar fate. It appears that the ciliary epithelium has a great regenerative capacity and even though the pigment epithelium can be destroyed by laser, it quickly regrows and secretion is resumed. The other approach is that of Beckman and co-workers[9] who have used both ruby and neodymium lasers to go transsclerally to affect the ciliary body in a way analogous to that of cryo destruction, that is, an effect on the blood supply. He reported on the treatment of 17 eyes with a 20 mm. drop lasting around six months.

Surgical treatment of glaucoma in these three areas requires specific instruments to accomplish each task. The same may well be true of experimental laser treatments in glaucoma. The continuous-wave argon laser has the advantage that long burns of very low wattage can be delivered similar to that from a photocoagulator. In contrast, the solid-state lasers, such as the ruby laser, have to be pulsed and only with repetitive pulsing can photocoagulation be simulated. In all three glaucoma procedures the effect desired is largely tissue destruction. If one uses the same parameters as are used for retinal work, that effect will not be achieved. It is well known in handling various materials with lasers that one can create a weld or a hole by varying the parameters. If a very short, but high-wattage burst is given to almost any absorptive material, a hole will be created because vaporization effects exceed thermal effects. In contrast, if a very long burn of low wattage is given, the tissues tend to weld together and burn due to the predominance of thermal effects. The response of a given material is largely a function of its thermal relaxation constant. Assuming the tissue within the eye to be water and if the effect of the laser treatment is on a roughly slab-shaped area of approximately 100 microns, it can be calculated[9] that the thermal relaxation constant is probably in the range of 7 milliseconds. Therefore, in any attempted laser treatments to the iris or trabecular meshwork, the faster the pulse and the higher the intensity would cause vaporization and hole creation and minimize the thermal or burning effects. Likewise in treatments of the ciliary body transsclerally a laser beam that would pass through much of the white and translucent tissue until it reaches pigmented tissue would be of advantage. The ruby laser is more dependent upon the presence of pigment or melanin. Therefore, for both trabecular and lightly pigmented iris hole creation, a rapidly pulsed, high intensity, green wavelength laser would theoretically by the best and likewise for transscleral destructive procedures, probably the pulsed ruby laser would be best. A Q-switched ruby laser has a duration in nanoseconds as compared to the micro or milliseconds for either pulsed ruby or pulsed argon lasers. It is not clear that the nanosecond range is necessary on the basis of these theoretic calculations. The ruby laser also has the disadvantage of requiring pigmented tissue. The use of agents injected into the bloodstream or applied topically on the eye might well alter the absorption spectrum and lessen the necessity for the presence of pigment. If laser treatment for retina work proves to be as good or better than xenon light photocoagulation, future technology might revolve around a hybrid instrument that could be used for both retinal disease and glaucoma therapy. The total amount of energy delivered with these various systems appears to be quite similar, that is, if one calculates the total joules which is the duration of the pulse times its wattage, it is similar for the Q-switched, pulsed ruby laser, and either pulsed argon or shuttered, continuous-wave argon.

The world's experience with these methods for the treatment of glaucoma is limited and can be measured in years. Although initial results might be encouraging, it is mandatory that each investigator compare the proposed technique with those that are already established and clearly demonstrate that it is either safer, more effective, or longer lasting. Safer, more effective treatment, even if not long lasting, might be a useful addition to the treatment of glaucoma. Any question of either ineffectiveness or long-range complications would render the technique inappropriate. Only time and careful study will place these new techniques in their proper perspective in our armamentarium for glaucoma therapy.

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