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REVIEW ARTICLE

Vascular lasers and IPLS: Guidelines for care from the European Society for Laser Dermatology (ESLD)

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Abstract

Dermatology and dermatologic surgery have rapidly evolved during the last two decades thanks to the numerous technological and scientific acquisitions focused on improved precision in the diagnosis and treatment of skin alterations. Given the proliferation of new devices for the treatment of vascular lesions, we have considerably changed our treatment approach. Lasers and non-coherent intense pulse light sources (IPLS) are based on the principle of selective photothermolysis and can be used for the treatment of many vascular skin lesions. A variety of lasers has recently been developed for the treatment of congenital and acquired vascular lesions which incorporate these concepts into their design. The list is a long one and includes pulsed dye (FPDL, APDL) lasers (577 nm, 585 nm and 595 nm), KTP lasers (532 nm), long pulsed alexandrite lasers (755 nm), pulsed diode lasers (in the range of 800 to 900 nm), long pulsed 1064 Nd:YAG lasers and intense pulsed light sources (IPLS, also called flash-lights or pulsed light sources). Several vascular lasers (such as argon, tunable dye, copper vapour, krypton lasers) which were used in the past are no longer useful as they pose a higher risk of complications such as dyschromia (hypopigmentation or hyperpigmentation) and scarring. By properly selecting the wavelength which is maximally absorbed by the target – also called the chromophore (haemoglobin in the red blood cells within the vessels) – and a corresponding pulse duration which is shorter than the thermal relaxation time of that target, the target can be preferentially injured without transferring significant amounts of energy to surrounding tissues (epidermis and surrounding dermal tissue). Larger structures require more time for sufficient heat absorption. Therefore, a longer laser-pulse duration has to be used. In addition, more deeply situated vessels require the use of longer laser wavelengths (in the infrared range) which can penetrate deeper into the skin. Although laser and light sources are very popular due to their non-invading nature, caution should be considered by practitioners and patients to avoid permanent side effects. These guidelines focus on patient selection and treatment protocol in order to provide safe and effective treatment. Physicians should always make the indication for the treatment and are responsible for setting the machine for each individual patient and each individual treatment. The type of laser or IPLS and their specific parameters must be adapted to the indication (such as the vessel's characteristics, e.g. diameter, colour and depth, the Fitzpatrick skin type). Treatments should start on a test patch and a treatment grid can improve accuracy. Cooling as well as a reduction of the fluence will prevent adverse effects such as pigment alteration and scar formation. A different number of repeated treatments should be done to achieve complete results of different vascular conditions. Sunscreen use before and after treatment will produce and maintain untanned skin. Individuals with dark skin, and especially tanned patients, are at higher risk for pigmentary changes and scars after the laser or IPLS treatment.

Key words: *Acquired vascular alterations, congenital vascular malformations, guidelines, intense pulsed light source, IPLS, vascular laser*

Introduction

Vascular lasers: actual knowledge

Continuous-wave lasers (e.g. argon laser, copper vapour laser) were the first lasers used to treat cutaneous vascular lesions. Their use was often complicated by unacceptable side effects such as scarring and permanent pigmentary alterations. The development of the pulsed dye laser (PDL) in the 1980s improved the treatment efficiency and

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This report reflects the latest data available at the time the report was written (May 2006). Nevertheless, caution should be taken when interpreting the data. Results of future studies may require changes in the conclusion or recommendations set forth in this report. Ideal treatment parameters should be chosen individually, depending on the indication, patient selection, and the system used.

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decreased the incidence of these untoward effects. Since then new systems have been introduced, such as kalium-titanyl-phosphat (KTP) lasers (532 nm), followed by longer wavelength lasers such as alexandrite lasers (755 nm), diode lasers (800–900 nm) and finally the long pulsed (LP) neodymium:yttrium-aluminium-garnet (Nd:YAG) lasers (1064 nm), offering a wide range of lasers available for the treatment of different congenital and acquired vascular conditions.

The effects of lasers and intense pulse light sources (IPLS) are based on the principle of selective photothermolysis. Upon impact of the laser on the vascular target, histologically selective vascular injury with coagulation, vessel wall necrosis and perivascular collagen damage with relatively little associated thermal effects on the epidermis and the surrounding dermis can be observed.

As described by Parrish and Anderson, the theory of selective photothermolysis states that a specific chromophore (haemoglobin in the case of vascular lesions) can be selectively targeted and damaged with minimal damage to surrounding tissues.

Oxyhaemoglobin contained in red blood cells within blood vessels has a maximum peak of absorption around 540 nm (alpha peak) and 580 nm (beta peak). This holds true of small superficial vessels mainly located on the face and the neck. Vessels on the legs are usually located deeper and contain more desoxyhaemoglobin. This situation moves the absorption curve to the right, from 800 nm to 1200 nm. The longer the wavelength the deeper its penetration into the skin. For example, Nd:YAG lasers (1064 nm) can penetrate millimetres below the epidermis. Very high energy levels are required to coagulate vessels located so deep. Infrared wavelengths tend to be more effective in treating deeper blue vessels while shorter wavelengths are more effective for superficial red telangiectasias.

Since large structures require more time for sufficient heat absorption, longer laser-pulse durations have to be used. Pulse duration has been clearly demonstrated as a milliseconds domain for intradermal vessel treatment. As we must deliver very high energy pulses to thermocoagulate vessels located deep in the skin, the epidermis should be protected by cooling to minimize damage to melanocytes as well as keratinocytes.

Cooling has become an integral part of laser treatments. Spatially selective cooling can be achieved by active cooling using a cryogen spray, cold sapphire contact handpieces or air pre-cooled and blown across the skin surface. These devices promote rapid epidermal cooling to lower temperatures without affecting the target. When using the contact cooling method the pressure and the low temperatures can blanch the underlying blood vessels, minimizing the desired absorption of laser energy by haemoglobin. This can result in lesion persistence in some cases.

Clinical applications

Appropriate treatment begins with a correct diagnosis. A significant number of patients with a vascular birthmark receive ineffective and potentially harmful treatment based on misdiagnosis. A variety of vascular lasers are available for the treatment of different vascular conditions. A detailed medical history and examination should identify the nature of the vascular condition.

Classification

In 1996, the ISSVA (International Society of the Study of Vascular Anomalies) classification of vascular anomalies was accepted by the members in Rome. This biological classification is based on clinical and vascular features, natural behaviour, haemodynamic characteristics and biological differences. A multidisciplinary vascular lesion team is highly recommended when determining appropriate therapeutic strategies.

I **Vascular tumours** (arise by endothelial hyperplasia):
- Haemangioma
  - Proliferating
  - Involuting

II **Vascular malformations** (arise by dysmorphogenesis and exhibit normal endothelial turnover)
a) High flow
- Arteriovenous fistula (AVF)
- Arteriovenous malformation (AVM)

b) Low flow
- Capillary malformation (CM)
- Venous malformation (VM)
- Lymphatic malformation (LM)
  - Macrocystic
  - Microcystic
- Combined

Lasers and IPLS are the treatment of choice for the following vascular conditions.

Congential vascular lesions
- Hemangioma
- Port-wine stains (nevus flammens)

Acquired vascular alterations
- Angiofibroma
- Blue Rubber Bleb Nevus syndrome
- Campbell de Morgan angiomas
- Cutaneous lesions of Kaposi sarcoma
- Facial telangiectasia
- Granuloma telangiectaticum (pyogenic granuloma)
- Leg veins and telangiectasias

- Morbus–Osler (hereditary haemorrhagic telangiectasia)
- Nevus araneus (spider angioma)
- Poikiloderma of Civatte
- Rosacea
- Senile angioma (ruby dot)
- Telangiectasias associated with other conditions:
  - Goltz's syndrome
  - Venous angiomas
  - Venous lake

Other skin diseases with vascular alternations

- Acne
- Early immature striae atrophicae distensae
- Inflammatory linear verrucous epidermal nevus
- Psoriasis
- Red or hypertrophic scars
- Viral warts
- Xanthelasma palpebrarum

Remember: never treat arterial malformations with laser or IPLS.

Patient selection

Proper patient selection is mandatory for reasonable success rates. Patients who present for treatment with vascular lasers have different conditions to treat: from the smallest telangiectasia to the most disfiguring nodular port-wine stain (PWS). It is up to the practitioner to determine whether each individual patient is suitable for laser treatment and whether the correct technology and skills are available for treatment.

The major goals should target:

1. prevention of life- or function-threatening complications
2. prevention of disfigurement
3. minimizing psychological distress
4. avoiding aggressive procedures
5. preventing or treating ulcerated lesions.

Patients should always be scanned for unrealistic expectations.

Preoperative patient evaluation

Several factors require consideration before discussing the patient's treatment options. The following issues should be addressed.

- Does the patient have a lesion amenable to vascular-specific laser treatment?
- Has the patient received previous treatment to the lesion which can attenuate laser treatment?
  - Vascular lesions that have been treated with electrodesiccation or earlier vascular technology may have developed mild to severe surrounding tissue fibrosis within the treatment area. A similar development may occur after the treatment of haemangiomas with irradiation or intralesional application of corticosteroids or sclerosants.
  - The side effects of previous laser or IPLS treatments such as oedema and erythema or any residuals of necrosis should have cleared before the next laser or IPLS session is undertaken in order to prevent additional absorption or treatment of the wrong vessels (erythema).
- Has the patient suffered from any complications or side effects as a result of the lesion?
- What is the patient's skin type?
  - Vascular lesions in patients with darker skin types can be treated, but more care has to be taken in selecting an appropriate energy level and in choosing proper treatment intervals.
    - *The overlying melanin is a competing chromophore for the yellow laser light; it can shield the underlying vascular lesion and reduce the amount of effective light reaching the lesion.*
    - *A higher risk of postoperative hyperpigmentation or hypopigmentation.*
  - All treatment-induced pigmentary alterations should be completely resolved before additional laser treatment.
- Does the patient have realistic expectations?
  - Patients with telangiectasias should be prepared for one to three laser treatments.
  - Patients with PWS or haemangiomas typically require six or more treatments within 2 years to achieve significant clinical clearing.
    - *Patients with PWS in certain locations (medial cheeks, upper lip, distal extremities) need additional treatments and may have incomplete clearing.*

Proper patient preparation and realistic expectations are paramount to the success of the treatment.

Patient information and consent

Most vascular lesions require more than one laser treatment and 4–6 or even more weeks between treatments for optimal tissue healing. It is important that patients are fully aware of both the initial healing time (average of 7–10 postoperative days) and the overall time needed for the complete treatment protocol.

- Before treatment, patients should be questioned about a history of:
  - postinflammatory hyperpigmentation
  - excessive scarring.
- Patients should be advised to avoid excessive sun exposure before, during and after laser treatments; sun exposure can contribute to

postinflammatory changes or limit the effectiveness of the treatment.

Possible side effects and complications should be discussed in detail and should be added to the consent form to be signed by the patient before the treatment is started.

Pre-laser treatment care

In order to achieve optimal results the patient should be advised to get the palest skin colour possible. A broad-spectrum sunscreen with SPF 50+, started at least 4 weeks prior to the first treatment, would help to achieve paler skin, even during the summer. In severely tanned individuals, bleaching agents are recommended prior to the laser therapy. The skin area to be treated should be make-up free.

Laser treatment is not a painless procedure. Most patients do not require local anaesthesia for this procedure. Topical anaesthetic cream may be applied 1 hour before the scheduled treatment. A disadvantage of topical anaesthetics is the vasoconstriction that occurs, which may make it difficult to see all the vessels. However, anaesthesia is not suggested in general in adult patients because pain is the best early warning system to prevent side effects caused by heat destruction.

Preoperative checklist

Using a checklist can be helpful when first evaluating a patient for vascular laser treatment. The data obtained are a part of the patient's medical record and can be referred to or updated during subsequent patient visits.

- Prior to laser treatment detailed pretreatment education is initiated with information sheets.
- Preoperative photographs should be taken before laser treatment and upon the occurrence of side effects.

Before laser treatment, the patient must sign an informed consent and be given the opportunity to ask further questions.

Treatment

Different lasers systems are used at different fluences, pulse widths and spot sizes to treat the same vascular lesions. The physician should choose proper treatment parameters for each laser system, vascular lesion and body location. The treatment protocol must be based individually on each patient's clinical examination, skin type, history and tissue response.

Before the laser or IPLS treatment every person in the treatment room (including the patient) should wear protective goggles designed for the specific wavelength or wavelength range emitted by the light source. Before the start of and during longer treatment sessions the equipment should be checked.

In laser therapy each of the following four parameters has to be selected individually and adapted to the clinical situation:

- wavelength
- beam diameter (spot size)
- pulse duration
- fluence (energy density per cm^2).

The optimal parameters vary considerably with regard to laser/IPLS, vascular lesions (indication) and the patient. Therefore, a test treatment on a representative but small (and hidden) area is recommendable.

Treatment principles

- Smaller vessels need shorter pulses; larger vessels need longer pulses.
- The deeper the blood vessel is located in the dermis, the larger the spot size, the longer the wavelength and the longer the pulse duration should be, combined with cooling to protect the epidermis.
- Darker skin types need longer pulses and longer pulse intervals.

To thermocoagulate leg veins, the system should be able to deliver very high energy pulses through large spot sizes to enhance scattering into the dermis. When a larger spot size is used the dermal penetration is deeper. When a spot size is reduced, a higher fluence is required to achieve the same result.

When required, a thin layer of gel (optical indifferent ultrasound gel) is applied to the area to be treated in order to enable the contact handpiece to glide on the skin and to improve the light penetration into the skin as well as the temperature exchange with the skin surface. Alternatively, thin gel pads could be used and are helpful during KTP laser treatment to cool the surface, avoiding secondary erythema during treatment and magnifying smaller vessels. The contact handpiece touches the skin surface over the vascular lesion without pressing. The contact method is mainly used with diode and Nd:YAG lasers as well as with flashlamps. The handpiece of the (flashlamp-pumped) pulsed dye laser (PDL) (FPDL) and pulsed alexandrite laser normally operates as a non-touch system with a distance tip. Parallel cold air cooling improves the use of these laser types in order to increase the possible fluence and to reduce the risk of side effects.

Laser light penetration is decreased in more darkly pigmented skin. Higher fluences are required to produce similar clinical effects in darker skin types but should be administered with care to prevent side effects caused by higher absorption of the pigmented epidermis.

Areas prone to scarring, such as the anterior chest or neck as well as areas where skin is fragile (periorbital region), require a 10–20% reduction in fluence. Epidermis on the legs tends to be more sensitive to injury. A reduction of fluence is also recommended in case of underlying bones reflecting the laser beam. Care should be taken to prevent pulse overlapping by more than 10% in order to minimize the risk of scarring and textural changes.

The treatment should start on a small but representative test area using the proper pulse duration, spot size and the highest tolerable fluence. The treatment is painful, but the pain should always be tolerable. If the patient is complaining about intolerable pain the risk of adverse effects is high. Signs of side effects and proper treatment endpoints are very close and should be sorted out carefully as they may be different in each laser or IPLS.

Laser treatment of vascular lesions usually requires more than one treatment session. Intervals between each session should be 4–6 weeks or even more, especially in darker skin types.

Compression has not been demonstrated to be necessary for good results following the laser treatment of leg telangiectasias.

Treatment of different vascular lesions

Facial telangiectasias

Facial telangiectasias are a common cause of cosmetic concern. Current treatment modalities present various untoward effects and limits.

Classification

- Simple or linear
- Arborizing, spider or star
- Punctiform
- Papular

Red linear and arborizing telangiectasias often occur on the face, especially on the nose, midcheeks and chin. They measure 0.1–1.0 mm in diameter and represent a dilated venule, capillary or arteriole. They probably result from a variety of factors (genetic predisposition, presence of other diseases, hormones, physical stress, chronic sun exposure, surgical or physical trauma, hormonal considerations such as corticosteroid use, pregnancy, alcohol or oestrogen ingestion).

Choice of the appropriate system

First choice: FPDL, KTP (532 nm), IPLS.
Second choice (use with maximal care): pulsed dye laser/flashlamp pumped (APDL), argon, copper vapour.

The size and configuration of the telangiectasia will determine the optimal treatment laser.

The pain associated with laser treatment of telangiectasias varies according to the laser used and the size of the area treated. A topical anaesthetic cream can be applied before treatment to reduce patient discomfort. However, it causes vasoconstriction and can therefore have negative influence on the outcome.

The cooling system (contact, cryogen spray and cold air cooling) can cause an immediate prelaser anaesthesia. Epidermal cooling can reduce the epidermal surface temperature, thereby reducing treatment discomfort and protecting the epidermis from thermal injury.

Rosacea

Patients with rosacea often complain of facial flushing and erythema. Telangiectasias are frequently present and are unresponsive to classic topical or systemic therapy. As vessel dilatation and higher permeation of inflammation-inducing factors are pathogenic in rosacea, the treatment of these vessels also contributes to other phases of rosacea (papular and papulo-pustular rosacea).

Choice of the appropriate system

First choice: FPDL, KTP (532 nm), IPLS.
Second choice (use with maximal care): APDL, argon, copper vapour.
The erythema (first stadium of rosacea) can only be treated with FPDL, KTP or IPLS.

Haemangiomas

Cutaneous haemangiomas are the most common tumours arising in infancy. More than 50% of haemangiomas develop in the head and neck regions. Although it may be present at birth, it usually becomes apparent within a few weeks of life as a small erythematous macular patch, localized telangiectasia or hypopigmented spot in a neonate, with growth occurring over the following few months. This rapid phase of growth is referred to as the proliferative phase. The proliferative phase is followed by a gradual spontaneous involution (the involution phase) which is complete in 50% by 5 years and in 70% by 7 years of age.

An accurate diagnosis and a clear understanding of the differences between vascular malformations (PWS, birthmark) and haemangiomas are important since the natural history and the treatment recommendations for these two conditions are very different.

The majority of strawberry haemangiomas are of cosmetic concern. Some haemangiomas may cause serious problems; most complications occur during the proliferative phase.

Treatment requirements:

- All haemangiomas in childhood should be treated as early as possible to prevent the proliferative phase (and its complications) as well as the

psychosocial implications associated with persisting haemangiomas.

- In the following cases, treatment must be started:
  - haemangiomas that cause functional or structural abnormalities (e.g. airway obstruction, ophthalmologic disturbances)
  - haemangiomas that ulcerate and bleed
  - haemangiomas with secondary infection
  - haemangiomas that may result in disfigurement or scar
  - haemangiomas with the slightest appearance of growth must be treated to avoid further cosmetic or functional impairment.

Remember that large cervicofacial haemangiomas can be associated with posterior fossa brain malformations, including Dandy–Walker malformations.

It is important not to underestimate the psychosocial implications of this condition for both children and parents.

Choice of the appropriate system

First choice: FPDL, IPLS, Nd:YAG, KTP.

Treatment will not minimize the deeper growth, but will only affect the superficial component of haemangioma. Frequent treatments at intervals of 2–3 weeks at higher energies should be performed. Although treatment should begin early when the haemangioma is just starting to occur, it is often difficult to predict whether or not there will be a superficial and deep component; the deeper component may still develop despite successful treatment of the superficial component.

The management of patients with potentially problematic haemangiomas should involve a multidisciplinary approach. For life-threatening proliferative haemangiomas, a combination of laser therapy, intralesional and systemic glucocorticoids, topical immunosuppression with imiquimod and other agents may be required.

The complications of bleeding and ulceration respond very well to laser therapy. To stop bleeding or ulceration usually one or two treatments are required and often there is a prompt response.

In the incompletely regressed capillary haemangioma of the older child, superficial ectatic blood vessels can be treated with the vascular laser.

In view of contemporary anaesthetic techniques, safer and more selective laser therapy, and conservative tissue-sparing surgical approach, we recommend an early intervention whenever a haemangioma in childhood is diagnosed.

Treatment

Most haemangiomas treated with FPDL or IPLS do not require general anaesthesia because the duration of treatment is limited and discomfort is minimal. Patients older than 1 year can be treated either with topical anaesthetics (EMLA) or with nerve blocks. Patients treated with the Nd:YAG laser or those with extensive haemangiomas may require general anaesthesia.

Kasabach–Merritt phenomenon

Some haemangiomas cause life-threatening conditions. In such a condition, the haemangioma destroys the blood platelets, which can in turn result in a fatal bleeding disorder. Any large haemangioma should be a suspect for Kasabach–Merritt syndrome, and blood platelet levels should be checked if a child has an aggressive, large haemangioma prior to 6 months of age.

Life threatening: never use laser treatment, systemic steroids or vincristine.

Vascular malformations, port-wine stains (PWS)

Vascular malformations in general increase in size throughout life because of the continual intraluminal hydrostatic pressure. During adolescence some vascular malformations rapidly expand while others do not. They are subcategorized as capillary, venous, arterial, lymphatic or a combination of these. Vascular malformations do not involute.

PWS are present at birth. They are not neoplasms but instead exhibit normal endothelial turnover and are errors of vascular morphogenesis which manifest as various vascular channel abnormalities. They are congenital vascular malformations composed of a superficial collection of ectatic vessels that grow commensurably with the child. They may occur anywhere on the body. The vessels are located in the papillary and superficial reticular dermis, with a mean vessel depth of 0.46 mm. Initially, a PWS may appear as a pale, erythematous macule or patch that darkens in colour with age. The surface may become raised and nodular, especially as the individual ages. There may also be soft-tissue hypertrophy within the affected area, particularly in the lip region. The growth of the lesion is commensurate with the child's growth and it does not resolve spontaneously.

When to start with laser treatment?

Any PWS should be treated as they turn darker and thicker with age.

- There is a marked reduction in PWS in children whose treatments begin at less than 1 year, in order to prevent progression and thus increase the likelihood of complete removal.
- Younger children may have smaller and more superficial vascular malformations that are more amenable to treatment.
- Some authors have reported that children between 3 and 8 years of age required more treatments for clearance of the lesion than either younger or older children; residual ectatic blood vessels in these children grow rapidly between laser treatment in response to intrinsic growth factors.

- The morbidity is associated with the malformation in patients of all ages and in the patients' families.

Choice of the adequate system
First choice: FPDL, IPLS, Nd:YAG, KTP (large spot).

Grade I: earliest, smallest vessels, 50–80 μm. Light and dark pink macules.
FPDL, KTP, IPLS.

Grade II: clearly indistinguishable, more advanced, 80–120 μm with individual vessels clearly visible to the bare eye.
FPDL (long pulse), KTP, IPLS.

Grade III: reddish patches with vessels even more ecstatic, 120–150 μm.
FPDL (long pulse), KTP (large spot), IPLS.

Grade IV: thick, purple, palpable, possibly nodular. Advanced dilated vessels $>$ 150 μm.
IPLS, alexandrite, Nd:YAG (avoid the orbital area), diode.

Treatments are repeated at an interval of about 8 weeks.

Some individuals appear to be able to tolerate large treatments without distress. Topical anaesthetic agents can assist (EMLA), but it is not indicated for children under 6 months old (excessive absorption on highly vascular surfaces and formation of methaemoglobin causing cerebral hypoxaemia). Infiltrational and nerve block anaesthesia can be used. The majority of children will require general anaesthesia.

Efficiency of laser treatment
The efficiency of laser treatment depends on the following.
The patient's age
- Since the PWS become thicker and darker as the child ages, it is best to start treatment as early as possible. The earlier the treatment is started, the easier and better they clear.

Lesion colour
- Pink PWS, especially in children, are more difficult to lighten than mature red PWS.
- Deep purple and nodular PWS respond least well to laser treatment; longer wavelengths (755 nm, 800–900 nm and 1064 nm) are more suitable.

Depth and size of the vascular components
- Malformations may have a deep vascular component that cannot be reached with a FPDL, but can be reached with Nd:YAG laser or IPLS.
- Smaller PWS (less than 20 cm^2) clear better than larger ones, irrespective of age.

Location of the PWS
- Central forehead lesions give the best response and are, in order of effectiveness, followed by periorbital, peripheral facial and neck lesions.
- Centrofacial lesions and those in the V2 distribution are less responsive to laser therapy than are PWS located elsewhere on the face.
- PWS on the distal extremities are more difficult to clear than lesions on the proximal extremities.
- PWS on the head and neck respond more favourably to treatment than lesions elsewhere on the body.

There is decreasing effectiveness in the response of PWS to successive laser treatments, but there is still slow improvement with continued treatment.

Sturge–Weber's syndrome (SWS)

The location of PWS may suggest that the child is at risk for an underlying syndrome. In 10–15% of patients with PWS occurring in the ophthalmic (forehead and upper eyelid) region, there may be a risk for developing SWS, a sporadic neurologic disorder associated with ocular and leptomeningeal abnormalities. All children presenting with a PWS in this distribution should be given ocular and neurological evaluation.

Laser treatment
Be careful: there is faster scarring due to greater absorption.

Klippel–Trenaunay syndrome (KTS)

Patients with PWS occurring on the limbs should be evaluated for underlying KTS, which presents as a progressive overgrowth of the affected extremity.

Blue Rubber Bleb Nevus syndrome (BRBNS)

This is a rare disorder characterized by multiple cutaneous venous malformations in the skin and gastrointestinal tract associated with intestinal haemorrhage and iron deficiency anaemia. Other organs may also be involved. BRBNS has a potential for serious or fatal bleeding. The causes of this syndrome are unknown. Around 200 case reports were published by the year 2003. It is important to treat it early when the lesions are small because when they grow bigger they need to be excised, which could prove to be quite difficult due to the locations and the multitude.

Choice of adequate system
First choice: Nd:YAG, IPLS, CO_2, diode.

No general anaesthesia is required (EMLA cream, contact cooling and double dose paracetamol).

Morbus–Osler – hereditary haemorrhagic telangiectasia

Choice of the adequate system
First choice: Nd:YAG, diode.

Treat frequently, every 3–4 weeks in the beginning. Diode laser treatment may leave a small depression as large as the telangiectatic papule after the treatment.

Spider angioma

These occur in up to 15% of completely normal individuals, and more frequently in children. They occur in large numbers during pregnancy. They are also characteristically found in liver disease, of which they may be a presenting sign. The main vessel of the spider is an arteriole. The blood flows from this to the periphery, and then passes into a capillary network.

Choice of the adequate system
First choice: KTP, FPDL, IPLS, Nd:YAG.
Second choice: argon, copper vapour.

Poikiloderma of Civatte (erythosis interfollicularis colli)

Poikiloderma of Civatte is a variant of telangiectasia associated with more or less symmetrical atrophy and pigmentary irregularity of the upper chest, lateral neck, and occasionally the lateral cheeks, but spares the area shaded by the chin. Induced by sun exposure, poikiloderma is unresponsive to most standard forms of therapy.

Choice of the adequate system
First choice: FPDL, IPLS.
Second choice: KTP (caution: it can cause scarring if inadequate parameters are used).

It is important to reduce the fluence when treating scar-prone areas such as the neck and upper chest and to use larger spot sizes, such as 10 mm. Be cautious with the overlying hyperpigmentation, which may be present at the same time (erythromelanosis interfollicularis colli).

Granuloma telangiectaticum (pyogenic granuloma)

These granulomas are benign vascular tumours that often ulcerate and bleed with trauma and are most commonly seen in children. They may occur after insect bites or minor trauma.

Choice of the adequate system
First choice: Nd:YAG, IPLS; multiple treatments are needed.
Second choice: CO_2, argon, FPDL.

Low fluences should be used because of the high incidence of post-treatment hypopigmentation and possible scarring.

Venous lakes

These are a form of senile angioma occurring on the face, lips and ears of elderly patients. Histologically, they consist of greatly dilated, thin-walled venules without the proliferation of vascular tissue of the true angioma. There is degeneration of the supporting convective tissue.

Choice of the adequate system
First choice: KTP, Nd:YAG, FPDL, IPLS.

Cherry angioma

Cherry angiomas are produced by spherical and tubular dilatations of capillary loops in dermal papillae with tortuous cross-connections between individual loops. These are particularly common on the trunk of middle-aged or elderly individuals. They disappear in extreme old age.

Choice of the adequate system
First choice: KTP, Nd:YAG, IPLS, FPDL.

Leg veins and telangiectasias

In the past, the use of lasers and light sources in treating lower extremity blood vessels has not been as successful as laser treatment of facial telangiectasia. Among various reasons for this partial success in the past are increased hydrostatic pressure on the lower extremities, the anatomy of lower extremity blood vessels and occasionally association with underlying venous disease.

The variation in size, blood flow, depth and type of vessel make this procedure more difficult to manage with a laser. In comparison with facial telangiectasia, leg veins have thick surrounding adventitial tissue and increased basal lamina.

There exist clinical observations and theoretical considerations which favour longer wavelengths and longer pulses for the treatment of leg veins. The longer the wavelengths (e.g. the 1064 nm Nd-YAG laser), the better the advantage of deeper penetration, the better the absorption in deoxyhaemoglobin and the greater the sparing of the epidermis. An additional benefit of the longer wavelength laser is a decreased melanin coefficient absorption.

By selectively cooling the epidermis during laser treatment while maintaining peak temperatures of the dermal blood vessels, the practitioner minimizes the risk of damage to the skin. To thermocoagulate leg veins of deeper location and of greater diameter, the laser systems should be able to deliver very high energy pulses through large spot sizes to enhance scattering into dermis. Pulse duration has been clearly demonstrated to be in the millisecond domain for intradermal vessel treatment. The longer pulse duration is closer to the thermal relaxation time of larger vessels (1–50 ms), thus being able to

target larger-diameter vessels (0.1–2 mm), including leg telangiectasia.

Indications

Lasers should be considered prior to sclerotherapy in patients:

- with needle phobia
- who do not tolerate sclerotherapy
- who fail to respond to sclerotherapy
- who have developed untoward side effects from sclerotherapy
- who are prone to telangiectatic matting.

Others include:

- fair-skinned individuals who either have vessels of less than 2 mm in diameter or require treatment of foot and ankle vessels difficult to treat with sclerotherapy
- patients who are unwilling or unable to tolerate compression hosery or bandaging required after sclerotherapy.

Lasers and IPLS enable treatment of the following:

- spider veins: 0.2–2 mm red and blue vascular ectasias, often associated with larger reticular veins
- reticular veins: 'non-bulging' subcutaneous veins ranging up to 5 mm in diameter
- telangiectasias: 0.2–1 mm, reside about 300 μm below the skin surface, from dark blue to bright red
  - bright red: smaller (0.2–0.5 mm)
  - blue: deeper vessels, regardless of size and degree of oxygenation.

Choice of the adequate system

Over the last few years, Nd:YAG laser systems became the lasers of choice for leg vein treatment. Additionally, isolated, relatively small diameter ($<$ 1 mm) leg telangiectasias:

- KTP, FPDL (long pulse), Nd:YAG, IPLS.

Larger-diameter, moderately deep leg vessels:

- Nd:YAG, alexandrite, diode, IPLS.

Sometimes, simultaneous treatment with lasers of longer wavelengths and pulse durations for larger veins in combination with lasers of shorter wavelengths and pulse durations for the smaller veins may provide comparable outcomes to treating patches of heterogenous vessels by sclerotherapy.

Treatment endpoints and initial signs of adverse effects

Using different vascular lasers we are able to induce selective vessel damage and perivascular changes with relative sparing of the epidermis and surrounding dermal tissue. The ideal immediate response to treatment with vascular laser is coagulation of the intradermal vessel with no other apparent effect. This effect can be observed in the form of bluish or greyish discolouration visible on the skin surface. In leg veins, blanching or disappearing of the vessel may also occur.

Side effects

Complications from laser treatment are reduced by operator education and experience.

Pain

The snapping and burning sensation of each laser pulse can produce a minimal to moderate amount of discomfort. An anaesthetic cream or injection can be used to block the pain. However, pain is an important marker of possible side effects occurring.

Purpura, bruising

Immediately after the laser treatment the area will in some cases appear grey or blue-black in colour. The discolouration will fade over the next 7–10 days.

Bleeding, haematoma, disruption

Can be caused by inadequate treatment parameters (e.g. pulse duration too short combined with fluences that are too high).

Swelling

Within a few minutes after the laser treatment an erythema and oedema will occur over the treatment area. Areas most likely to swell are under the eyes and the neck. The swelling subsides within 3–5 days if ice is regularly applied. Parallel and post-cooling will diminish the amount of oedema.

Discolouration, blisters or scabs

- Develop rarely (mostly caused by overtreatment).
- Grey or pale white discolouration of the epidermis is a sign of early dermal damage indicating inappropriately high fluences. This sign will only last a few seconds.
- Blister formation, epidermal disruption and epidermis necrosis (and dermis necrosis in severe cases) will follow.
- Intense cooling, reduction of the fluence and prolongation of the pulse duration are consequent reactions.
- Can take 1–2 weeks to resolve.

These findings can be immediate or delayed; it is important to carefully observe the treated test spot for at least 5 minutes before proceeding with the full treatment.

Infection

Increasing (instead of decreasing) swelling, redness, crusting, pain and fever can be an indication for an infection. Topical antiseptics or oral antibiotics should be used.

Reactivation of herpes simplex on the face (when the face is treated) or genitals (when legs are treated)

Preventive oral virostatic therapy (acyclovir, valcyclovir, famcyclovir) is recommended when

the patient has frequent herpetic recidives (more than six per year), starting the day before laser treatment.

Skin darkening (hyperpigmentation)

- This reaction is more common in patients with darker skin types (Fitzpatrick III–V). The darkening worsens if the laser-treated area is exposed to the sun.
- Eventually fades within 2–6 months.
- Topical bleaching cream, such as hydroquinone, can be used either as a pretreatment (2 weeks prior to laser or IPLS) or to speed up the blanching.

Skin lightening (hypopigmentation)

- Mostly caused by overtreatment.
- Pale areas usually darken or repigment within 3–6 months.
- Could be persistent, most frequently on the neck, legs and chest.

Skin texture changes

- Mostly caused by overtreatment.
- Occur when either excessive fluences or overlapping laser spots are used.

Scarring

- Mostly caused by overtreatment.
- Occur when either excessive fluences or overlapping laser spots are used.
- Can occur on disruption of the skin surface.
- Following all advised postoperative instructions can reduce this possibility.

Lesion persistence, non-responders

- Some vascular lesions may not go away completely despite the best effort made by the doctor. This may also be the case in lesions with high blood flow.

The likelihood of these adverse events in any individual depends on vessel diameter, vessel colour, location, intraoperative technique and pre- and postoperative care.

Post-laser treatment care

After alexandrite, diode, Nd:YAG lasers or IPLS, the skin appears minimally erythematous with oedema. After PDL the skin may appear purpuric with surrounding tissue hyperaemia.

- To prevent or reduce swelling, post-cooling with ice packs (or cold air) is advised on larger areas such as the cheeks or neck after laser treatment until any pain or redness has disappeared. The ice or frozen cold pack should be wrapped in a soft cloth and applied for 10–15 minutes each hour for 4 hours or as long as the burning sensation is noticed.
- If the treatment has been performed close to or around the eye there will be a risk of periocular oedema. The oedema under the eyes may develop 1–2 days after laser therapy of the cheeks. Patients should be instructed to sleep with an extra pillow to encourage gravitational removal of leaked oedema fluid.
- Patients should be instructed to avoid sun exposure (unless sun protection is used, SPF 50+) to prevent post-inflammatory hyperpigmentation.
- It is important not to pick or scratch treated areas.
- A topical antiseptic ointment could be applied to the irradiated areas to avoid secondary infection during the healing period (7–10 days).
- A mild, non-irritating soap can be used twice daily on the treated areas.
- Makeup can be used immediately after treatment except if blistering occurs.
- Showers are allowed, but prolonged bathing or sauna is not advised.
- The treated area is extremely delicate and must be handled with care during the initial healing phase (7–10 days).
- Patients should avoid swimming and contact sports while skin is healing.
- In case of blistering with open wounds, hydrocolloid dressings should be applied to avoid crust formation. The operator may consider use of topical antibiotics.

It may take a few weeks after the bruising or scabs have disappeared to notice fading of the primary vascular lesions. During the next weeks the absorption of coagulated treated vessels will occur by the surrounding tissue. The response to treatment should not be evaluated for several weeks until the healing process is complete. Leg vein results may not be visible until 2–3 months after treatment.

Physician qualifications

Laser technology has become so advanced that specific cutaneous targets can be eliminated without adverse sequelae to the normal overlying and surrounding skin. Despite the specificity of lasers used today, complications may still appear. Although some of the complications are laser-related, many are still caused by an operator error, either in consciousness or postoperative mismanagement.

When proper laser parameters and postoperative care are applied in adequately chosen patients, the risk of complications remains low. Treatments performed by a physician and maximal use of time and resources, help to achieve a high safety standard.

The physician treating vascular lesions with lasers or IPLS should have completed residency training in an appropriate specialty area such as dermatology and he/she should have general knowledge of basic laser physics, laser-tissue interaction and laser safety. Before starting treatments, the physician should attend corresponding laser training courses including hands-on experience or work under the

supervision of an appropriately trained laser expert (Dover 1999). The physician has to have been trained for at least 1 year and should be given enough insight into adverse effects and how to avoid them.

Standardized informed consent documentation should be made available for every single medical/surgical act.

Continuous medical education (CME) as well as active membership in a medical society specializing in laser applications in medicine (e.g. ESLD, ASLMS, national laser societies) are recommended.

Safety precautions and adverse effects

Since all vascular lasers and IPLS are designed for deep penetration and strong absorption in haemoglobin, they have a high potential for eye injury (thermal destruction of the retina and iris). Treatment in the area near the eye is not recommended unless the eyes are covered with metal lenses, and adequate eye protection goggles are obligatory for all people within the operating room (including the patient).

Methods to reduce the incidence of adverse effects include lightening of the skin and sun avoidance prior to laser treatment, cooling of the skin during treatment, and sun avoidance and protection after treatment. Cooling devices, either spray, cold air or contact cooling, are helpful in protecting the epidermis but may not be sufficient to protect tanned or darker skinned patients. Patients with a tan should delay treatment until the tan fades.

Individuals with a history of hypertrophic scarring or keloids should be treated with caution (test spot).

Pregnancy

Although vascular laser or IPLS physically have no impact on pregnancy, most laser manufacturers exclude the use of these lasers in pregnant women in their application notes. The treatment does cause pain and can be distressing.

Laser treatment should be discontinued in the first two trimesters of pregnancy. In the third trimester laser treatment of vascular lesions can be undertaken within the responsibility of the physician, as the foetus is completely formed and no risk of foetal malformation is known. But, in most situations, laser treatment may be postponed until after delivery.

Disclaimer

Adherence to these guidelines will not ensure successful and safe treatment in each and every situation. The ultimate judgement regarding the suitability of any specific procedure must be made by the physician in light of all the circumstances presented by the individual patient.

Supporting evidence

These guidelines of care for vascular lasers are based on the experience of the members of the European Society for Laser Dermatology (ESLD) and a review of literature articles (Dierickx 1999, Hobbs 2000, Liew 2002). The articles supporting the statements mentioned in these guidelines are given in the reference list.

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