Lasers in dermatology *

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Laser is a very useful tool in modern medicine. It has already become established in the fields of ophthalmology, genito-urinary surgery, biliary surgery, otolaryngeology, plastic surgery, gynaecology and dentistry. In fact, the list is growing very rapidly. Laser surgery is becoming increasingly popular worldwide among the dermatologic surgeons.

"LASER" stands for Light Amplification by Stimulated Emission of Radiation. It has several unique characteristics [1];

1. Monochromaticity — Light is of one emitted wave length or colour
2. Spatial coherence — No divergence of the rays once emited
3. Intense brightness.

Mechanism [2]

Firstly an electric power source stimulates randomly moving photons into an 'excited' energy state which causes these photons to move in one frequency. This movement of photons is amplified by a series of reflecting mirrors on both sides of the laser chamber. At the end of the laser chamber one mirror is partially reflective in such a way to emit the laser light. This emited laser light is then carried to the desired site through a fibreoptic tube system.

The most variable component of each laser is the 'gain medium'. This determines the wave length of the light emited.

The gain medium may be

(a) Liquid eg. Dye
(b) Gas eg. Argon, Carbon dioxide, Helium, Neon
(c) Solid eg. Ruby, Nd YAG, Gold, Copper

The electric power source can change the pulse width. eg. Flash lamp pumped dye laser (candela) has a pulse duration of 450 micro seconds where as the Q switched ruby laser emits pulses of 40 nano-seconds.

Laser light may be in (a) UV range (100-400 n.m.)
(b) Visible range (400-750 n.m.)
(c) Infra-red range (750-10,000 n.m.)

The tissue effects depend on

(a) Wave length
(b) Power density (W/cm^2)
(c) Length of exposure
(d) Tissue absorption

The wave length of the light emited determines the 'Biologic Chromophore' affected.

Laser light can be delivered in continuous mode, pulsed mode or Q switched mode [2]. Continuous mode lasers emit light continuously without fluctuation but emission can be shuttered or gated to produce pulses that may vary from 0.01 seconds to several seconds in duration. Pulsed lasers emit pulses of light which are very brief (ie less than 1 millisecond in duration) and of very high energy, limiting damage to a designated cutaneous chromophere. This minimizes the thermal damage to surrounding structures. A 'Super pulsed' mode is available on some lasers (Co_2). This mechanism allows high peaked power to be delivered in a repetitive pattern as a train of short duration pulses. Super pulsing also allows thermal injury to be confined to the target with minimal spread to surrounding structures. In 'Q switched' mode laser an electromagnetic or chemical switch allows excessive energy to accumulate in the laser cavity before the emission of a short single pulse (in nano second range) of very high power. The Q switch is available on Ruby and Nd YAG lasers.

Now I will discuss in detail about the various types of lasers relavent to the dermatogists.

Carbon dioxide laser [2]

Often used in the treatment of cutaneous precancerous and cancerous lesions. Principal chromophore in the skin for the Co_2 laser is the water molecule. Laser heats the water molecules and vapourises tissue.

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As the Co_2 laser is invisible, a Helium-Neon red aiming beam is used to guide the operator. Co_2 laser may be used in focussed (cutting) mode or defocussed (vapourization) mode. The smoke (or vapour) produced should be sucked out through a tube kept close to the targeted area. Ideally the operator should wear a mask to prevent inhalation of fine particles.

When Co_2 laser is used in the cutting mode 'as a scalpel' it often gives a 'bloodless field' as it seals off blood vessels of 0.5 mm or less in diameter. This mode is useful in vascular tumours, in patients with bleeding diatheses and patients with pacemakers where electro cautery may be contraindicated. The 'laser scalpel' causes some coagulation necrosis at the excision margins but this is less than that due to electrosurgery.

Vapourization mode of Co_2 laser is used to destroy targeted tissue. Its uses include, viral warts, condylomata accuminata, epidermal naevi, seborrhoeic keratoses, tumours esp. squamous cell and basal cell carcinomata, erythroplasia of queyrat, bowenoid papulosis, keloids, actinic cheilitis, solar keratosis, leukoplakia, kaposi's sarcoma, capillary haemangiomata and rhinophyma [2,4].

Flash lamp pumped pulsed dye laser (FDP or candela laser)

FDP laser is absorbed by oxyhaemoglobin in the third absorption peak of haemoglobin causing 'selective photothermolysis'. FDP laser is most useful in Port wine stains (vascular malformations). The other uses include telangiectasia due to various causes (rosacea, actinic injury, essential, post irradiation, post dermabrasion, scleroderma etc.) haemangioma, angiokeratoma, poikiloderma of civatte, spider naevi and venous lakes [1,3,4,5].

Candela laser uses only short pulses and as the 450 micro second pulse width corresponds with the thermal relaxation time of the blood vessels the surrounding tissue is not damaged. Therefore the scarring risk is minimal with this laser. FDP laser emits yellow light at 577 or 585 nm wave length.

The beam diameter is generally 5 mm and when the area to be treated is mapped out the operator uses a foot or hand switch to deliver the pulses through the hand piece. Slight overlap of 5 mm circles gives best results. It is always advisable to do a test patch with several energy ranges, (eg. 5.75 J/cm^2, 6 J/cm^2, 6.50 J/cm^2) to find the optimal energy level. As the FDP laser pulses are felt as brief stings (as if a rubber band is pulled and let it hit on the skin) most adults prefer to have a topical anaesthetic such as EMLA cream (prilocaine and lidxocaine) or local anaesthetic injections. For children general anaesthesia is recommended. In a study done on 133 patients (140 port wine stains) Lowe NJ (1991) reported the following immediate skin changes; purpura in all (normal response), crusting and scabbing (49.2%), scaling and peeling (18.6%), swelling (2.1%) and blistering (1.4%).

The long term response was good or excellent in 84% (average number of treatments 3-4) and none or poor in 16%. However in the poor response group skin types IV and V were common. Atrophic scarring was 1.4% overall. Yonger patients responded very well; 1-10 years group giving 90% excellent results. There findings are quite in keeping with authors experience in Perth, Australia.

In another study [5] on 27 rosacea patients 88.9% showed an excellent response especially for the telangiectasia component. FDP laser therapy improved the papular and pustular activity in 59.2% of patients.

Argon laser

This is a continuous mode laser, but can be shuttered or gated. Argon laser causes selective destruction of two cutaneous chromopheres Haemoglobin and Melanin. 80% of its emission is in 480-515 nm range.

Melanin has its absorption peak at 200-500 nm range and Haemoglobin has three peaks at 420, 540 and 577 nm, argon laser has been used successfully in vascular lesions (such as port wine stains, and telangiectasia) and pigmented lesions. However in the treatment of vascular lesions a major problem is the absorption by melanin causing damage to the epidermis and dermis. Thus the scarring tendency is relatively high (5-30%) with the argon laser. This laser is now mostly supeceded by newer candela laser which is more selective.

Nd: YAG. Laser (Neodymium Yttrium Aluminium Garnet Laser

Nd: YAG Laser has a wave length of 1064 nm and is available in continuous, pulsed and Q switched modes. This has a deeper tissue penetration and destroys the targeted tissue by coagulation necrosis. Nd YAG laser is not as good a cutting tool as Co_2 laser but seals bleeders better (seals vessels upto 1-2 mm in diameter). Nd YAG laser is particularly useful in bulky vascular tumours. It has been reported to be useful in condylomata accuminata, basal cell and squamous cell carcinoma, Bowen's Disease,

metastases basal cell naevus syndrome, actinic keratosis, oral florid papillomatosis, leukoplakia, Bowenoid papulosis, Kaposi's sarcoma, hypertrophic and nodular portwine stains, vascular tumours of mucosae and tongue and haemangiomas [2,3].

The Q switched Nd YAG (1064 nm) laser can be used for treatment of tattos and dermal pigmented lesions where as frequency doubled Q switched Nd: YAG (532 nm) can be used for tattos and epidermal pigmented lesions. However, still these lasers are not widely used clinically [3].

Photodynamic therapy

This is a form of photochemo-therapy combining a photosensitizer and non-ionizing radiation to destroy malignant cells.

Principle: Porphyrins have selective affinity for cells with a rapid turnover such as malignant cells. Several agents are known to photosensitize tumour cells. However, most extensively studied are Haematoporphyrin Derivatives (H.P.D.) HPD are used topically or systemically, and are taken up and retained by malignant cells. Then they demonstrate a 'Salmon Red' fluorescence when viewed with a mercury are lamp emiting 400 nm rays. HPD containing cells absorb light at 405 nm and 628 nm (red) and cause coogulation necrosis. Usually, gold vapour laser emiting 628 nm red light is used for photodynamic therapy. Less commonly, argon-pumped tunable dye laser (488-630 nm) is used. This type of therapy has been described as ideal for Basal cell Naevus syndrome. Other uses include BCC, SCC, metastases, Kaposi's sarcoma and even psoriasis [2,3].

However, photodynamic therapy is not yet widely used by the clinicians due to;

(a) HPD and light doses need to be refined further
(b) Uncertainity about the adequacy of tumour eradication
(c) Persistent photosensitivity — may last up to 6/12

Ruby laser

This causes coagulation necrosis if high energy densities are used. Highly pigmented tumours such as melanoma, pigmented BCC, Kaposi's sarcoma absorb ruby laser light more strongly.

Q switched ruby laser is a very useful modification. It emits light at 694 nm wave length causing selective 'photothermolysis' of melanin destroying melanosomes. The 'Q switch' allows energy to be stored briefly in the laser cavity and it is released in pulses of nanoseconds. A single pulse has a power or over a million watts [3].

Q switched ruby is probably the treatment of choice for tatoos, particularly for the blue/black types. It is also useful in cafe au lait spots, Becker's naevus, lentigens, ephelids, naevus spilus, chloasma, naevus of ota and melanocytic naevi [2,3].

Copper vapour laser (CVL)

This is a laser emiting yellow light at 511-578 nm range. Copper Vapour Laser emits trains of 20 nano second pulses with 100 micro seconds between pulses. These pulses are of very high energy. Copper Vapour Laser causes immediate blanching of the treated skin as opposed to the purpura one sees with the Candela (FDP) laser [3].

A newer development, which was perfected in New Zealand, combines a high power copper vapour laser with a robotic scanner [3]. This is fast, efficient and allows large areas to be treated in one session. Its cost is less than (FDP) laser. In fact, in near future the copper vapour laser with the robotic scanner may replace FDP laser as the treatment of choice for port wine stains. However, CVL with robotic scanner has a few shortcomings at present; larger physical size of the machine, need to have operation theatre setting, and occasional difficulty in positioning the patient in a plane perpendicular to the laser beam.

Excimer lasers

These lasers use halide gases.

Xenon fluoride	351 nm
Xenon chloride	308 nm
Krypton fluoride	248 nm
Argon fluoride	193 nm

These are basically cutting lasers with very good precision causing very little or no damage to adjacent tissues (superficial penetration less than 100 μm) [2].

Xenon fluoride excimer laser has been used successfully in blue/black tattoos as it destroys melanosomes selectively like the Q switched ruby laser [2,3]. However, there is concern among some authorities about the mutagenic potential of excimer lasers as its in UV range [2].

Table 1 gives an outline of the lasers used in Dermatology with the type of light emited, wave length and therapeutic uses. New research is going on in further development of frequency doubled Nd: YAG, Alexandrite, KTP, Free Electron Beam, Ultra short pulsed Titaneum sapphire and super pulsed Co_2 lasers.

Table 1. Lasers used in dermatology

	Type	*Light Emited*	*Wave Length*	*Therapeutic use*
1.	Argon laser	Blue - Green	488-514	Vascular and pigmented lesions
2.	Co_2 laser	Infra-Red	10600	cutting, vapourization, coagulation
3.	Flash lamp pulsed dye laser (candela)	Yellow	577-585	Vascular lesions and pigmented lesions
4.	Argon pumped Pulsed dye laser	Blue-Red	488-630	Photodynamic therapy and vascular lesions
5.	Nd: YAG laser	Near Infra-Red	1060	Deep coagulation of tissue
6.	Q switched Ruby laser	Red	694	Tattoos & pigmented lesions
7.	Gold vapour laser	Red	628	Photodynamic therapy
8.	Excimer laser	UV	193, 248, 308, 350	Tissue cutting and tattoos
9.	Copper vapour laser	Green-yellow	511, 578	Vascular and pigmented lesions

In summary, lasers have become an important user friendly tool in dermatologic surgery. More and more fine adjustments are done to the existing machines and technology is improving rapidly. Co_2 laser, candela pulsed dye laser, copper vapour laser and Q switched ruby laser are the most useful to the dermatologist. In fact, for some conditions lasers have become the treatment of choice; FDP laser for port wine stains and Q switched ruby laser for tattoos.

In conclusion, I would like to thank the Sri Lanka Association of Dermatology for giving me this opportunity to talk to you today and to share some of my experiences on lasers. I also wish to express my gratitude to Dr Carl Vinciullo of Royal Perth Hospital, although in absentia, for guiding me in the path of lasers.

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