Argon Laser Trabeculoplasty

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Managing glaucoma patients is becoming standard practice in optometry. Knowing the different types of glaucoma, how to diagnose them, and the therapeutic regimen for each type are important factors optometrists managing patients with glaucoma should consider.

However, there are patients where medical management may not be effective because of allergies, compliance, or medical or topical therapy drift. It is at this point the optometrist must make a decision and recommendation for the management of the patient's glaucoma. It is the purpose of this review to familiarize the optometrist with laser trabeculoplasty and all its aspects regarding mechanism of action of argon laser trabeculoplasty (A.L.T.), procedure, patient selection, types of glaucoma effectively treated, side effects, and other miscellaneous aspects of A.L.T., such as repeat A.L.T. (R.A.L.T.) results.

Understanding these interacting factors will help the optometrist make an appropriate referral, and educate prospective patients about their condition and likelihood of success with this procedure.

I. Mechanism of Action of A.L.T.

By placing laser beams around the circumference of the anterior chamber angle it was found to decrease I.O.P. by increasing outflow facility. Increased outflow facility was determined to be the sole contributor to decreased I.O.P by

fluorophotometry clinical studies conducted by Brubaker and Liesegang.[6] They found that aqueous flow, corneal permeability to fluorescein, and the blood-aqueous exchange coefficient did not differ significantly.

There are various theories describing the mechanism of increased outflow facility. One theory describes the laser scars retracting the trabecular tissue between them, thereby opening up the meshwork for better aqueous permeability.[6] This is commonly referred to as the mechanical theory.

The physiologic,or cellular theory, postulates that a physiologic change in the laser treated trabecular meshwork is responsible for the increased outflow facility. Melamed et al reported that laser treated meshwork cells appeared to be more actively phagocytic and suggested that a cellular change had been promoted in the meshwork.[6] This mechanism may be triggered initially by chemical changes in the cells that causes them to divide, and therefore provides an increased number of cells to phagocytize the aqueous and ultimately increase flow into Schlemm's canal.

Lastly, there is the more popular academic theory of a mixed mechanism. This theory promotes a mixture of the first two theories. It does not give more credit to one of the two previous theories, but emphasizes the result of A.L.T. lowered I.O.P. by a cooperative mechanical and physiological mechanism.[6]

Reviewing these three theories I would emphasize the importance of the mechanical theory to my patients. The laser

burns destroy the tissue causing a measurable stretching of the meshwork betweens scars. This in turn opens up clogged and flaccid tissue so that more surface area is again exposed to the aqueous. The physiologic responses occurring here initially are scar formation with subsequent cell mitosis by adjacent healthy tissue. It is after the mitotic phase that one may see the added benefit to aqueous outflow by increased phagocytosis of aqueous fluid to Schlemm's canal. This increased phagocytosis would only be occurring around the circumference of the laser beam spot and would presumably be a negligible increase in outflow considering there may be only 50 to 100 scars around the circumference of the anterior chamber angle.

II. Procedure/Technique

Appropriately placed argon laser burns are spaced throughout the trabecular meshwork with precisely determined parameters in hopes to minimize side effects of the treatment and maximize the reduction in I.O.P. Kahn et al reported more successful outcomes in patients treated by more experienced attending physicians compared to resident physicians.[6] They suggested that laser parameters alone were not the determinant as to whether or not the treatment would be delivered appropriately.

The portion of angle treated in one laser session has also been evaluated. The amounts are divided by 90 degree allotments, with 90 degrees being the minimum treatment. Schwartz et al found

that treating 90 degrees of the angle dropped the pressure 10 %, on average, while 180 degree treatment dropped pressure 28 %.[6] Wienreb et al demonstrated that less acute post-treatment I.O.P. elevation occurred if 180 degrees of the angle was treated with 50 burns compared to 50 burns spaced throughout 360 degrees of the angle.[6] There have been other studies that reported no significant differences between groups receiving 360 degrees versus 180 degrees of treatment. It was observed by Weinreb et al that the largest pressure decreases were most numerous in the 360 degree treatment groups.[6]

Also considered is the location of the burns within the angle structures. Popular burn sites include the anterior border of the pigmented meshwork, directly on the pigmented meshwork, and as far posterior as the scleral spur.[6] Rouhiainen and Schwartz reported in separate studies that burn location did not affect outcome while Higgins found the best response when either the posterior or anterior aspects of the meshwork were treated.[6] These comparison studies of burn placement require great skill in the laser treatment technique.

In addition to strategic burn placement anterior chamber angle anatomy was investigated as to whether or not it affected the efficacy of A.L.T. Pennebaker and Stewart found no significant difference in the therapeutic effect of A.L.T. based on refraction or anterior chamber anatomy.[5] They added that patients whose angle was visualized poorly tended to have a slightly less absolute decrease in I.O.P. than those in whom visualization of the

trabecular meshwork was good. From this they concluded that A.L.T. can be successful as long as the trabecular meshwork can be visualized.

The amount of energy delivered in a single burn, the size of the burn spot, and the laser wavelength have all been investigated. The amount of energy is determined by a combination of duration, power, and spot size.[6]

It has been found that there was no significant difference in pressure drop between .1 and .2 second duration- most clinicians use .1 second duration.[6] The minimum power level required to cause I.O.P. reduction was 500 milli-watts as demonstrated by Rouhiainen and Terasvirta.[6] Wise has theoretically proposed that larger spots affect the angle in less than an ideal way, causing undesirable scarring and adverse architectural modification.[6] Doubling of spot size decreases power density by 75 %, which may inadvertently effect the outcome of treatment.[6]

Argon blue-green and green lasers were compared by Smith in 100 patients with primary open-angle glaucoma (P.O.A.G.). He found no significant difference in pressure response, post-operative course, or complication rate.[6] MaKabe found no sustained effect on pressure by Krypton red laser.[6] Robin and Pollack have recently proposed using a Q-switched laser, which has the feature of delivering high energy levels in short pulses, lending to mechanical instead of thermal effects.[6] Nd:YAG lasers administered with 10 millisecond pulses for A.L.T. have had outcomes similar to conventional argon energy lasers.[6]

Considering all aspects of A.L.T. treatment, it would be advantageous to refer patients to technically experienced professionals. Given that the eye care professional is using the most effective and current laser parameters for the amount of the angle treated, spacing of burns, amount of energy delivered, size of the burn, and laser wavelength, the location of the burns in the angle structure, and the patient's angle anatomy are the only variables to consider.

Placing the burns in the anterior or posterior portion of the meshwork would be most effective based on angle anatomy because the scleral spur and Schwalbe's line provide tissue anchors for the burns to retract the flaccid and clogged trabecular meshwork towards. Shallow anterior chamber angles can be artificially deepened by applying pressure on the gonioscopy lens during treatment thereby possibly breaking any peripheral anterior synechiae and steepening the iris approach to the angle structures, making them more accessible to A.L.T. treatment. This technique can make at least the anterior border of the trabecular meshwork accessible in hyperopic and shallow anterior chamber angles.

Knowing the criteria for A.L.T. treatment and technique used by the laser therapist in your area allows you to make appropriate referrals based on each patient's unique case.

III. Patient Selection

Correctly selecting patients with physical attributes that are

more probable for successful A.L.T. is important for the optometrist to know. These factors may include, but are not limited to the following: age, race, pigmentation of trabecular meshwork, pre-laser pressure, stage of glaucoma, anterior chamber anatomy, and previous success in the patient's first eye.

In general, younger patients are less successful candidates for A.L.T. than their older counterparts with the same type of glaucoma, such as P.O.A.G. A retrospective study conducted by Safran et al comparing patients younger than and older than 40 years with P.O.A.G., uncontrolled by maximally tolerated medical treatment, showed only 7 % of eyes in the older group versus 60 % in the younger group required surgical intervention after laser.[6] They also found the older groups to have a statistically greater decrease in pressure (12 + or - 6 mmHg) than those less than 40 years (5 + or - 6 mmHg).

White and black patients have been compared as groups to determine whether or not A.L.T. is more successful in one race than another. There is opposing evidence as to whether or not race is significant between investigators, and in different reports by the same investigator. Initially, Schwartz reported a 97 % success rate within an 18 month follow-up period of a predominately black group of patients.[6] Later he reported that A.L.T. failed to a greater degree in black patients than in whites.[6] Krupin retrospectively examined A.L.T. results in 68 black and 42 white P.O.A.G. patients over one- and two-year periods and found no statistical difference in response.[6]

The degree of pigmentation in the trabecular meshwork appears to be advantageous in certain types of glaucoma managed by A.L.T., and deleterious in others. It has not been emphatically stated that pre-operative pigment is advantageous, but there is suggestion in various reports that it is advantageous. Pigmentation is thought to correlate with post-laser pressure drop by one of several mechanisms: 1.) ability to obtain good laser focus on more pigmented trabecular meshwork 2.) absorption of laser energy by pigment, permitting more efficient conversion of laser energy to heat in the desired location; and 3.) removal of pigment, which may play a pathogenic role in causing outflow compromise.[6] In pigmentary dispersion and exfoliative syndromes the pigment factor is complicated by the fact that the A.L.T. response may be affected by the disease itself, independent of the amount of pigment present.[6]

Preoperative I.O.P is another factor to consider regarding prospective A.L.T. patients. Most investigators agree that there is a linear relationship between initial I.O.P. and absolute pressure reduction: the average pressure drop in P.O.A.G. patients being 30% or less of the pre-laser I.O.P. Knowing this, optometrists can defer referral for insufficient I.O.P drop or advise the educated glaucoma patient of average successful I.O.P decreases.

For patients that present with advanced cup damage secondary to increased I.O.P., A.L.T. may not be effective enough alone to sufficiently control I.O.P. Wise stated that 51 % of eyes with a

cup/disc ratio of 0.9 or more required surgery subsequent to A.L.T. compared to only 15 % of eyes with smaller cup/disc ratios.[6] Wise added that the pre-laser average pressure and pressure drop from A.L.T. were similar in the two groups. He states that A.L.T. doesn't have less of an effect, but not a great enough effect for severely damaged eyes in preventing further damage.

The effect of refractive error and crowded anterior chamber angles has been investigated by Pennebaker and Stewart to determine the effects on A.L.T. outcome.[5] They found that patients whose angle was poorly visualized tended to have a slightly less absolute pressure decrease in I.O.P. than those in whom visualization of the trabecular meshwork was good. From this they concluded that A.L.T. is more successful in patients where the trabecular meshwork can easily be visualized. Angle structures should be assessed through gonioscopy on all patients by their optometrist before referring for A.L.T. to determine accessibility to the angle.

Commonly, increased I.O.P. secondary to glaucoma is bilateral. If a patient presents with A.L.T. and monocular uncontrolled I.O.P. in the other eye they should be referred based on the outcome of the first eye? It has been found that, in general, if a good response occurred in the first eye, the second eye will also do well; and conversely, if there was minimal or no response in the first eye, it is uncommon to see a good response in the second eye.[6] Based on these recommendations this is an excellent guideline for effective patient management.

When considering A.L.T. for medically uncontrolled glaucoma

patients an assessment of their profile may provide insight as to whether or not the procedure will be worthwhile for them and how effective it will be in lowering their I.O.P.

Reserving the procedure for older patients may be more effective based on the mechanical and physiologic properties of their angles. Over time there is an average and clinically insignificant amount of pigment deposited in the trabecular meshwork of all patients angles. This has been suggested to inadvertently direct the laser response in the angles of all patients, helping decrease I.O.P. However, A.L.T. may not be the correct treatment to effectively manage pigment dispersion or exfoliation syndromes based on the etiology of these types of glaucoma.

Referring to the patients first eye that was treated is also important to consider. Most types of glaucoma are bilateral with the same etiology in each eye. A.L.T. that effectively treats P.O.A.G. in the first eye will most likely be successful in the second eye because of their common but unknown etiology. The unknown etiology can either be physiologic or mechanical. If it is mechanical a pre-operative gonioscopic angle evaluation will provide a good estimate of success, and allow comparison of angle anatomy between the two eyes.

It follows that symmetric anatomy and glaucomatous findings between two eyes with similar pre-operative I.O.P. will respond similar to A.L.T. treatment.

Understanding pre-operative I.O.P and how it will help predict

outcome is important also. Low to moderate I.O.P. with moderate and severe cup damage secondary to glaucoma are not likely to be successful A.L.T. eyes. If A.L.T. only lowers I.O.P. 30 % on average, an eye with 21 mmHg and .7/.8 C/D ratio will maximally be dropped to 15 mmHg. This I.O.P. may not be low enough to stop further damage in an eye highly sensitive to I.O.P.

Therefore, the ideal candidate for A.L.T. would be an older patient, white or black, with normal pigmentation of the trabecular meshwork. On gonioscopy the trabecular meshwork should be easily visualized. Pre-operative and glaucomatous I.O.P history should be higher than 26 mmHg to insure an effective pressure drop into the teens.

IV. Type of glaucoma effectively treated by A.L.T.

Success rates of P.O.A.G. patients post-A.L.T. with average follow-up of five months or more have been reported at 72.5% to 97 % in various studies.[6] Lund reported I.O.P. control in 94% of eyes with chronic simple glaucoma after one year, and 82% after two years.[6] Because of the large clinical data base P.O.A.G. is considered the standard to which other diagnostic groups are compared.[6]

Thomas et al reported an average I.O.P. reduction of 30.4 % in 237 eyes with P.O.A.G., similar to the 29.8 % decrease in 222 eyes reported by Hornes et al.[6]

Pigmentary and exfoliative glaucoma have responded

successfully to A.L.T. treatment and should by recommended for treatment if I.O.P. is not controlled by medical management.[6] Although effective, the pressure reduction by A.L.T. appears to be transitory in nature in this diagnostic group, and should be explained to the patient before the procedure is performed.

The transitory response cannot fully be explained but is thought to be related to the increased efficiency of A.L.T. on pigmented trabecular meshwork. Higgenbotham and Richardson showed that despite a large pressure reduction immediately after A.L.T., these patients failed at a faster rate after both initial and second stage treatments, as compared to P.O.A.G. controls.[6] Despite its transitory nature in this diagnostic group, A.L.T. should be recommended to these patients as a treatment for uncontrolled I.O.P.

Patients diagnosed with low tension glaucoma present with normal I.O.P., but exhibit visual field loss and/or glaucomatous optic nerve damage. A.L.T. is recommended for these patients if maximized medical therapy is not successful or surgical intervention is required. Sharpe and Simpson treated 85 eyes with low tension glaucoma and reported a 46.3% success rate, with success defined as a pressure drop of at least 20%, no increase in medications, stable visual fields, and no subsequent glaucoma surgery, based on an average 30 month follow-up.[6] However, they did state that those patients who failed, the treatment was ineffective within six months. Overall, their results support the use of A.L.T. as a treatment means to reduce I.O.P. below 12 mmHg

in low tension glaucoma patients.

I.C.C.E. and E.C.C.E. patients with glaucoma may also benefit from A.L.T. Data from patients with E.C.C.E. and A.L.T. treatment has not been widely reported, but it is thought that this may help reduce I.O.P. without any additional complications than normal. However, post-I.C.C.E. patients with vitreous in the anterior chamber are unlikely to benefit from A.L.T.[6] For those I.C.C.E. patients with a clear anterior chamber, A.L.T. should be effective as success rates from 71.4% (Goldberg) to 47% (Spaeth) have been reported.[6]

When considering A.L.T. for glaucoma patients who have uncontrolled I.O.P. on maximal medical therapy, the etiology or diagnostic group to which they belong will provide valuable insight towards estimating their probability of success. It is widely know that A.L.T. is effective on P.O.A.G. patients, and often provides adequate I.O.P. reduction without medical treatment. It must be assumed that there is an outflow problem in these patients and over-production does not contribute to their increased I.O.P. Increased outflow facility by mechanically altered trabecular meshwork is the effective treatment for these patients - not cyclocryotherapy or ciliary body medical manipulation.

Knowing that the trabecular meshwork is clogged in pigmentary and exfoliative glaucoma, the mechanism by which A.L.T. works explains why it is beneficial to these patients also. Here, it appears as though the pigment coating on the trabecular meshwork is disrupted and frees the trabecular spaces to facilitate

aqueous outflow. Unfortunately these opened spaces are refilled with freed pigment and explain the transitory response seen in this patient population.

Low tension glaucoma patients are difficult to identify and manage. Their I.O.P. must be lower than normal physiologic I.O.P. This requires effective and reliable treatment. A.L.T. is a constant and effective treatment to artificially reduce I.O.P. below normal and work synergistically with topical medications reducing ciliary body production of aqueous to provide a large reduction in I.O.P.

As with any anterior chamber obstruction malformation, or physical disruption, A.L.T. would be ineffective based on the inability to effectively reach the trabecular meshwork. Unlike free floating pigment that has settled on the trabecular meshwork, vitreous cannot be easily disrupted based on its more solid and large body form. Otherwise I.C.C.E. as well as E.C.C.E. patients should benefit from A.L.T as any phakic eye would.

V. Side Effects

As with any treatment the benefits and risks must be weighed against each other. Depending on each patients diagnostic profile and chances for success, potential side effects must be understood by the patient before the procedure is performed. Table 1 lists the major side effects of A.L.T. which range from minor to catastrophic.[6]

Table 1: Complications associated with A.L.T.

1.) Intraocular pressure rise (transient and chronic)

2.) Loss of vision (central island)

3.) Peripheral anterior synechiae

4.) Uveitis

5.) Hyphema

6.) Corneal abrasion/punctate keratopathy

7.) Corneal burns

8.) Syncope

9.) Adverse effects on future filtering success

Increased I.O.P. following A.L.T. is a common post operative occurrence. Thomas et al reported a 25.3% incidence of pressure elevation, with 20.9 % of eyes later considered successful, and 47 % of eyes later classified as failure.[6] Forbes and Bansal noted a failure rate of 36 %, twice that of their entire treated group, in those patients who experienced pressure elevation.[6]

Determining the onset of pressure elevation was reported by Weinreb et al. They found that post-laser elevation was most likely to occur 3 to 5 hours in the 360 degree treatment group and earlier in the 180 degree treatment group.[6]

Several investigators have reported higher post-A.L.T. I.O.P. than original I.O.P. Thomas et al reported 3 % of eyes with worse I.O.P, as did Horns et al (7.4%) and Hoskins and coworkers (6%).[6] Chronic I.O.P. rise has been documented as a post A.L.T. risk.

An acute rise in pressure after treatment has been associated

with loss of central vision, especially in end-stage disease.[6] To minimize this side effect has been the goal of many laser therapists. Schwartz et al reported less I.O.P. elevation with anterior placement of the laser burns in the trabecular meshwork.[6] Thomas et al noted a higher incidence of pressure elevation from investigators who treated the posterior trabecular meshwork versus the anterior trabecular meshwork.[6]

Also correlated with increased I.O.P. post-A.L.T. is the amount of angle pigmentation. This has been advocated as the most important risk factor for an acute pressure rise. Keightley et al reported correlation between a low coefficient of outflow and a greater risk of a post-treatment rise in I.O.P. (no statistical analysis was provided).[6]

Fewer and lower pressure elevations have been documented by many investigators when they treated only 180 degrees versus 360 degrees of the angle. Weinreb et al found only 1.3 + or - 4.91 mmHg pressure rise in the 180 degree group, as compared to 7.35 + or - 9.28 mmHg in the 360 degree group.[6] This unequivocally shows that two laser sessions are safer against I.O.P. rise than one laser session.

Medical intervention has also been investigated to prevent and decrease post A.L.T. pressure rise. Pre-treatment with topical steroids for 36 hours before laser therapy did not prevent post operative pressure rises.[6] Ofner et al did report that 4% pilocarpine immediately post-laser reduced the frequency and magnitude of pressure elevations.[6] Elsas et al reported that pre-

treatment with pilocarpine, acetazolamide, and apraclonidine reduce the pressure increase of A.L.T. in glaucoma patients on medication prior to treatment, while anti-inflammatory drugs seen to have no effect.[1] They also stated that the pressure reduction was greater the more pigmented the angle.[1]

Although P.A.S. formation following A.L.T. has been reported, Schwartz et al were not able to correlate its occurrence to success or failure of the treatment and found no racial relationship either.[6] Factors presumed to promote P.A.S. formation include high laser power levels and posterior placement of the burns. Rouhiainen et al reported that those eyes with P.A.S. demonstrated small post-laser decreases in I.O.P.[6]

Eyes more prone to P.A.S. are also more likely to develop a significant iritis.[6] Most types of uveitis are transient and of minor significance and are avoided with frequent topical steroids in the immediate post-operative period.

Transient micro hyphema were reported by Thomas et al (2.3%) and Wise (5%).[6] They are easily controlled with direct photocoagulation and are of minor significance.

Corneal complications are usually not the result of A.L.T, but a previous or underlying corneal pathology.[6] It is not believed to be a permanent or significant complication.

Comparing A.L.T. to traditional filtration surgery, the lower morbidity of A.L.T. is worth noting. However, patients with previous A.L.T. demonstrated a doubling in the incidence of encapsulated blebs compared to those without it (33 % versus 16

%).[6] No statistical link was found between the interval between laser and filtration surgery nor the number of spots.[6] Because of this finding the use of A.L.T. on presurgical patients is discouraged unless a reasonable chance of success exists.[6]

Informing patients of their risks post-A.L.T. is important in defining the value of this treatment for them. In cases where maximal medical treatment is no longer effective and surgery is too much of a risk, A.L.T. is an excellent alternative. Unfortunately not all cases are easily decided. A well informed glaucoma patient can weigh the risks and benefits of A.L.T. for themselves if they are provided the appropriate information. It is the managing doctor's responsibility to inform each patient of the relevant post-operative complications that may affect them. For example, the P.O.A.G. patient would be more likely to have a sustained decrease in I.O.P. than the exfoliative or pigmentary glaucoma patient, but they may be with greater risk for I.O.P. rise immediately after treatment.

Providing all patients with pilocarpine pretreatment, and laser burns placed at the anterior border of the trabecular meshwork is the best way to avoid all post-operative complications. It is the responsibility of the referring eye care professional and laser therapist to work together to prevent and minimize post-operative complications.

VI. A.L.T. Findings

Although A.L.T. may be effective initially, there may be a slow and steady rise in I.O.P. over time. Through long term follow-up several authors have investigated the failure of A.L.T. and how long it may remain effective in controlling I.O.P. Singleton et al predicted a 52% chance of satisfactory control at four years. They also stated that failure rate seemed highest (23%) within the first year following treatment, with failure rate occurring at a rate of 7-10 % per year thereafter.[6] Wise has reported what appears to be the largest follow up period with I.O.P. of less than 21 mmHg in 79% at one year, 63% at four years, and only 45% at seven years. This did increase to 70% at 10 years due to patient selection factors that were as yet undefined.[6] From these findings, A.L.T. is thought to control I.O.P. for extended periods of time in many patients and in some may eliminate the need for filtration surgery, with its attendant risks and potential complications.[6]

Another post-A.L.T. factor to consider is anti-glaucoma medications after treatment. In some patients medications are not needed altogether. Although, in general, A.L.T. has not allowed discontinuation of all medications, but a reduction in the number of medications has been reported.[6] Horns et al reported that medications could be reduced in 28.7 % of eyes with P.O.A.G, while Thomas et al reported to taper medications in 26.1% of eyes with P.O.A.G and 41.2% of eyes with exfoliative glaucoma.[6] This

demonstrates that most patients do continue to use some topical medication post-A.L.T. to help control I.O.P.

Repeating A.L.T. has been investigated as to whether or not this is an effective and safe alternative after initial A.L.T. has lost efficacy. Feldman et al demonstrated that patients who had I.O.P controlled by A.L.T. for at least one year indeed had a statistically better chance of R.A.L.T. controlling I.O.P. for one year.[3] Their data showed that R.A.L.T. was successful for one year in 33% of eyes that were successful for one year after A.L.T. Unfortunately, no eyes maintained adequate pressure for longer than 48 months, and R.A.L.T. was recommended as a temporary measure. They couldn't demonstrate any difference in success rates based on diagnosis, pre-R.A.L.T. I.O.P, or angle pigmentation.

Grayson et al reported 73% of eyes post-R.A.L.T. at 12 months follow-up were successful.[6] They retreated 38 eyes, most P.O.A.G. and phakic. Eventually 8 eyes needed filtration surgery to maintain I.O.P.

Offering A.L.T. as initial treatment before medical management would be a unique alternative available to patients. In a retrospective study by Tuulonen, he reported 81 % success rate at 12 months and 78% success at 18 months using A.L.T. as initial treatment for patients who either were reluctant to use medical therapy or had problems with compliance.[6] A current study by Tuulonen comparing initial A.L.T. and medical treatment found no statistically significant difference at the end of one year.

Citing the Glaucoma Laser Trial, Van Buskirk states that

initial laser treatment offers no real advantage to medical therapy for the patient with newly diagnosed glaucoma, except a couple of years' grace before starting other medications.[8] Van Buskirk also states that the economic comparison is nearly equal as is the risk for advancing neuropathy, where the requirement for additional medications could not be accurately assessed based on the experiment design.[8]

How A.L.T. effects diurnal I.O.P. variation is unknown, but the effects are advantageous. Greenridge et al specifically looked at A.L.T.'s effect on diurnal curves before and 8 weeks after treatment, and found that pressure spikes were not totally eliminated, but mean peak pressure decreased by 25 %.[6] Elsas et al report that I.O.P. was stable with small fluctuations during the daytime in patients who were successfully treated by A.L.T.[2] They found the normal physiologic pressure fluctuations during the daytime seemed to be abolished. This suggests a positive therapeutic effect to some patients who do not demonstrate an obvious pressure response on routine office visits.

Recommending A.L.T. to patients as a means to reduce medications needed, or to avoid medications should only be reserved for patients who cannot tolerate medications or cannot comply for various reasons. Considering that there is no economic advantage to doing A.L.T. as initial treatment or in place of two years of glaucoma medications, and there is no therapeutic advantage, it is best to reserve A.L.T. after maximal medical treatment is no longer effective. In essence this would give topical medications a

renewable and synergistic effect post A.L.T.

Retreating patients whom initial A.L.T. was successful is a viable and reasonable treatment, provided the patient knows the relatively short duration of efficacy of the treatment.

Using A.L.T. on R.A.L.T. as a means to control potentially damaging pressure spikes is a secondary and often overlooked therapeutic advantage of A.L.T. Although this alone is not reason to perform A.L.T. it can be emphasized to patients who do not receive extremely dramatic results in I.O.P. reduction. The reduction in frequency and magnitude of pressure spikes will undoubtedly have advantageous effects on the optic nerve and subsequent visual field of the post-laser patient.

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