USES OF PULSED DYE LASER IN DERMATOLOGY

Essay

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ABBREVIATIONS

AK	:	Actinic keratosis
ALA	:	Amino levulinic acid
CM	:	Capillary malformation
CW	:	Continuous wave
EMLA	:	Eutectic mixture local anesthetics
ET	:	Erythemotelangectatic
IH	:	Infantile hemangioma
KTP	:	Potassium-titanyl-phosphate
LPDL	:	Long pulsed dye laser
MAL	:	Methyl amino levulinic acid
NAFL	:	Non-ablative fractional laser
Nd:YAG	:	Neodynium: yttrium-aluminium garnet
PDL	:	Pulsed dye laser
PDT	:	Photodynamic therapy
PWS	:	Portwine stain
TRT	:	Thermal relaxation time

Abstract

History & introduction: Lasers as light sources to generate heat are very useful because they can, depending on parameters, allow for exquisite control of where & how much one heats. Four properties are common to all laser types; monochromatic, coherent, collimated & being of a very high intensity. The flashlamp-pulsed dye laser (FLPDL) was the first vascular laser that was developed based on the principle of selective photothermolysis. It was specifically designed to treat port wine stains. Although initially used with a 577 nm wavelength (a hemoglobin absorption peak) and a 450 μs pulse duration (shorter than the thermal relaxation time of treated cutaneous vascular lesions), currently available pulsed dye lasers emit wavelengths between 585 and 595 nm with pulse durations between 350 μs and 400 μs & sufficient energy to produce 3 mm spot size & above. Variable wavelengths and pulse durations lead to the targeting of a variety of different tissues. Pulsed laser systems have become the mainstays of therapy for both congenital and acquired vascular lesions. These lasers offer excellent clinical improvement with a low risk of adverse sequelae. Transient purpura is the most common adverse effect of PDL treatment. Current technologic improvements include dynamic surface cooling and extended pulse duration, which enhance clinical results and minimize adverse effects. Cutaneous vascular lesions which can respond to PDL are categorized according to pathology and age of onset. Congenital lesions begin in infancy and include port-wine stains, hemangiomas, venous malformations, and lymphangiomas. Pulsed dye laser treatment may be a more efficacious method for flat warts and recalcitrant periungual warts, and it can be an effective modality for newly-developed warts. Laser treatment has been attempted for scar revision since the 1980s. The PDL is the optimal treatment for reducing scar bulk and symptoms. It also decreases erythema and telangiectasia associated with scars, normalizes the skin surface texture, and improves the scar pliability. Other studies results concluded that PDL treatment could be developed as a new therapeutic approach that would allow simultaneous treatment of both active acne and associated scarring, PDL laser treatment should be further explored as an adjuvant or alternative to daily conventional pharmacological treatments**.** Another use is nonablative rejuvenation, as it has been reported the presence of increased extracellular matrix proteins in patients after periorbital treatments with both PDL and IPL. Type I and III collagen, procollagen, elastin receptors and collagenase all showed increase 6 weeks post-treatment. Another study concluded that PDL when used for dermal remodeling could increase up to 86% the levels of type I & III collagen, as well as elastin.

Aim of Work: To review the literature regarding the different uses & efficacy of Pulsed Dye laser in various diseases in dermatology.

Keywords:

Portwine
Dye Laser
Flashlamp

INTRODUCTION

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Lasers as light sources to generate heat are very useful because they can, depending on parameters, allow for exquisite control of where & how much one heats. Four properties are common to all laser types; monochromatic, coherent, collimated & being of a very high intensity **(Ashinoff and Geronemous, 1991)**.

The flashlamp-pulsed dye laser (FLPDL) was the first vascular laser that was developed based on the principle of selective photothermolysis. It was specifically designed to treat port wine stains. Although initially used with a 577 nm wavelength (a hemoglobin absorption peak) and a 450 μs pulse duration (shorter than the thermal relaxation time of treated cutaneous vascular lesions), currently available pulsed dye lasers emit wavelengths between 585 and 595 nm with pulse durations between 350 μs and 400 μs & sufficient energy to produce 3 mm spot size & above. Variable wavelengths and pulse durations lead to the targeting of a variety of different tissues. Pulsed laser systems have become the mainstays of therapy for both congenital and acquired vascular lesions **(Anderson and Parrish 1983).**

These lasers offer excellent clinical improvement with a low risk of adverse sequelae. Transient purpura is the most common adverse effect of PDL treatment. Current technologic improvements include dynamic surface cooling and extended pulse duration, which enhance clinical results and minimize adverse effects. Cutaneous vascular lesions which can respond to PDL are categorized according to pathology and age of onset. Congenital lesions begin in infancy and include port-wine stains, hemangiomas, venous malformations, and lymphangiomas. Congenital

lesions are found most commonly on the head or neck and may be isolated or found as part of a congenital syndrome such as Sturge-Weber syndrome. Acquired lesions develop in persons of any age and include telangiectasias, cherry angiomas, pyogenic granulomas, venous lakes, poikiloderma, and Kaposi sarcoma. Acquired lesions may occur spontaneously, or they may be caused by trauma, ultraviolet exposure, or hormonal changes **(Alster, 2003).**

Also pulsed dye laser treatment is a safe, tolerable and relatively effective treatment method for viral warts. Pulsed dye laser treatment may be a more efficacious method for flat warts and recalcitrant periungual warts, and it can be an effective modality for newly-developed warts **(Park and Choi, 2008).**

Laser treatment has been attempted for scar revision since the 1980s. The PDL is the optimal treatment for reducing scar bulk and symptoms. It also decreases erythema and telangiectasia associated with scars, normalizes the skin surface texture, and improves the scar pliability. Other studies results concluded that PDL treatment could be developed as a new therapeutic approach that would allow simultaneous treatment of both active acne and associated scarring, PDL laser treatment should be further explored as an adjuvant or alternative to daily conventional pharmacological treatments **(Goldman and Fitzpatrick, 2002)**.

Another use is nonablative rejuvenation, as it has been reported the presence of increased extracellular matrix proteins in patients after periorbital treatments with both PDL and IPL. Type I and III collagen, procollagen, elastin receptors and collagenase all showed increase 6

weeks post-treatment. Another study concluded that PDL when used for dermal remodeling could increase up to 86% the levels of type I & III collagen, as well as elastin **(Brent et al., 2008)**.

Regarding other uses as psoriasis, some studies showed that UVB-based 308-nm excimer laser was more effective for psoriasis than the PDL. Although the PDL requires fewer treatments and has fewer side effects, these advantages do not outweigh its very modest benefits. The PDL might be useful in excimer-laser-resistant cases; some of these patients did not respond to the excimer but did respond to the PDL. The two systems target different parts of the psoriasis pathway, with the PDL targeting the abnormal microvasculature of psoriatic plaques **(Noborio, 2009)**.

One of the new uses of PDL is Kaposi's sarcoma, PDL therapy offers another option to the traditional methods of treatment, studies suggest that the success of pulse dye laser treatment lies in the fact that all tumors contain an increased number of dilated blood vessels, but it's to be further evaluated **(Tappero, 1993).**

Aim of Work:

To review the literature regarding the different uses & efficacy of Pulsed Dye laser in various diseases in dermatology.

Chapter 1

BASIC CONSIDERATIONS

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Definition of laser:

Light amplification by stimulated emission of radiation (LASER or laser) is a mechanism for emitting electromagnetic radiation, typically light or visible light, via the process of stimulated emission. The emitted laser light is (usually) a spatially coherent, narrow low-divergence beam that can be manipulated with lenses. In laser technology, "coherent light" denotes a light source that produces (emits) light of in-step waves of identical frequency, phase, and polarization. The laser's beam of coherent light differentiates it from light sources that emit incoherent light beams, of random phase varying with time and position **(Adamic et al., 2007).**

Laser skin interactions:

The principle of selective photothermolysis is to deliver energy precisely into the target with minimal damage to surrounding tissue. This energy targeted at and absorbed by chromophores, is converted to heat, which creates a thermal effect within the tissue. The buildup of denatured material increases with temperature, and proportionally with time. Near a certain critical temperature, coagulation results. This critical temperature is specific to particular targets. Between 60°C and 70°C , collagen and other structural proteins are denatured. Between 70°C and 80°C , nucleic acids denature. Temperatures above 100°C bring intracellular water to its boiling point. The vaporizing steam produced in tissue leads to a sudden increase in pressure and injury to most of the cell structures and blood vessels. Rapid vaporization is especially valuable in separating or

ablating tissues, although if heating at these high temperatures continues, charring results **(Stier et al., 2008).**

The longer the tissue is exposed to the laser, the thermal energy diffuses into surrounding tissues by conduction. Thermal relaxation time (TRT), measured in seconds, is the amount of time for a particular type of tissue to lose half the heat gained from the laser. To keep the laser from causing widespread damage to other tissues, the laser ablation must occur faster than heat is conducted into outside tissue. Effective heating occurs using a pulse duration approximately equal to the target's TRT **(David et al., 2003)**.

Different blood vessels have different TRTs: capillaries have a TRT of tens of microseconds, PWS venules have a TRT of tens of milliseconds, and leg veins have a TRT of hundreds of milliseconds. Small targets (e.g., nevus of Ota) are treated with submicrosecond pulses, whereas bigger targets (e.g., hair follicles) are treated with longer pulses. TRT also depends on the shape of the tissue, spheres will cool faster than cylinders, and cylinders will cool faster than planes. To effectively target specific tissues, these factors of pulse duration, spot size, and TRT, in addition to selecting a particular wavelength, must be taken into account **Chapas and Geronemus, 2005)**.

To limit damage and improve results, skin cooling is used during laser treatment. The 3 main types of skin cooling are precooling, parallel cooling, and postcooling with the nomenclature relating to the temporal application of the coolant. Precooling lowers skin temperature before the arrival of the laser pulse on the skin. For very short pulses (<5 milliseconds), less time is needed to extract heat, and the precooling

provides any necessary epidermal protection. Dynamic cooling devices such as the cryogen cooling spray allow the most vigorous epidermal precooling. Parallel cooling chills the skin during the laser pulse and is best for pulses longer than 5 to 10 milliseconds. Postcooling helps alleviate pain and erythema **(Burstein et al., 2006).**

Pulsed Dye Laser:

A dye laser is a laser which uses an organic dye as the lasing medium, usually as a liquid solution. Compared to gases and most solid state lasing media, a dye can usually be used for a much wider range of wavelengths. The wide bandwidth makes them particularly suitable for tunable lasers and pulsed lasers. Moreover, the dye can be replaced by another type in order to generate different wavelengths with the same laser, although this usually requires replacing other optical components in the laser as well **(Tanghetti et al., 2005).**

Flashlamp-pumped PDL:

The FLPDL uses a high power flashlamp to excite electrons in an organic dye (rhodamine). Originally, this led to emission of yellow light at 577-nm. The dye has been modified to emit photons at different wave lengths corresponding with the absorption peaks of hemoglobin in its various states of oxygenation **(Anderson and Parrish, 1983)**.

Light energy emitted by the flashlamp-pumped PDL is primarily absorbed by oxyhemoglobin contained within vascular lumina, thus minimizing thermal damage to other structures. The PDL was originally available at a wavelength of 577 nm, corresponding directly with the third absorption peak of oxyhemoglobin, and a pulse duration of 450 microseconds. Over the past decade, the wavelength was extended to 585