Ambulatory laser-assisted surgery: a multicenter application and experience

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BACKGROUND: *The widespread use of surgical lasers has found place in dermatologic and aesthetic surgery largely because they are well tolerated with a reduced incidence of postoperative haemorrhage and oedema, few associated adverse events and a high rate of patient satisfaction.*
PATIENTS AND METHODS: *A retrospective analysis of 1232 consecutive patients was performed on patients undergoing a range of laser treatments between January 2005 and January 2010. A mixed variety of indications for laser use included dermatologic surgeries for the removal of fibromas, angiomas and naevi, aesthetic surgeries for acne, superficial vascular conditions, facial rejuvenations and remodelling and tattoo removals as well as many miscellaneous conditions. A range of lasers were employed including CO_2, Erbium: Yttrium Aluminum Garnet (Er:YAG), diodes, Alexandrite, Ruby and Neodymium:Yttrium Aluminum Garnet (Nd:YAG) lasers with variable use for different indications in combination with a selective protocol of topical anaesthesia and local cooling systems.*
RESULTS: *Patient satisfaction was high overall (92.4%) with most reported failures amongst those treated for general surgical conditions where there were the highest recorded complication rates. The main failures occurred in those with small cutaneous telangiectases (36.2% incomplete treatment response and 31.9% dissatisfaction rate). In those patients where lasers were used for aesthetic reasons,(most notably in those undergoing tattoo or scar removal and in those with hypertrichosis and dermatofolliculitis), incomplete results occurred in 7.2% with an 11.8% dissatisfaction rate and rare complications (0.9%). In this group, the highest reported incomplete results occurred in patients undergoing tattoo removal (13.9%), followed by scar removal (12.5%) and then by those undergoing treatment for hypertrichosis and dermatofolliculitis (8.8%).*
CONCLUSIONS: *Laser use in general surgery is associated with a high success rate for a wide variety of conditions with high patient satisfaction and a low incidence of adverse events in experienced hands. The advantages and disadvantages as well as the specific recommendations for different laser types are presented with clinical advances resulting from the development of non-ablative laser systems designed for dermal remodeling.*

KEY WORDS: Cross-disciplinary, General surgery, Laser, Outpatient

Introduction

The more widespread application of lasers in surgical practice reflects newer innovations in general surgery such as the use of ultrasonic shears and dissection instruments,

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(including the Ultracision harmonic scalpel and the CUSA Cavitron device)[1,2] as well as the radiofrequency LigasureTM apparatus; [3] each designed to reduce intraoperative haemorrhage and postoperative oedema [4]. Laser-assisted technology has shown distinct advantage in an outpatient setting for a range of surgeries including dermatological use, [5-8] plastic surgery, [9,10] aesthetic operations, [11,12] vascular procedures [13,14] and an array of gynaecological applications [15]. Different types of lasers have specific indications and advantages within medical practice where laser use has shown specific advantage over the use of conventional scalpels, electrocautery and cryosurgery, providing a relatively bloodless field, more precise incision/excision, improved visualization, minimal perioperative oedema and pain and reduced postoperative complications.

The introduction of the CO_2 laser in the 1990's has provided a precise, bloodless light scalpel with the sealing of small blood vessels <0.5 mm in maximal diameter and lymphatics and nerve endings with instantaneous vaporization at low temperatures where its greatest efficacy has been found in otorhinolaryngology, maxillofacial surgery, neurosurgery, gynaecology and plastic surgery [16]. Its pulsed, high energy use has been extensively used in skin resurfacing and epidermal ablation with energy absorption in the epidermis and papillary dermis without producing underlying thermal damage [17]. This latter application has been somewhat replaced by newer laser systems which result in dermal remodelling without epidermal ablation and which rapidly reduce post-procedural recovery times. Argon lasers which produce narrow band wavelength light have found their principal place in ophthalmology, gastrointestinal bleeding for endoscopic use after polypectomy and endoscopic mucosal resection and in the cutaneous treatment of haemangiomas, telangiectasis and tattoo removal. The Nd-YAG laser produces coherent infrared light for deeper absorption into the tissues specifically for the removal of benign and malignant tumors, whereas the erbium-YAG laser is more often used in superficial rejuvenation techniques [18]. Ruby and Alexandrite lasers have found particular application in tattoo removal through photothermolysis [19].

Dermatologic laser therapy has resulted in many new innovations with the aesthetic introduction of fractional photothermolysis for skin rejuvenation and acne scars showing advantage over both ablative skin resurfacing and non-ablative laser skin rejuvenation techniques and the use of laser lipolysis has shown benefit over conventional liposuction technology 8. The latter technique results in substantially less bleeding and post-procedural skin laxity although the ideal wavelengths and treatment protocols are yet to be established. This paper discusses the multi-institutional use of lasers in an ambulatory setting over a 5-year period providing recommendations for different types of laser use based on our experience.

Materials and Methods

This study represents a retrospective analysis of 1232 consecutive patients (mean age 45 years; range 6-92 years) who underwent a range of laser treatments at our satellite institutions (Second University Naples, **ASL Na1 Naples, ***Coloproctology Unit ARS Medica, Rome,) between January 2005 and January 2010. Data were stored using the Epi Info™ (CDC Atlanta) 3.5 software and Institutional Board Review permission from all institutions was obtained for data access and analysis. Most patients (79.9%) were female with the majority of procedures being performed for dermatologic surgeries or for aesthetic reasons (Fig. 1). A range of lasers were employed including the CO_2 laser, the Erbium:Yttrium Aluminum Garnet (Er:YAG) laser, diode lasers, Alexandrite and Ruby lasers and the Neodymium:Yttrium Aluminum Garnet (Nd:YAG) laser, with the latter only being used during the first two years of the study period (4 patients not included in the study). The indications and advantages of the different laser types are shown in Table I.

In 41.3% of patients (n=508), most notably fibromas, angiomas, and naevi, satisfactory results were achieved after just one outpatient session, or following only one surgical procedure (e.g. frenulectomy, upper eyelid blepharoplasty, vaginoplasty and ablative facial rejuvenation). Other procedures 446 cases (36.2%) required repeated (< 7) laser treatments for a range of conditions including epitheliomas, verrucae, lentigo, acne scars, other scars, some superficial vascular conditions, ulcers, condylomata, semi-ablative facial rejuvenation and tattoo removal. Other conditions in 278 patients (22.6%) required > 7 specific treatments for complete effectiveness most notably for Thermage® and definitive depilation. These treatment protocols and patients are shown in Fig. 2. Topical anaesthetic creams comprising either 10% carbocaine (40 patients) or lidocaine/prilocaine (EMLA®) in 155 patients were administered to cases undergoing surface treatments and no anesthesia was required in 572 cases although local ice was occasionally applied to low-

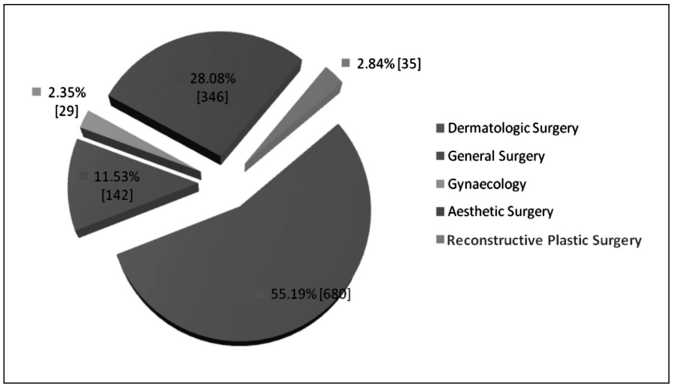

Fig. 1

TABLE I - *Laser types in the reported patient cohort: advantages and indications*

Laser type	Active medium/state	Wave length	Target	Technical notes	Main indications/ Advantages
CO_2	Carbon dioxide gas Fractional	10600 nm Light in the far infrared spectrum	water	Most often used as a precise surgical laser	Dermatological surgery Surgical cutting Skin resurfacing
ERBIUM : YAG	Erbium: Yttrium Aluminium Garnet (Er:Y3Al5O12). Solid Fractional	2940 nm Light in the far infrared spectrum	water	tissue ablation plus precise coagulation	Superficial skin deformities or discolorations skin resurfacing
DIODE	Semiconductor similar to that used to produce a light-emitting diode (LED) Formed from a P-N junction and powered by an injected electric current.	808 nm light in the infrared spectrum	Hemoglobin and exogenous chromophores (used to artificially stain normochromatic lesions) Poorly absorbed by water	Selective thermolysis of target lesions Minimal risk of damage to surrounding tissue	Vascular defects and anomalies Dermatologic surgery Aesthetic medicine Great versatility Minimal pain
ALEXA-NDRITE	Cr:BeAl2O4 Solid	755 nm Light in the infrared spectrum	Melanin in hair follicles	Thermokinetic selectivity May be used in combination with a skin cooling system to diminish thermal damage	Permanent depilation. Spot size must be at least 10-12 mm guaranteeing extension to the hair follicle base
RUBY	Synthetic ruby Solid	694.3 nm Light in the infrared spectrum	Pronounced affinity for dark chromophores	Thermokinetic selectivity	Especially useful for tattoo removal
Nd:YAG	Yttrium Aluminium Garnet crystal (YAG) neodimiumdoped (Nd:Y3Al5O12). Solid	1064 nm Light in the infrared spectrum	Affinity for dark chromophores	Very versatile	Vascular defects and anomalies Dermatological surgery Aesthetic surgery

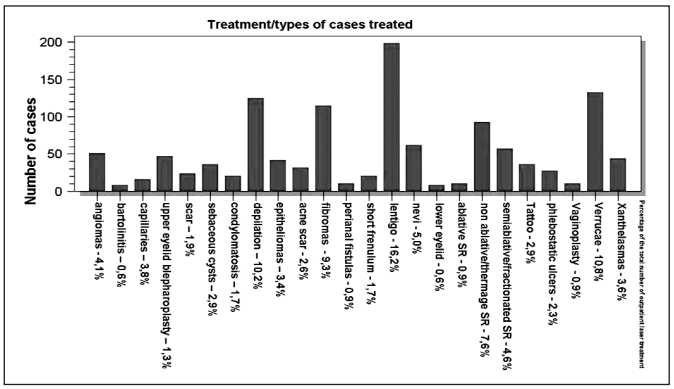

Fig. 2

er tissue temperature and in order to provide adequate analgesia. Local infiltrative anaesthesia (1% Mepivacaine) was used in 418 cases with Ropivacaine (2.2%) in 46 cases (0.26%).

Results

Table II shows the success (complete result) and failure (incomplete result) rates for each main type of laser therapy and the overall complication rates. The main complications included superficial skin burns and/or minor infections, each of which were promptly treated and resolved without permanent adverse effects. There were

TABLE II - *Overall success, complication rates, complete and incomplete result for the main different laser groups.*

Laser indication	Success Rate (%)	Complication Rate (%)*	Complete Result	Incomplete Result
Dermatologic Surgery	96.7	0.3	96.7	3.3
General Surgery	85.9	3.5	85.9	14.1
Gynaecologic Surgery	96.6	3.4	96.6	3.4
Aesthetic Surgery	92.8	0.9	92.8	7.2
Reconstructive Surgery	97.1	2.9	97.1	2.9

TABLE III - *Complications, incomplete results and temporary adverse effects for different sections).*

Section	Patients	Complications % - #Patients	Incomplete Results %	Temporary Adverse Effects %
Dermatologic surgery	680	0.3 - 2	3.3	1.5
General surgery	142	3.5 - 5	14.1	8.5
Gynecology	29	3.4 - 1	3.4	0
Aesthetic surgery	346	0.9 - 3	7.2	2
Reconstructive plastic surgery	35	2.9 - 1	2.9	0
Total	1232	1.0 - 12	5.6	2.4

no major complications; most notably ocular damage or serious other organ injury or severe allergic reactions to anaesthetic agents. Overall, 5.6% of patients felt the treatment result was incomplete and 7.6% were dissatisfied with the final results. Failed treatment responses were most commonly recorded by patients undergoing laser therapy for general surgical problems where there were also the highest detectable complication rates. Analysis of this group showed that laser treatment for small capillary type cutaneous telangiectases resulted in a 36.2% incidence of incomplete treatment response where 31.9% of patients were dissatisfied with the outcome and where temporary adverse effects were recorded in 19.1% of patients with a complication rate of 2.1%. (Capillary/teleangiectasia: 47 patients, 3,8% of the total: complications in 1 patient : thermal damage which left a scar) Lasers used for aesthetic reasons resulted in the second highest reported rates of incomplete results (7.2%) where 11.8% of patients were dissatisfied with their treatment although temporary adverse events were uncommon (2%) and actual complications were very low (0.9%). In this group, the highest reported incomplete results occurred in patients undergoing tattoo removal (13.9%), followed by scar removal (12.5%) and then by those undergoing treatment for hypertrichosis and dermatofolliculitis (8.8%). In this latter group, ablative, semi-ablative, and non-ablative skin resurfacing has the highest reported rate of success and patient satisfaction. The incomplete treatment rate is very low: 0.0%; 4.3%; 3.5%.

The incidence in the entire patient cohort of complications is shown in Table III, representing a very low rate including only one patient undergoing aesthetic surgery (a patient undergoing a superior blepharoplastiy who developed lagopthalmus due to excessive removal of tissue from the eyelid), 2 patients undergoing dermatologic surgery (a recurrence of basal cell carcinoma with reactionary haemorrhage and a further case presenting with reactionary after treatment for an angioma) and one patient undergoing gynaecologic laser surgery (who presented with urosepsis after a vaginoplasty). In the general surgery group there were complications in 5 patients (3.5%), one treated for telangiectasia with some thermal scarring, one with an incomplete frenuloplasty, 2 who presented with recurrent perianal fistulas (After CO_2 fistulotomy) and one with an infected venous ulcer (after diodes biostimulation with Methylen Blue). In the aesthetic surgery group there were 3 complications (2 patients presenting with recurrent xanthelasma and one further patient left with a deep skin depression following a Erbium treatment of an infiltrative lentigo).

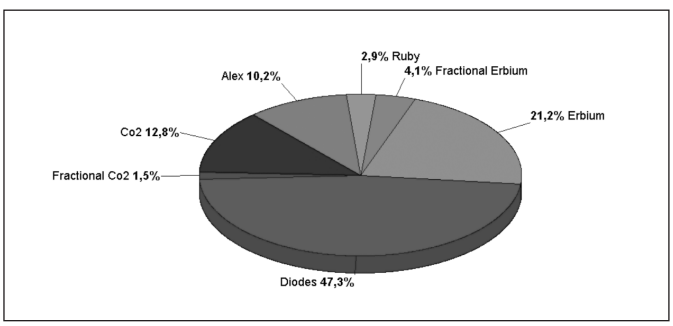

Fig. 3

Temporary adverse effects followed the same trend and were particularly rare (Plastic reconstructive surgery: 0%; Dermatologic surgery 10 Pts.: 1,5%; Ginegology: 0%). ("Temporary adverse effects" refers to small temporary problems like erythema, small burns, etc. which resolve rapidly, within 24/72 hours, without leaving any marks.) Fig. 3 shows the incidence in the patient cohort of the different lasers used.

Discussion

The ambulatory use of a range of lasers in our units in a large patient cohort for a wide variety of dermatologic and aesthetic conditions has shown a high rate of success and patient satisfaction with a reported low incidence of adverse events, most of which were of a minor nature. The least successful outcomes occurred in patients undergoing laser therapy for small cutaneous telangiectases where procedural complications were also most commonly encountered. Patient dissatisfaction was next most common in those undergoing laser treatments for aesthetic reasons although complications in this group were minimal. This latter group specifically included those undergoing tattoo removal, scar revisions and treatments for dermatofolliculitis where there were the highest rates of incomplete treatment outcomes.

The specific operative advantages of laser treatment in an outpatient setting include its precise mode of action with limited surrounding thermal skin damage accompanied by minimal bleeding and post-procedural pain. Lasers have unique operating properties which suit such indications. They emit polarized, monochromatic light with a pronounced phase coherence, the properties of which are defined by the individual wavelength, peak intensity and average emission intensity as well as by the laser type. Their advantagelie in their power, their target specificity, their precision and their adjustability where in recent years there has been rapid expansion of their medical use through an improved understanding of their epithelial effects [4,20]. Definitive subcellular effects of lasers have been shown to alter tissue growth factors, fibroblasts and stem cells [21].

The use of different lasers for specific indications permits some operative standardization. The CO_2 infrared laser (10600 nm) shows considerable precision for bloodless light scalpel use in the incision and excision of tissues with the immediate sealing of small blood vessels and lymphatics < 0.5 mm in diameter as well as of nerve endings, making it ideally suited for use in otolaryngology, maxillofacial surgery, urology, gynaecology, neurosurgery and plastic surgery. In these settings, tissues with high water content absorb its energy for immediate vaporization at relatively low temperatures. Its delivery processes are being expanded for microscopic, coloposcopic and hand-held use with utilization in combination mode with variable pulse Er:YAG systems (2940 nm) for dual ablative/coagulative mode or with non-ablative Nd:YAG systems at low wavelength (1064 nm) as well as with diode lasers (808 nm) for mixed effects to resurface photo-damaged and scarred skin by producing variable depths of controlled thermal skin injury. Used in the continuous mode, the CO_2 laser simultaneously cuts and coagulates whereas in the pulsed mode it is a powerful tool for epidermal ablation. More superficial rhytides, mildly atrophic scars, lentiginous discolorations and superficial textural changes resultant from fibrosis and dermatochalasis are eradicated by the minimal penetration of the Er:YAG laser avoiding unwanted damage to the deeper layers of the dermis with the CO_2 laser being used for deeper scars and more photo-damaged skin in combination techniques to maximize collagen contraction [12,22]. Both systems are water absorbed, however, the wavelength of the Er: YAG laser more closely approximates the absorption peak of water (3000 nm) so that nearly all the energy of the laser is absorbed in the epidermis and papillary dermis [23].

The short wavelength diode (808 and 1450 nm) lasers which are most commonly used in dermatologic surgery, have a specific ability to selectively target dark chromophores, (both naturally occurring and exogenously administered), inducing photothermolysis of pigmented areas and sparing vaporization of healthy tissues where they have shown specific advantage in the treatment of intractable acne vulgaris, [24] and in small vascular defects. The Alexandrite laser (755 nm) is ideal for permanent depilation. This laser is indicated for the treatment of both small and large areas of skin and can be used in combination with a skin cooling system to prevent thermal damage and make the treatment more tolerable. The Q-switched ruby laser (694 nm) has a pronounced affinity for dark chromophores and is especially useful for tattoo removal being the most commonly used laser for this purpose. It has been used along with the Q-switched Alexandrite, the 532 nm and the 1064 nm Nd: YAG lasers each of which have different effects on dyspigmentation and ink darkening [19,25]. The Nd:YAG laser (1064 nm) is particularly useful for the control of normal and abnormal blood vessels producing coherent infra-red light which is deeply absorbed in the tissues without colour or tissue specificity. It is specifically used in gastrointestinal medicine and urology where it has benefit in the treatment of stenoses, granulomas and for cytoreductive purposes in some malignancies. It may also be used for vascular defects, dermatological surgery and for aesthetic procedures. The results of Nd:YAG treatment in our 4 patients were, however, somewhat inferior to those obtained with the other lasers.

The treatment of vascular lesions by lasers has undergone considerable change where there is a wide variety available for the management of congenital and

acquired vascular lesions including pulsed dye (FDL, ADL) lasers (577, 585 and 595 nm), KTP lasers (532 nm), long-pulsed Alexandrite lasers (755 nm), pulsed diode lasers (in the range of 800-900 nm) and long-pulsed 1064 Nd: YAG lasers. These systems have superceded the older 'vascular' lasers (such as the argon, dye, coppervapour and krypton lasers) which resulted in higher rates of dyschromia and scarring. These newer lasers preferentially injure the target through correct wavelength and pulse duration selection where the pulsing characteristics are shorter than the thermal relaxation time of the target and where larger targets requiring more time for heat absorption require longer pulse durations and where more deeply situated vessels need longer laser wavelengths [26].

Although the efficacy and patient satisfaction in our study was high, analysis of treatment failures particularly for general surgical and aesthetic indications showed that the worst group was that presenting with cutaneous telangiectases where the highest rate of complications was also observed. In this group with a range of small disfiguring reticular veins it can be difficult to obtain complete results particularly in the lower limbs and face where it is essential that patients are informed that the anomaly tends to fade by degrees although it may not disappear entirely [27-30]. In this scenario, both the type of laser and its settings are critical, [31] with superior results achieved with green or yellow light lasers [32] in the 532 and 578 nm wavelength range respectively, taking advantage of the oxyhaemoglobin absorption peaks. In this group acceptable results have also been obtained with infra-red or near-infra-red lasers with wavelengths at or near 810nm [33]. We currently use an 808 nm semi-conductor diode laser (with gallium-arsenium diodes – the AR GII) mostly at a high power setting (20/25 watts,15/17 J/cm^2) with very short pulse durations (20ms) and a 1mm spot size which is in keeping with previous published reports of its use [32,33]. Such an approach may be combined with conventional sclerotherapy [34,35] which is by itself, still considered a gold standard of treatment.

Our results for laser use in aesthetic complaints mirrored other publications with a moderate patient dissatisfaction rate but a very low rate of adverse events and complications [10,12]. Tattoos and hypertrichosis can be treated with lasers which target dark pigments and in our series, the ruby and the Alexandrite lasers were most commonly used. The results of tattoo removal depend upon many variables including the pigments, the laser settings, patient compliance with the proposed number of treatment sessions [36] and with patient expectations. These same caveats also apply to depilation and treatment for dermatofolliculitis. In accordance with the literature, fractionated CO_2 laser therapy appears best for scar removal, [10,37] although fractionated Er:YAG laser use provides superior results in acne scars [38] and most cases of surgical scars or burns are substantially improved using unfractionated Er:YAG laser protocols.

Conclusions

Laser technology is an indispensable part of specialized surgical outpatient treatment where the best results for a range of general surgical and aesthetic conditions is obtained with familiarity with the advantages and disadvantages of the variety of different laser systems available for cross disciplinary use. Although widely used by cosmetic dermatologists we suggest that this approach is also advanced by the general surgeon where it is currently uncommonly employed [39]. Public acceptance of ablative laser treatments in the outpatient setting for dermatologic and aesthetic indications will depend upon improvements in newer non-ablative laser systems utilized for dermal remodeling.

Acknowledgment

The authors declare that they have no conflict of interest

Riassunto

È ormai assodato che l'impatto tecnologico, sopratutto nel settore della sanità ed in particolar modo nelle branche chirurgiche, sia divenuto, oggi, preponderante ed imprescindibile nell'ottica del miglioramento continuo dei risultati. Scopo di questo studio è quello di dimostrare l'indispensabilità della tecnologia laser in un ambulatorio chirurgico, così come si vuole sottolineare come la disponibilità di diverse apparecchiature (CO_2, Her-Yag, Diodi, Alessandrite, etc.) e la completa padronanza del mezzo, porti il chirurgo ad una naturale evoluzione professionale verso una trasversalità specialistica, con necessità di approfondimenti in diverse discipline affini (dermatologia, chirurgia plastica, medicina estetica, ginecologia etc.). A nostro modo di vedere la figura professionale medica che meglio si presta ad un acquisizione di competenze specialistiche trasversali risulta il chirurgo generale che per propria forma mentis e per formazione è maggiormente incline a spaziare in tutto il "chirurgico" approcciabile più facilmente di chirurghi di branche specialistiche (ortopedici, otorinolaringoiatri, ginecologi) poco disponibili ad abbandonare procedure settoriali standardizzate o dermatologi e medici estetici ai quali spesso manca una formazione professionale di tipo chirurgico. Un'analisi retrospettiva di 1232 pazienti consecutivi è stata condotta su pazienti sottoposti a una serie di trattamenti laser tra gennaio 2005 e gennaio 2010. Una varietà mista di indicazioni. Una gamma di laser è stata impiegata tra cui CO_2, Erbium: Granato alluminio ittrio (Er: YAG), diodi, Alessandrite, Ruby e Neodimio: Granato alluminio ittrio (Nd: YAG) laser con l'utilizzo variabile per diverse indicazioni, in combinazione con un protocollo selettivo di anestesia topica e sistemi di raffreddamento locale.

La soddisfazione dei pazienti è stata complessivamente elevata (92,4%).

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