GUIDELINES

Guidelines of care for vascular lasers and intense pulse light sources from the European Society for Laser Dermatology

M. Adamič,[1,*] M.D. Pavlović,[1,2] A. Troilius Rubin,[3] M. Palmetun-Ekbäck,[4] P. Boixeda[5]

[1]Dermatology Center Parmova, Ljubljana, Slovenia
[2]Faculty of Medicine, University of Maribor, Maribor, Slovenia
[3]Department of Dermatology, Centre for Laser and Vascular Anomalies, Skåne University Hospital, Malmö, Sweden
[4]Department of Dermatology, University Hospital Örebro, Örebro, Sweden
[5]Laser Service, Department of Dermatology, Ramón y Cajal Hospital, University of Alcalá, Madrid, Spain
*Correspondence: M. Adamič. E-mail: metka.adamic@dcp.si

Abstract

Aim 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 been developed for the treatment of congenital and acquired vascular lesions which incorporate these concepts into their design. Although laser and light sources are very popular due to their non-invasive nature, caution should be considered by practitioners and patients to avoid permanent side-effects. The aim of these guidelines is to give evidence-based recommendations for the use of lasers and IPLS in the treatment of vascular lesions.

Methods These guidelines were produced by a Consensus Panel made up of experts in the field of vascular laser surgery under the auspices of the European Society of Laser Dermatology. Recommendations on the use of vascular lasers and IPLS were made based on the quality of evidence for efficacy, safety, tolerability, cosmetic outcome, patient satisfaction/preference and, where appropriate, on the experts' opinion. The recommendations of these guidelines are graded according to the American College of Chest Physicians Task Force recommendations on Grading Strength of Recommendations and Quality of Evidence in Clinical Guidelines.

Results Lasers and IPLS are very useful and sometimes the only available method to treat various vascular lesions. It is of a paramount importance that the type of laser or IPLS and their specific parameters are adapted to the indication but also that the treating physician is familiar with the device to be used. The crucial issue in treating vascular lesions is to recognize the immediate end-point after laser treatment. This is the single most important factor to ensure both the efficacy of the treatment and avoidance of serious side-effects.

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Conflicts of interest

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Since the publication of previous European Society of Laser Dermatology (ESLD) guidelines in 2007, there have been significant advances in the field of laser treatment of common vascular lesions.[1] These guidelines have been updated by the Consensus Panel under the auspices of the ESLD. Methodology, search strategy and recommendation formulation are described in Appendix II.

A brief overview of vascular lasers

Standard vascular lasers include pulsed dye lasers (585 and 595 nm), and KTP-lasers (532 nm), followed by longer wavelength lasers such as alexandrite lasers (755 nm), diode lasers (800–900 nm) and millisecond Nd:YAG lasers (1064 nm). New developments include a non-uniform pulse sequence or a dual-wavelength modality (combined dual wavelength 595 and 1064 nm–pulsed dye and Nd:YAG laser) and microsecond Nd:YAG lasers.[2–6] Even fractional photothermolysis has begun to be used for selected vascular lesions.[7]

Lasers' and intense pulse light sources (IPLS) effects are based on the principle of selective photothermolysis. In general, they deliver a precisely graded aliquot of energy to a defined area of the skin in a reproducible, standardized manner that almost always involves addition or evacuation of heat. The greatest

The first two authors have contributed equally to the manuscript.

difference between lasers and IPLS is that the latter simultaneously deliver multiple light wavelengths (500–1200 nm) at different intensities. The greatest advantages of laser light are the intensity and its monochromatic character which allow for the highest precision not reproducible with non-laser sources. The high power of the light is not attainable outside of laser sources. The ability to focus the laser beam is an important contributor to the peak power density of the laser. With the exception of ablative resurfacing devices, virtually all cutaneous energy devices are 'selective' in that they preferentially target one or more constituents of the epidermis, dermis, or subcutis, while sparing the rest.[2]

Upon the laser impact on the vascular target histologically selective vascular injury with thrombosis, vessel wall necrosis and perivascular collagen damage with relatively little associated thermal effects on the epidermis and the surrounding dermis can be observed.[8]

Regardless of vascular lesions being of arterial, venous or capillary origin, the principle of targeting haemoglobin with appropriate wavelengths of light remains the same. As described by Parrish and Anderson, the theory of selective photothermolysis states that a specific chromophore (haemoglobin in case of vascular lesions) can be selectively targeted and damaged with minimal damage to surrounding tissues.[9]

Wavelength

Oxyhaemoglobin contained in red blood cells within blood vessels has a maximum peak of absorption 542 nm (α peak) and 577 nm (β 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 deoxyhaemoglobin. This situation moves the absorption curve to the right, from 800 to 1200 nm. Theoretically, preferential photocoagulation of venous blood is possible at wavelengths with a high Hb/HbO(2) absorption coefficient ratio. Malformations of post-capillary venules such as port wine stains (PWS) could potentially be treated more selectively with ~630–780 nm sources, whereas Nd:YAG laser (1064 nm) tend to affect arterial more than venous blood.[10] Because of the discrete peaks of haemoglobin absorption, the laser physician can optimize heating of the vessel with excellent protection of the surrounding structures.

The longer the wavelength, the deeper is its penetration into the skin.[11] For example, Nd:YAG lasers (1064 nm) can penetrate millimetres below the epidermis. On the other hand, longer wavelengths tend to bypass epidermal melanin making it safer for darker skin types. However, much higher radiant exposures are required to obtain coagulating effect at the depth of the laser beam penetration. Infrared wavelengths tend to be more effective in treating deeper blue vessels while shorter wavelengths are more effective for superficial red telangiectasia. Although it is often stated that some wavelengths, like 532 nm, penetrate only very superficially (hardly through the epidermis) recent experimental evidence contradicts this and shows that multiple scatter photons of the 532-nm laser may reach deep dermis and even subcutaneous tissue.[12] As its absorption is high also in melanin it may well affect its depth of penetration.

Pulse duration

A heated target cools delivering heat over the time by diffusion: the thermal relaxation time (TRT) is the time interval required for the target to deliver 50% of heat to surrounding tissues. To minimize the thermal damage to surrounding tissues and to avoid scarring, the laser pulse duration should be shorter or equal than the TRT of the target.[9] Thermal energy produced within the red blood cells diffuses through the blood and damages the walls of the vessels, producing thrombosis. Accordingly, different laser pulse lengths must be considered taking into account the blood flow and the different diameters of the vessels.[2,11] 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.[13]

Pulse frequency

Generally, pulse stacking or high pulse frequencies should be avoided to reduce the thermal damage of surrounding tissue. However, in certain controlled situations and in hands of an experienced surgeon it may be tried. For LPDL previous studies have suggested that stacked pulses of a lower fluence may have a similar effect on the target as a single pulse at a higher fluence.[14–16] Moreover, treating superficial facial telangiectasia with a pulse stacking technique may improve clinical results without significantly increasing adverse effects.[14–18] Similar findings were corroborated in an animal model for a 532-nm laser: after a single laser pulse, the radiant exposure required to induce blood vessel photocoagulation was 7 J/cm^2 as compared to only 2 J/cm^2 per pulse for multiple laser pulses; for the latter, two pulses at a repetition rate of 5 Hz and a radiant exposure of 3 J/cm^2 can induce photocoagulation of more than 80% of irradiated blood vessel.[19]

Spot size

Our target in vascular lesions is a dynamic chromophore; as blood flows into the vessels, new, untargeted blood takes away the heat induced by light absorption, protecting the vessel by thermal-induced damage. Large spot sizes are recommended to increase the heated volume of the blood. Furthermore, these tend to have deeper dermal penetration at equal radiant exposure values without increasing epidermal damage.[11]

Skin cooling

As we must deliver very high energy pulses to thermocoagulate vessels located deeply in the skin, the epidermis should be

protected to minimize damage to melanocytes as well as keratinocytes. This is mainly achieved by cooling the epidermis.

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 onto across the skin surface. These devices promote rapid epidermal cooling to lower temperatures without affecting the target.[11]

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.

Caution is mandatory, especially but not exclusively in patients with darker skin types, as post-inflammatory hyperpigmentation due to air or cryogen spray cooling, though very rare, is possible (M. Adamič & M. D. Pavlović, unpublished observation).[20]

Principal laser sources employed in the field of vascular dermatosurgery are given in Table 1.

Clinical indications

Appropriate treatment begins with a correct diagnosis. A significant number of patients with 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. The most recent classification of vascular anomalies was adopted at the 20th ISSVA (International Society of the Study of Vascular Anomalies) workshop held in April 2014 in Melbourne.[21] 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. An abbreviated classification of vascular anomalies relevant to dermatologists is given in Table 2.[21,22] Only conditions more or less amenable to transcutaneous vascular laser treatment are selected.

Many acquired benign vascular tumours, growths and alterations, isolated or being a part of clinical presentation of other diseases are also good indications for transcutaneous vascular lasers (Table 3).

Recommendation 1: *A large number of congenital and acquired vascular lesions are appropriate indications for laser and/or IPLS treatment (GRADE 1A). However, arterial malformations should not be treated with vascular lasers or IPLS (GRADE 1C).*[23]

Qualification of providers of laser and/or IPL treatment

Recommendation 2: *We recommend that the health care provider should possess competence required to diagnose the patient's cutaneous vascular disorder, establish and explain his/her treatment needs, recognize and manage risks and deliver safe and appropriate laser/IPL treatment to remove or reduce vascular lesions in accordance with current standards of care and patient's expectations (GRADE 1C).*[24–33]

Lasers used to treat vascular lesions are high energy devices and as such may induce serious side-effects.[30,32] A multitude of vascular lesions, isolated or as part of many complex diseases, needs proper diagnosis and treatment. Therefore, specific dermatologic training and skills under an experienced and qualified practitioner is necessary for proper understanding and use of the technology. The practitioners should be involved in continuing medical education on newer devices and techniques. We support the regulation adopted in Denmark which states that the laser treatment may be performed only by physicians.[31] However, local legislation may allow a qualified physician to delegate some procedures to a specialized nurse/technician but under full responsibility of the supervising physician.

Laser is an art as well as medical science. It is operator dependent and therefore it is extremely important that the operator is familiar with his or her machine's performance and limitations including laser physics as well as knowledge regarding the dermatologic lesion and histopathology.

Pre-treatment and post-treatment evaluation, documentation and skin care

Recommendation 3: *We recommend a clinical and digital photographic evaluation and documentation to be completed in conjunction with the laser/IPL procedures (GRADE 1C).*[30,33,34] *We recommend against avoidance of laser treatment in patients who are on or have recently stopped using oral isotretinoin (GRADE 2C).*[35–37]

Medical history and clinical examination

A complete medical history should be taken and recorded with a special attention paid to sun and sun-bed exposure over preceding weeks as well as previous skin-directed procedures and skin diseases. Reasons for seeking the treatment should be carefully documented including patient's expectation from the treatment. Infants with haemangiomas and patients with complex vascular malformations usually require a multidisciplinary approach, and laser and/or IPL treatment is only a part of the treatment plan. All changes relevant to the vascular disorder are recorded.

Several factors require special consideration before discussing the patient's treatment options.

The following issues should be addressed:

1 Does the patient have a lesion amenable to vascular – specific laser treatment?

Table 1 Main laser and light sources used for vascular surgery[1,2,9,11,28]

Laser type	Absorption peaks and penetration depth	Common parameters	Major indications	Disadvantages
KTP (532 nm; green)	Oxyhaemoglobin > melanin; cc. 1 mm	*Duration*: 2–100 ms; *radiant exposure*: 3–45 J/cm^2; *spot sizes*: 1–6 mm; *external cooling*: with or without; possibility of multiple passes, stacked pulses	Facial telangiectasias and diffuse erythema, rosacea, cherry and spider angiomata, poikiloderma Civatte, thin leg telangiectasias (<1 mm), PWS	Generally for more superficial vessels; epidermal damage in darker-skinned persons (dyschromia and texturao changes); scarring is rarely encountered
PDL (585–595 nm; yellow)	Oxyhaemoglobin > melanin; 1–1.5 mm	*Duration*: 0.45–50 ms; *radiant exposure*: 5–24 J/cm^2; *spot size*: 1–10 mm; *external cooling*: yes; possibility of multiple passes	PWS, infantile haemangioma, facial telangiectasias, rosacea, cherry and spider angiomata, poikiloderma Civatte, thin leg telangiectasias	As with KTP, mainly for more superficial vessels; pain, purpura (especially shorter pulses and higher radiant densities)
Alexandrite laser (755 nm; infrared)	Melanin > deoxyhaemoglobin > oxyhaemoglobin; 2.5–3 mm	*Duration*: 3–80 ms; *radiant exposure*: up to 90 J/cm^2; *spot size*: up to 10 mm; *external cooling*: yes	PWS, wider leg telangiectasias	High risk for hyperpigmentation and scarring especially in darker skinned individuals
Diode lasers (800–983 nm; infrared)	Oxyhaemoglobin ≥ melanin; above 900 nm low melanin absorption; 3–5 mm	*Duration*: 10–150 ms; *radiant exposure*: up to 500 J/cm^2; *spot size*: up to 15 mm; *external cooling*: with or without, depending on the device	Facial telangiectasia, PWS, leg telangiectasia, venous lakes	More suitable for larger vessels; still scarce clinical data on efficacy
Nd:YAG laser (1064 nm; infrared)	Ratio of melanin to blood absorption is similar to PDL but due to generally low absorption, higher energies are needed; 5–6 mm	*Duration*: 3–300 ms; *radiant exposure*: up to 600 J/cm^2; *spot size*: up to 18 mm; *external cooling*: yes; various pulse forms (on-off), repetition rates, train of pulses; also microsecond devices with pulses of 0.3 ms	PWS, larger leg telangiectasia, infantile haemangiomas, venous malformations, pyogenic granuloma	Painful treatments, risks for thermal damage and scarring (solid knowledge of a specific device is required)
IPLS (500–1200 nm)	For vascular lesions cutoff filters at 550 and 570 nm are used (deliver mainly yellow and red light)	Various pulse durations and delays, repetition frequencies; large rectangular spots (up to 1 × 4 cm)	Facial telangiectasia and diffuse erythema; rosacea, PWS; fine leg telangiectasia; poikiloderma Civatte	Pain, thermal damage, dyspigmentation, reliable treatment parameters hard to establish due to a plethora of various devices

IPLS, intense pulsed light source; KTP, potassium titanyl phosphate; Nd:YAG, neodymium yttrium aluminium garnet; PDL, pulsed dye laser; PWS, port wine stains.

Table 2 Vascular anomalies which may be treated by transcutaneous vascular lasers. Adapted from ref. [21] and [22]

Benign vascular tumors
Infantile hemagioma
Pattern: focal, multifocal, segmental, indeterminate
Types: superficial, deep, mixed, reticular/abortive/minimal growth, others
Within complex anomalies: PHACE and LUMBAR syndromes
Congenital hemangioma
Rapidly involuting (RICH)
Non-involuting (NICH)
Partially involuting (PICH)
Pyogenic granuloma (lobular capillary hemangioma)
Angiokeratoma
Vascular malformations
Capillary malformations (CM)
Cutaneous and/or mucosal CM (PWS)
PWS associated with other anomalies (e.g. Klippel-Trennaunay. . .)
Telangiectasia
Hereditary hemorrhagic telangiectasia (verious subtypes)
Nevus simplex (salmon patch, stork bite. . .)
Venous malformations (VM)
Common venous malformation
Familial VM cutaneo-mucosal
Blue rubber bleb nevus syndrome
Glomuvenous malformation
Combined malformations
Various combinations: CM, VM, LM, AVM

Table 3 Acquired vascular growths which may be good indications for vascular lasers and IPLS

Facial telangiectasia
Rosacea
Naevus araneus (spider angioma)
Venous angiomas
Venous lake
Senile angioma
Poikiloderma of Civatte
Granuloma teleangiectaticum (pyogenic granuloma)
Angiofibroma
Cutaneous lesions of Kaposi sarcoma
Leg telangiectasias
Red or hypertrophic scars
Viral warts
Early atrophic striae
Inflammatory linear verrucous epidermal nevus
Acne
Psoriasis

2 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. Similar can happen after the treatment of haemangiomas with irradiation or intralesional application of corticosteroids or sclerosants.

3 Has the patient suffered from any complications or side-effects as a result of the lesion?

4 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;[30,38] it can shield the underlying vascular lesion and reduce the amount of effective light reaching the lesion. There is a higher risk of postoperative hyperpigmentation or hypopigmentation.[30,39]

5 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.[40] Patients with PWS or haemangiomas typically require multiple treatments within 2 years to achieve significant clinical clearing.[41] Patients with PWS located in certain locations (medial cheeks, upper lip, distal extremities) need even more additional treatments and may have incomplete clearing.[42–44] In addition, recurrences of PWS after successful laser treatment are not an extremely rare event.[45–47] Proper patient preparation and realistic expectations are paramount to the success of the treatment.[34] Appropriate digital photographic documentation should be performed periodically and used to assess the treatment efficacy and guide the treatment.

6 Recent clinical studies showed that invasive acne scar treatments and laser procedures in patients on oral isotretinoin bring no additional risks and that the drug does not delay wound healing.[35–37]

Disease-related measurements and reporting standards[30,34]

Recommendation 4: *We recommend the use of clinical (depending on the disorder treated) and photographic outcome measurements to evaluate the primary outcome of laser/IPL procedures (GRADE 1A).*

Pre-treatment evaluation should include appropriate disease-related measurement tools and assessment of patient's motivation, which will help assess the outcome of treatment and its impact on the patient.

Patient information and consent

Most vascular lesions require more than one laser treatment and 2–6 or even more weeks between treatments for optimal tissue healing. It is important that patients are fully aware of both ini-

tial healing time (in average 7–10 post-operative days) and overall time needed for the complete treatment protocol. Before treatment, patients should be questioned about a history of post-inflammatory hyperpigmentation and excessive scarring. Patients should be advised to avoid excessive sun exposure before, during and after laser treatments; sun exposure can contribute to post-inflammatory changes or limit the effectiveness of the treatment.

Recommendation 5: *We recommend detailed discussion about possible side-effects, complications and preventive measures and signing the consent form prior to the treatment (GRADE 1A).*

Pre-laser treatment care

Skin exposure to ultraviolet irradiation prior to and after laser treatment increases risks for side-effects, especially thermal burns and dyspigmentation.[48] To achieve optimal results the patient should be advised to get the palest skin colour possible and to protect the treated skin from sun exposure after laser treatment. A broad-spectrum sun screen with an SPF 50, started at least 4 weeks prior to the first treatment would help to get paler skin even during summer time.[49] 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. Moreover, anaesthesia is not advised in adult patients because pain is the best early warning system to prevent side-effects caused by heat destruction.

Post-treatment skin care depends on the type of laser used and condition treated but should always include adequate sun-protection measures (*see later*).

Recommendation 6: *We recommend strict sun-protection measures to be followed at least 4 weeks prior and after the treatment with vascular lasers. The type and duration of sun-protection should be determine by the treating physician (GRADE 1C).*[49]

Treatment principles

They could be summarize as follows:[1,50]

1 Smaller vessels – shorter pulses
2 Larger vessels – longer pulses
3 The deeper – the larger spot, the longer wavelength and the longer pulses combined with cooling to protect epidermis
4 Darker skin types – longer wavelengths, 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 hand piece to glide on the skin and to improve the temperature exchange with the skin surface. Alternatively, thin gel pads could be used and are helpful during KTP laser treatment cooling 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 flash lamps. The hand piece of the flashlamp-pumped pulsed dye laser, 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 and longer wavelengths 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.[35,36] In darker phototypes we recommend the combined use of chilled contact gel, ice, sapphire chilled tip, cryogen spray delivered by dynamic cooling device or external air cooling to preserve the epidermis and prevent pigmentary complications.

Areas prone to scarring such as the anterior chest or neck, areas where skin is fragile (periorbital region), require 10–20% reduction in radiant exposure. Epidermis on the legs tends to be more sensitive to injury. A reduction of radiant exposure is also recommended in case of underlying bones reflecting the laser beam.

Care should be taken to prevent from pulse overlapping by more than 10% 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 radiant exposure.

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 may vary from 2 to 6 weeks, depending on the type of lesion; longer intervals are advisable for darker skin types.

Treatment of different vascular lesions

Facial telangiectasia and diffuse facial erythema

Recommendation 7: *We recommend the use of lasers and IPLS for treatment of facial telangiectasia and diffuse facial erythema (GRADE 1A).*[2,51–56]

Facial telangiectasias are common cause of cosmetic concern. Among available treatment modalities (electrosurgery, lasers and light sources) the latter two are considered both safe and effective.

Classification:

1 simple or linear,
2 arborizing, spider or star,
3 punctiform,
4 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.

Recommendation 8: *As a first choice we recommend the use of LPDL (595 nm) and KTP (532 nm) lasers, and IPLs (GRADE 1A).*[50–58] *If failed, millisecond or microsecond Nd:YAG (1064 nm) or diode (940-nm or 980-nm) lasers may be used (GRADE 1B).*[5,53,56,59–64] *Long-pulse alexandrite (755 nm) and copper vapour lasers (510 and 578 nm) may also be employed but with maximal care (GRADE 2C).*[65,66]

The size and configuration of the telangiectasia will determine the optimal treatment laser. Numerous studies and large case series confirmed the safety and efficacy of LPDL (595 nm) and KTP (532 nm) lasers as well as IPLs for the removal of facial telangiectasia with at least 50–90% improvement after 1–3 treatments.[51–58,67,68] The data for the 940-nm and 980-nm lasers are scarce.[53,59,60] Only in carefully selected patients long-pulse (40 ms) alexandrite (755 nm) (light-skinned) and millisecond or microsecond Nd:YAG (1064 nm) lasers should be used. The latter two, however, bear a higher risk for side-effects.[52,56,61–64] In general, LPDL and KTP lasers are more effective in the treatment of smaller diameter telangiectasia and diffuse erythema, whereas longer wavelength devices might be more useful for wider, blue, deep seated telangiectasia. These devices, in general, have a higher potential for side-effects.

Pulse duration during the treatment with a KTP (532 nm) should be matched to the thermal relaxation time of respective facial telangiectasia to obtain optimal results.[13]

Recommendation 9: *Adequate cooling should be used to protect epidermis from thermal damage and in line with instructions given by manufacturers of specific devices (GRADE 1B).*

Epidermal cooling can reduce the epidermal surface temperature, thereby reducing treatment discomfort and protecting the epidermis from thermal injury. The epidermal cooling is particularly important with shorter wavelength (KTP and LPDL) lasers. It was shown that concurrent contact cooling with a transparent hydrogel provides adequate epidermal protection while does not cause energy loss.[69]

It is possible to obtain purpura-free removal of facial telangiectasia with LPDL either using multiple subpurpuric passes or newer devices that deliver macropulses (20 ms) composed of many pulselets.[70,71]

Rosacea

Patients with rosacea often complain of facial flushing and erythema.[72] Removal of superficial telangiectasia which do not contain a smooth muscle layer can be performed only with lasers and light sources.[73] The telangiectasia are frequently present and are unresponsive to classic topical or systemic therapy. The treatment of these vessels probably contributes to attenuation of inflammation and disease progression in rosacea.[72]

Recommendation 10: *Diffuse erythema and telangiectasia of rosacea can be effectively and safely reduced by the use of LPDL (595 nm) and KTP (532 nm) lasers, and IPLS (GRADE 1A).*[56,73–77] *Less evidence is available for millisecond and microsecond Nd:YAG (1064 nm) lasers (GRADE 1C).*[56,78]

Pre-treatment with topical niacin safely enhanced the effect of 585-nm PDL treatment of rosacea-associated erythema overcoming the relatively lower effect of subpurpuragenic PDL in dark-skinned Asians.[79] The 595-nm LPDL and IPL (a filter set at 560 nm) showed a similar efficacy and safety in patients with erythematotelangiectatic rosacea; they are first choice for the treatment of diffuse erythema.[75,80]

Blue rubber bleb nevus syndrome

Blue rubber bleb naevus syndrome (BRBNS) is a rare disorder characterized by multiple venous malformations in the skin and gastrointestinal tract associated with intestinal haemorrhage and iron deficiency anaemia.[81] It is important to *treat 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.

Electrodesiccation, excision, cryotherapy, sclerotherapy and laser have been suggested as potential treatment modalities for the cutaneous lesions.[82]

Recommendation 11: *Cutaneous lesions may be treated by millisecond Nd:YAG (1064 nm), diode or carbon-dioxide lasers, whereas gastrointestinal lesions may be removed endoscopically with argon plasma coagulator or Nd:YAG laser (GRADE 1C).*[83–87]

Cutaneous lesions of BRBNS can be successfully treated with laser under topical anaesthesia (EMLA cream) or contact cooling.[83]

Hereditary haemorrhagic telangiectasia (Ossler–Weber–Rendu disease)

Hereditary haemorrhagic telangiectasia is a rare genetically heterogeneous disease with autosomal dominant inheritance

characterized by vascular malformations in mucocutaneous tissues, internal organs and the central nervous system.[88]

Recommendation 12: *Both cutaneous and mucosal lesions may be treated by KTP (532 nm), millisecond Nd:YAG (1064 nm), diode (810 nm), LPDL (GRADE 1B), argon and carbon-dioxide lasers (GRADE 1C).*[40,89–94]

Treatment may leave a small depression as large as the telangiectatic papule after the treatment. Intranasal injections of bevacizumab may be combined with the diode laser treatment.[95] It was shown that the responsiveness of nasal telangiectasia to the Nd:YAG laser depends upon the type of the vessels.[96] The best response is obtained in isolated punctate telangiectasia or individual small arteriovenous malformation, and large solitary arteriovenous malformation, which may be associated with scattered telangiectasia.[96]

Spider angioma

It is characterized by a central feed arteriolar vessel with radiant fine red telangiectasia.[2]

Recommendation 13: *We recommend that spider angiomas be removed by millisecond Nd:YAG (1064 nm), KTP (532 nm) and LPDL lasers and IPLS (GRADE 1B).*[2,40,63,97]

Sometimes several treatment sessions are needed because of its high flow nature. Rarely, as a second choice, argon or copper vapour lasers may be used for treatment of spider angioma.

Poikiloderma of Civatte

Induced by sun exposure, poikiloderma is unresponsive to most standard forms of therapy.[98]

Recommendation 14: *We recommend that, apart from appropriate photoprotection and patch testing, lesions of poikiloderma of Civatte may be treated by IPLS, KTP (532 nm) and LPDL (595 nm) lasers (GRADE 2B).*[98–102]

Generally two to three treatment sessions are required for satisfactory response. It is important to reduce the radiant exposure by 20–30% when treating scar-prone areas such as the neck and upper chest, to avoid overlapping pulses and to use larger spot sizes, such as 10 mm.[101] Good results have been obtained with an ablative fractional laser for all aspects of skin lesions (dyschromia, pigmentation and textural changes).[103]

Granuloma telangiectaticum (pyogenic granuloma)

Pyogenic granulomas (PGs) are benign vascular tumours that often ulcerate and bleed with trauma and are most commonly seen in children.[104] PGs may be treated with surgical excision (necessary in case of any diagnostic doubt to avoid confusion with cutaneous tumours including melanoma), cryotherapy, electrocautery, intralesional sclerotherapy or corticosteroids, topical agents (silver nitrate, phenol and imiquimod) and/or lasers.[104,105]

Recommendation 15: *Small and superficial cutaneous pyogenic granulomas may be treated with LPDL (595 nm), carbon dioxide (10 600 nm), and millisecond Nd:YAG lasers (1064 nm) (GRADE 1C).*[105–108]

Despite the lack of appropriate published data, the authors also recommend the use of bipolar electrocautery with the forceps turned upside down. Usually only one treatment without bleeding is required. It is faster and less painful in comparison to lasers and bears the same risk of scarring.

Multiple (2–6) sequential PDL or Nd:YAG laser treatments are typically required for clearance, compared to a single CO_2 laser vaporization procedure, but the former are easier for children to undergo because they are practically painless.[105,106,108]

Venous lakes

Venous lakes are cutaneous vascular ectasias formed from dilated venules located in the upper dermis.

There have not been comparative therapeutic trials. Many case reports have been published describing the successful use of various modalities to treat venous lakes: surgical excision, cryosurgery, infrared coagulation, argon lasers, intense pulsed light, pulsed dye lasers, Nd:YAG laser, dual PDL-Nd:YAG laser, diode lasers, carbon dioxide lasers and sclerosing agents.[109,110]

Among them, the long-pulsed Nd:YAG laser is superior to achieve fast and safe results.[2] However, dual PDL-Nd:YAG and diode lasers have proved to be equally effective as well as the 755 nm alexandrite laser (P. Boixeda, personal communication).

Recommendation 16: *Venous lake may be safely and efficiently removed, as a first-line treatment, with millisecond Nd:YAG (1064 nm), dual PDL-Nd:YAG laser, alexandrite (755 nm) and diode (800, 808 and 980 nm) lasers (GRADE 1C), whereas KTP (532 nm) and LPDL (595 nm) are less useful for this indication (GRADE 2C).*[40,109–113]

Cherry angioma

Cherry angioma (or senile angioma) is the most common benign vascular tumour seen in the aged skin.

Recommendation 17: *Cherry angiomas may be safely and efficiently removed with KTP (532 nm), millisecond Nd:YAG (1064 nm), LPDL (595 nm) lasers and IPLS (GRADE 1C).*[40,114–116]

Though millisecond Nd:YAG laser may generally require only one treatment, patients prefer the KTP laser as a less painful and safer option with the exception of pigmented skin where Nd:YAG laser is a good alternative.[114]

Infantile haemangiomas

Laser treatment of infantile haemangiomas (IH) is still controversial and should only be done by experienced laser surgeons who have a vast knowledge in vascular anomalies as well. The management of patients with potentially problematic haemangiomas should involve a multidisciplinary approach.

An accurate diagnosis and a clear understanding of the differences between vascular malformations (PWS, birthmarks) and IH are important since the natural history and the treatment recommendations for these two conditions are very different.[21]

The majority of IH are of cosmetic concern and do not need any treatment. Some may cause serious problems – most complications occur during the proliferative phase.

Recommendation 18: *Treatment of IH should be considered in tumours which cause functional or structural abnormalities (e.g. airway obstruction, ophthalmologic disturbances), which ulcerate and bleed, are secondarily infected, or may result in disfigurement or scarring (GRADE 1A).*[117,118]

Large cervicofacial segmental haemangiomas can be associated with other malformations and should therefore be investigated with ultrasound (US) or magnetic resonance imaging (MRI).[117]

Recommendation 19: *We recommend against laser treatment of large cervicofacial segmental haemangiomas (GRADE 1C).*

Since 2008 oral β-blockers, mainly propranolol, have been successfully used in the treatment of the majority of IH. Early studies revealed that a combination of laser and propranolol may be more effective than propranolol alone if it is a superficial lesion.[119]

Recommendation 20: *We recommend the use of vascular lasers alone or in combination with other treatment modalities for IH when there is a contraindication for systemic propranolol, parents refuse systemic propranolol, there are unacceptable side-effects, haemangiomas are superficial, combination with topical propranolol is suitable, haemangioma is ulcerated or residual erythema and telangiectasias persist after involution (GRADE 1C).*[120]

Ulceration is the most common complication of IH and occurs in 15–25% of patients. It produces significant pain, bleeding and functional impairment.[118,120] Several reports have shown improvement in treating ulcerated haemangioma, although the exact mechanism of action is not understood.[121] 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 – 10-mm PDL spot size is preferred because is faster and safer compared to the 7-mm spot size.

Treatment will not minimize the deeper growth, but will affect only the superficial component of IH when treating with PDL. Frequent treatments, at 2–3 week intervals, 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 595-nm PDL has a depth of penetration of 1.2 mm and is therefore good only for superficial lesions. Thick haemangiomas can be resistant to treatment with PDL, IPL and KTP. Overtreatment may often results in dyspigmentation. Nd:YAG laser (1064 nm) is a viable option for resistant or difficult-to-treat lesions.[122] One of the vascular devices on the market has a first pulse with highly absorbable 595 nm laser followed millisecond later by the deeper penetrating 1064 nm laser. This combination is reported to be effective for the treatment of haemangiomas of all stages.[123] Extreme care needs to be taken when using the Nd:YAG laser due to its relatively low absorption by oxygenated haemoglobin, as it is able to generate collateral heat in the epidermis and dermis. This may cause burns and/or scarring. The same may happen with the long pulse alexandrite laser.[124]

In the incompletely regressed haemangiomas of older children, superficial ectatic blood vessels can be treated with various vascular lasers. 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), with nerve blocks or in general anaesthesia. Patients treated with the Nd:YAG laser or those with extensive haemangiomas may require general anaesthesia.

Ablative and non-ablative fractional lasers can be useful in ameliorating residual scarring.[125,126]

Recommendation 21: *We recommend early intervention when an IH is diagnosed as a haemangioma that will cause problems. First choices are LPDL (595 nm) or millisecond Nd:YAG(1064 nm) lasers with cooling (GRADE 1B).*[121–123] *As a second choice, alexandrite (755 nm) or KTP (532 nm; for superficial lesions) lasers may be used (GRADE 1C).*[124,127]

It should be stressed that a majority of haemangiomas, in particular the superficial varieties, require no treatment at all, and in these cases laser treatment offers no benefit in comparison to a wait-and-see approach.[128]

Recommendation 22: *We recommend treatment of ulcerated haemangioma with LPDL (595 nm) as it is able to induce rapid healing and pain relief (GRADE 1C).*[129–131]

Port-wine stain (capillary malformation)

The most common capillary malformation is port-wine stain (PWS). It affects roughly 0.3–0.5% newborns.[132] A hypertrophic

stage may begin in early 30' so that it is hypertrophic in most patients older than 50 years.[133] The mainstay of PWS treatment has been LPDL. Complete resolution is a rare event and almost 20% of lesions are resistant to further LPDL treatment (a plateauing effect is seen after 7–10 sessions).[41]

The morbidity is associated with the malformation in patients of all ages and in the patient's families.[41]

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.

Early age of treatment onset may improve response to treatment and lower long-term relapse rates.[46,134] Other authors have not confirmed this and have warned about neovascularization.[135]

Recommendation 23: *We recommend early onset of laser treatment of PWS. Treatments intervals may be shortened to 2–3 weeks in order to enhance efficacy at least when PDL (595 nm) is used.[136,137] Multiple treatments are needed and can be done until no treatment results are achieved (GRADE 1C).*

Efficacy of laser treatments depends upon many other parameters. Lesion colour – pink PWS, especially in children, are more difficult to lighten than mature red PWS; deep purple and nodular port-wine stains need longer pulse wave lengths and pulse durations (755 nm alexandrite laser, 800–900 nm diode laser and 1064 nm Nd:YAG laser). Depth and size of the vascular component: malformations may have a deep vascular component that cannot be reached with a LPDL, but only by Nd:YAG laser or IPLS.[138] Smaller PWS (<20 cm^2) clear better than larger ones, irrespective of age. Location of the port-wine stain: 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.[43]

Recommendation 24: *We recommend as the first choice use of FPDL (585 nm) or LPDL (595 nm) (GRADE 1B), but for flat lesions also large spot KTP (532 nm) and IPLS may be tried as well (GRADE 1C).[43,138–141] For treatment-resistant and/or hypertrophic PWS other systems may be used: millisecond Nd:YAG (1064 nm), dual wavelength systems (595 and 1064 nm), alexandrite (755 nm) and diode lasers as well as IPLS (GRADE 1C).[135,142–147]*

Studies did not find significant differences between single and double pass PDL treatment.[148] Also, no clear-cut advantage has been shown for 595-nm vs. 585-nm PDL though in selected patients longer-wave variety may be more effective.[149–151] However, change of parameters and wavelengths could improve the results. After initial maximal clearance we recommend a break until the residual vessels are ectatic again. Maintenance therapy may be required throughout life if full clearing is not achieved. Only 25% of lesions have complete clearing after multiple treatments. According to our experience, average clearing of 50% could be reached after multiple sessions. Some individuals appear to be able to tolerate long treatments without distress. Topical anaesthetic agents can be used but it is not indicated for children younger than 6 months. Infiltration and nerve block anaesthesia can be used. The majority of children over the age of 1.5 year or children with larger lesions will require general anaesthesia.

For recalcitrant PWS new approaches are being developed like photodynamic therapy, laser treatments combined with angiogenesis inhibitors (imiquimod, rapamycin), haemodynamic alterations in PWS vasculature and site-specific pharmaco-laser therapy.[41] However, these are considered still experimental.

Capillary malformations in *Sturge–Weber's* and *Klippel–Trenaunay syndromes* do not respond as good as ordinary PWS.

Leg veins and telangiectasias

The use of lasers and light sources in treating lower extremity blood vessels has not been as successful as treatment of facial telangiectasia. Among several reasons for this partial success are increased hydrostatic pressure on the lower extremities, 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 to facial telangiectasia, leg veins have thick surrounding adventitial tissue and increased basal lamina.[2,11]

Sclerotherapy is typically considered the first-line treatment for leg veins, both telangiectasia and reticular veins. When considering laser treatment, the choice of the appropriate laser should be primarily guided by target vessel size.[11] Shorter wavelength (<600 nm) laser modalities (KTP and LPDL) are safest and most effective in the treatment of narrow veins (<1 mm). For larger veins the use of a laser modality operating at a longer wavelength (alexandrite, diode and Nd:YAG) is recommended. The longer the wavelengths, e.g. 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 longer wavelength laser is decreased melanin absorption.[11]

By selectively cooling the epidermis during the laser treatment while maintaining peak temperatures of the dermal blood vessels, the practitioner minimizes the risk of damage to the skin.[152] 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.[153] 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:[11]

Lasers should be considered prior to sclerotherapy in patients:

1 with needle phobia,
2 those who do not tolerate sclerotherapy,
3 who fail to respond to sclerotherapy,
4 who have developed untoward side-effects from sclerotherapy,
5 prone to telangiectatic matting.

Others:

1 fair-skinned persons who either have vessels of diameter less than 2 mm,
2 patients unwilling or unable to tolerate compression hosiery after sclerotherapy.

Lasers enable treatment of the following:

1 Spider veins: 0.2–2 mm red and blue vascular ectasias, often associated with larger reticular veins.
2 Reticular veins: 'non-bulging' subcutaneous veins ranging up to 5 mm in diameter.
3 Telangiactasia: 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

Recommendation 25: *Leg telangiectasia of a diameter <1 mm should be treated by KTP (532 nm) or LPDL (595 nm) lasers (GRADE 1A).*[154–158] *Alternatively, IPLS may be used (GRADE 1C).*[159] *Larger vessels are preferentially removed by millisecond Nd:YAG (1064 nm) laser (GRADE 1A).*[153,160–162] *As a second-line treatment option, these vessels may be treated by alexandrite (755 nm) and various diode lasers (800, 810, 940 and 983 nm) (GRADE 1C).*[163–166]

When Nd:YAG laser is used for leg vessels' removal some general remarks may be given.[2,11,167] The 3- to 8-mm spot sizes are used depending on the vessels diameter – larger vessels, larger spot sizes. The pulse duration required for these lesions is generally 30–60 ms. Radiant exposures are variable (250–600 J/cm^2) in relation to spot size and pulse duration. Adequate cooling is absolutely necessary because of the high fluences needed. Overlapping of the treated area is not recommended when a larger spot size is used, whereas a mild overlapping is required with a 3-mm spot size. The clinical end points are the darkening of vessel for blue veins and the disappearance for red vessels.

The selectivity for venous blood is very strong for the 694-nm ruby laser, although this laser type has not yet been investigated in the treatment of leg veins.[10] IPLS are not regarded as first-line treatment as there is a lack of controlled clinical studies and a relatively high risk of damaging non-vascular structures. Indocyanine green injected shortly before laser radiation augments absorption of wavelengths between 700 and 801 nm.[168] Results are promising, but clinical evidence is still too weak to justify this technique as standard therapy.

Recommendation 26: *In case of signs of chronic venous disorder other than leg telangiectasia, especially with C2 and higher (according to Clinical Etiology Anatomy Pathophysiology classification) we recommend to perform leg venous system evaluation (clinical and ultrasound) to exclude venous insufficiency prior to transcutaneous laser treatment of leg telangiectasia (GRADE 1C).*

Treatment endpoints and initial signs of adverse effects[1,2]

By 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 or the rupture of the vessel with no other apparent effect. This effect can be observed in form of bluish or greyish discoloration visible on skin surface.

In leg veins blanching of the vessel may also appear.

Side-effects[1,30,169–174]

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

1 *Pain*. The snapping and burning sensation of each laser pulse can produce a minimal to moderate amount of discomfort. However, pain is an important marker of possible side-effects occurring so, generally, anaesthesia should be avoided.
2 *Purpura*, *bruising*. Immediately after the laser treatment the area will in some cases appear gray or blue-black in colour. The discoloration will fade over the next 7–10 days.
3 *Swelling*. Within few minutes after the laser treatment erythema and oedema will occur over the treatment area. Areas most likely to swell are under eyes and neck. The swelling subsides within 3–5 days if ice is regularly applied. Parallel and post-cooling will diminish the amount of oedema.
4 *Discoloration*, *blisters or scabs* develop rarely (mostly caused by overtreatment). Grey or pale white discoloration of the epidermis is a sign of early dermal damage indicating inappropriately high radiant exposures. This sign will last only a few seconds. Blister formation, epidermal disruption and epidermal necrosis (dermal in severe cases) will follow. Intense cooling, reduction of radiant exposure and prolongation of the pulse duration should be considered. These can take 1–2 weeks to resolve. The findings can be immediate or delayed so it is important to carefully observe the

treated test spot for at least 5 min before proceeding with full treatment.

5 *Infection*. Swelling, redness, crusting, pain and fever can be an indication for an infection. Topical antiseptics or oral antibiotics should be used.
6 *Reactivation of herpes simplex* on the face (when the face is treated) or genital (when legs are treated). Prophylactic oral virostatic therapy (acyclovir, valacyclovir, famcyclovir) is recommended when the patient has frequent herpetic recurrences (more than 6 per year), starting the day before laser treatment.
7 *Skin darkening* (*hyperpigmentation*) eventually fades within 2–6 months. This reaction is more common in patients with darker skin type (Fitzpatrick III–V). The darkening worsens if the laser-treated area is exposed to the sun. Topical bleaching cream, such as hydroquinone, can be used to speed up the process.
8 *Skin lightening* (*hypopigmentation*) is mostly caused by overtreatment. Pale areas usually darken or repigment within 3–6 months. But they could be persistent, most frequently on the neck, legs and chest.
9 *Skin texture changes* are mostly caused by overtreatment – in cases when excessive radiant exposures or overlapping laser spots are used.
10 *Scarring* is mostly caused by overtreatment, when excessive radiant exposures or overlapping laser spots are used. In general, scarring after PDL and KTP laser treatments is very rare; it is a bit commoner with alexandrite laser, while the risk is highest with Nd:YAG laser due to the deepest laser light penetration. Can occur on disruption of the skin surface. Following all advised post-operative instructions can reduce this possibility.
11 *Lesion persistence*, *non-responders*. Some vascular lesions may not go away completely despite the best effort made by the doctor.

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

Post-laser treatment care[1,30,174,175]

After alexandrite, diode or millisecond Nd:YAG lasers the skin appears mildly erythematous with oedema. After PDL with specific parameters the skin appears purpuric with surrounding tissue hyperaemia.

1 To prevent or reduce swelling, post-treatment cooling with ice packs (or cold air) is advised on larger areas such as cheeks or neck after the 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 min each hour for 4 h.
2 If treatment has been performed close to or around the eye there will be a risk of periocular swelling. Patients should be instructed to sleep with an extra pillow to encourage gravitational removal of leaked oedema fluid.
3 Patients should be instructed to avoid sun exposure (along with sun-protection measures like filters with SPF 50 plus UVA block) to prevent post-inflammatory hyperpigmentation.
4 The importance of not picking or scratching at treated areas.
5 A bland moisturizer should be applied to the areas of laser treatment.
6 A mild, non-irritating soap can be used twice daily on the treated areas.
7 Make-up can be used immediately after treatment except if blistering occurs, in this case it can be applied until after any crusting has settled.
8 Showers are allowed, but prolonged bathing or sauna is not advised.
9 The treated area is extremely delicate and must be handled with care during the initial healing phase (7–10 days).
10 Patient should avoid swimming and contact sports while skin is healing.
11 In case of blistering with open wounds petrolatum jelly should be applied.

It may take a few weeks for bruising or scabs to disappear and to notice fading of the primary vascular lesions. During the ensuing weeks the absorption of coagulated treated vessels will occur by the surrounding tissue. The response to the 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.

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.

Disclaimer

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

References

1 Adamič M, Troilius A, Adatto M, Drosner M, Dahmane R. Vascular lasers and IPLS: guidelines for care from the European Society for Laser Dermatology (ESLD). *J Cosmet Laser Ther* 2007; **9**: 113–124.
2 Bencini PL, Tourlaki A, De Giorgi V, Galimberti M. Laser use for cutaneous vascular alterations of cosmetic interest. *Dermatol Ther* 2012; **25**: 340–351.
3 Borges da Costa J, Boixeda P, Moreno C, Santiago J. Treatment of resistant port-wine stains with a pulsed dual wavelength 595 and 1064 nm

laser: a histochemical evaluation of the vessel wall destruction and selectivity. *Photomed Laser Surg* 2009; **27**: 599–605.
4 Mordon S, Brisot D, Fournier N. Using a 'non uniform pulse sequence' can improve selective coagulation with a Nd:YAG laser (1.06 microm) thanks to Met-hemoglobin absorption: a clinical study on blue leg veins. *Lasers Surg Med* 2003; **32**: 160–170.
5 Black JF, Wade N, Barton JK. Mechanistic comparison of blood undergoing laser photocoagulation at 532 and 1,064 nm. *Lasers Surg Med* 2005; **36**: 55–65.
6 Rose AE, Goldberg DJ. Successful treatment of facial telangiectasias using amicropulse 1,064-nm neodymium-doped yttrium aluminum garnet laser. *Dermatol Surg* 2013; **39**: 1062–1066.
7 Glaich AS, Goldberg LH, Dai T, Friedman PM. Fractional photothermolysis for the treatment of telangiectatic matting: a case report. *J Cosmet Laser Ther* 2007; **9**: 101–103.
8 Reddy KK, Brauer JA, Idriss MH *et al.* Treatment of port-wine stains with a short pulse width 532-nm Nd:YAG laser. *J Drugs Dermatol* 2013; **12**: 66–71.
9 Altshuler GB, Anderson RR, Manstein D, Zenzie HH. Smirnov MZ Extended theory of selective photothermolysis. *Lasers Surg Med* 2001; **29**: 416–432.
10 Rubin IK, Farinelli WA, Doukas A, Anderson RR. Optimal wavelengths for vein-selective photothermolysis. *Lasers Surg Med* 2012; **44**: 152–157.
11 Meesters AA, Pitassi LH, Campos V, Wolkerstorfer A, Dierickx CC. Transcutaneous laser treatment of leg veins. *Lasers Med Sci* 2014; **29**: 481–492.
12 Wang B, Milner T. Laser photocoagulation of port-wine stain blood vessels: three dimensional monte carlo/finite element simulation. Poster presented at: American Society for Laser Medicine and Surgery Annual Meeting, Kissimmee, FL, April 18–22, 2012.
13 Cameron H, Ibbotson SH, Ferguson J, Dawe RS, Moseley H. A randomised, blinded, controlled study of the clinical relevance of matching pulse duration to thermal relaxation time when treating facial telangiectasia. *Lasers Med Sci* 2005; **20**: 117–121.
14 Anderson RR, Dierickx CC. Have millisecond–domain lasers changed the approach to treatment of vascular anomalies and ectasia? In: Arndt K, Dover J, eds. Controversies and Conversations in Cutaneous Laser Surgery. AMA Press, Chicago, IL, 2002: 159–161.
15 Aldanondo I, Boixeda P, Fernández-Lorente M *et al.* Selectivity of photothermolysis in the treatment of port wine stains using multiple pulses with a pulsed dye laser. *Actas Dermosifiliogr* 2008; **99**: 546–554.
16 Boixeda P. Treatment with millisecond domain lasers of port wine stains and facial telangiectasia. In: Arndt K, Dover J, eds. Controversies and Conversations in Cutaneous Laser Surgery. AMA press, Chicago, 2002: 125–143.
17 Rohrer TE, Chatrath V, Iyengar V. Does pulse stacking improve the results of treatment with variable-pulse pulsed-dye lasers? *Dermatol Surg* 2004; **30**: 163–167.
18 Rajaratnam R, Laughlin SA, Dudley D. Pulsed dye laser double-pass treatment of patients with resistant capillary malformations. *Lasers Med Sci* 2011; **26**: 487–492.
19 Jia W, Tran N, Sun V *et al.* Photocoagulation of dermal blood vessels with multiple laser pulses in an in vivo microvascular model. *Lasers Surg Med* 2012; **44**: 144–151.
20 Manuskiatti W, Eimpunth S, Wanitphakdeedecha R. Effect of cold air cooling on the incidence of postinflammatory hyperpigmentation after Q-switched Nd:YAG laser treatment of acquired bilateral nevus of Ota like macules. *Arch Dermatol* 2007; **143**: 1139–1143.
21 ISSVA Classification of Vascular Anomalies © 2014 International Society for the Study of Vascular Anomalies. Available at issva.org/classification. (accessed: April 2014).
22 Hoeger PH, Colmenero I. Vascular tumours in infants. Part I: benign vascular tumours other than infantile haemangioma. *Br J Dermatol* 2014; **171**: 446–473.
23 Lapresta A, Hermosa E, Boixeda P, Carrillo-Gijón R. Acquired digital arteriovenous malformations: laser treatment of an uncommon vascular abnormality. *Actas Dermosifiliogr* 2014; **105**: e33–e37.
24 Roenigk RK. Dermatologists perform more skin surgery than any other specialist: implications for health care policy, graduate and continuing medical education. *Dermatol Surg* 2008; **34**: 293–300.
25 Ibrahimi OA, Bangash H, Green L, Alam M, Armstrong AW, Eisen DB. Perceptions of expertise in cutaneous surgery and cosmetic procedures: what primary care physicians think. *Dermatol Surg* 2012; **38**: 1645–1651.
26 Lee EH, Nehal KS, Dusza SW, Hale EK, Levine VJ. Procedural dermatology training during dermatology residency: a survey of third-year dermatology residents. *J Am Acad Dermatol* 2011; **64**: 475–483.
27 Hanke CW, Moy RL, Roenigk RK *et al.* Current status of surgery in dermatology. *J Am Acad Dermatol* 2013; **69**: 972–1001.
28 Sachdev M, Hameed S, Mysore V. Nonablative lasers and nonlaser systems in dermatology: current status. *Indian J Dermatol Venereol Leprol* 2011; **77**: 380–388.
29 Hammes S, Karsai S, Metelmann HR *et al.* Treatment errors resulting from use of lasers and IPL by medical laypersons: results of a nationwide survey. *J Dtsch Dermatol Ges* 2013; **11**: 149–156.
30 Alam M, Warycha M. Complications of lasers and light treatments. *Dermatol Ther* 2011; **24**: 571–580.
31 National Board of Health in Denmark. Statutory Order regarding Cosmetic Treatment. dated 24 October, 2007.
32 Haedersdal M. Potential risks of non-physicians' use of lasers and intense pulsed light in dermatology. *Ugeskr Laeger* 2005; **167**: 4095–4097.
33 Alam M, Dover JS, Arndt KA. Use of cutaneous lasers and light sources: appropriate training and delegation. *Skin Therapy Lett* 2007; **12**: 5–9.
34 Starr JC. Integrating digital image management software for improved patient care and optimal practice management. *Dermatol Surg* 2006; **32**: 834–840.
35 Chandrashekar BS, Varsha DV, Vasanth V, Jagadish P, Madura C, Rajashekar ML. Safety of performing invasive acne scar treatment and laser hair removal in patients on oral isotretinoin: a retrospective study of 110 patients. *Int J Dermatol* 2014; **53**: 1281–1285.
36 Picosse FR, Yarak S, Cabral NC, Bagatin E. Early chemabrasion for acne scars after treatment with oral isotretinoin. *Dermatol Surg* 2012; **38**: 1521–1526.
37 Yoon JH, Park EJ, Kwon IH *et al.* Concomitant use of an infrared fractional laser with low-dose isotretinoin for the treatment of acne and acne scars. *J Dermatolog Treat* 2014; **25**: 142–146.
38 Shah S, Alster TS. Laser treatment of dark skin: an updated review. *Am J Clin Dermatol* 2010; **11**: 389–397.
39 Alexis AF. Lasers and light-based therapies in ethnic skin: treatment options and recommendations for Fitzpatrick skin types V and VI. *Br J Dermatol* 2013; **169**(Suppl. 3): 91–97.
40 Becher GL, Cameron H, Moseley H. Treatment of superficial vascular lesions with the KTP532-nm laser: experience with 647 patients. *Lasers Med Sci* 2014; **29**: 267–271.
41 Chen JK, Ghasri P, Aguilar G. An overview of clinical and experimental treatment modalities for port wine stains. *J Am Acad Dermatol* 2012; **67**: 289–304.
42 Lanigan SW. Port wine stains on the lower limb: response to pulsed dye laser therapy. *Clin Exp Dermatol* 1996; **21**: 88–92.
43 Renfro L, Geronemus RG. Anatomical differences of portwine stains in response to treatment with the pulsed dye laser. *Arch Dermatol* 1993; **129**: 182–188.
44 Eubanks LE, McBurney EI. Videomicroscopy of port-wine stains: correlation of location and depth of lesion. *J Am Acad Dermatol* 2001; **44**: 948–951.
45 Soueid A, Waters R. Re-emergence of port wine stains following treatment with flashlamp-pumped dye laser 585 nm. *Ann Plast Surg* 2006; **57**: 260–263.

46 Michel S, Landthaler M, Hohenleutner U. Recurrence of port-wine stains after treatment with the flashlamp-pumped pulsed dye laser. *Br J Dermatol* 2000; **143**: 1230–1234.
47 Ozluer SM, Barlow RJ. Partial re-emergence of a port-wine stain following successful treatment with flashlamp-pumped dye laser. *Clin Exp Dermatol* 2001; **26**: 37–39.
48 Haedersdal M. Cutaneous side effects from laser treatment of the skin: skin cancer, scars, wounds, pigmentary changes, and purpura – use of pulsed dye laser, copper vapor laser, and argon laser. *Acta Derm Venereol Suppl (Stockh)* 1999; **207**: 1–32.
49 Fourtanier A, Moyal D, Seité S. Sunscreens containing the broad-spectrum UVA absorber, Mexoryl SX, prevent the cutaneous detrimental effects of UV exposure: a review of clinical study results. *Photodermatol Photoimmunol Photomed* 2008; **24**: 164–174.
50 Tanzi EL, Lupton JR, Alster TS. Lasers in dermatology: four decades of progress. *J Am Acad Dermatol* 2003; **49**: 1–31.
51 Uebelhoer NS, Bogle MA, Stewart B, Arndt KA, Dover JS. A split-face comparison study of pulsed 532-nm KTP laser and 595-nm pulsed dye laser in the treatment of facial telangiectasias and diffuse telangiectatic facial erythema. *Dermatol Surg* 2007; **33**: 441–448.
52 Karsai S, Roos S, Raulin C. Treatment of facial telangiectasia using a dual-wavelength laser system (595 and 1,064 nm): a randomized controlled trial with blinded response evaluation. *Dermatol Surg* 2008; **34**: 702–708.
53 Tierney E, Hanke CW. Randomized controlled trial: comparative efficacy for the treatment of facial telangiectasias with 532 nm versus 940 nm diode laser. *Laser Surg Med* 2009; **41**: 555–562.
54 Nymann P, Hedelund L, Hædersdal M. Long-pulsed dye laser vs. intense pulsed light for the treatment of facial telangiectasias: a randomized controlled trial. *J Eur Acad Dermatol Venereol* 2010; **24**: 143–146.
55 Tanghetti EA. Split-face randomized treatment of facial telangiectasia comparing pulsed dye laser and an intense pulsed light hand piece. *Lasers Surg Med* 2012; **44**: 97–102.
56 Alam M, Voravutinon N, Warycha M *et al.* Comparative effectiveness of nonpurpuragenic 595-nm pulsed dye laser and microsecond 1064-nm neodymium:yttrium-aluminum-garnet laser for treatment of diffuse facial erythema: a double-blind randomized controlled trial. *J Am Acad Dermatol* 2013; **69**: 438–443.
57 Adrian RM, Tanghetti EA. Long pulse 532-nm laser treatment of facial telangiectasia. *Dermatol Surg* 1998; **24**: 71–74.
58 Clark C, Cameron H, Moseley H, Ferguson J, Ibbotson SH. Treatment of superficial cutaneous vascular lesions: experience with the KTP 532 nm laser. *Lasers Med Sci* 2004; **19**: 1–5.
59 Carniol PJ, Price J, Olive A. Treatment of telangiectasias with the 532-nm and the 532/940-nm diode laser. *Facial Plast Surg* 2005; **21**: 117–119.
60 Dudelzak J, Hussain M, Goldberg DJ. Vascular-specific laser wavelength for the treatment of facial telangiectasias. *J Drugs Dermatol* 2009; **8**: 227–229.
61 Gambichler T, Avermaete A, Wilmert M, Altmeyer P, Hoffmann K. Generalized essential telangiectasia successfully treated with high-energy, long-pulse, frequency-doubled Nd:YAG laser. *Dermatol Surg* 2001; **27**: 355–357.
62 Schmults CD, Phelps R, Goldberg DJ. Nonablative facial remodeling:erythema reduction and histologic evidence of new collagen formation using a300-microsecond 1064-nm Nd:YAG laser. *Arch Dermatol* 2004; **140**: 1373–1376.
63 Ozyurt K, Colgecen E, Baykan H, Ozturk P, Ozkose M. Treatment of superficial cutaneous vascular lesions: experience with the long-pulsed 1064 nm Nd:YAG laser. *Sci World J* 2012; **2012**: 197139.
64 Bevin AA, Parlette EC, Domankevitz Y, Ross EV. Variable-pulse Nd:YAG laser in the treatment of facial telangiectasias. *Dermatol Surg* 2006; **32**: 7–12.
65 Ross EV, Meehan KJ, Domankevitz Y, Trafeli JP, Annandono J, Jacoby M. Use of a variable long-pulse alexandrite laser in the treatment of facial telangiectasia. *Dermatol Surg* 2010; **36**: 470–474.
66 Waner M, Dinehart SM, Wilson MB, Flock ST. A comparison of copper vapor and flashlamp pumped dye lasers in the treatment of facial telangiectasia. *J Dermatol Surg Oncol* 1993; **19**: 992–998.
67 West TB, Alster TS. Comparison of the long-pulse dye (590–595 nm) and KTP (532 nm) lasers in the treatment of facial and leg telangiectasias. *Dermatol Surg* 1998; **24**: 221–226.
68 Bjerring P, Christiansen K, Troilius A. Intense pulsed light source for treatment of facial telangiectasias. *J Cosmetic & Laser Ther* 2001; **3**: 169–173.
69 Bodendorf MO, Grunewald S, Simon JC, Paasch U. Efficacy and cosmetic results of contact gel cooling of the skin during non-ablative laser procedures. *J Dtsch Dermatol Ges* 2008; **6**: 647–652.
70 Ross EV, Uebelhoer NS, Domankevitz Y. Use of a novel pulse dye laser for rapid single-pass purpura-free treatment of telangiectases. *Dermatol Surg* 2007; **33**: 1466–1469.
71 Iyer S, Fitzpatrick RE. Long-pulsed dye laser treatment for facial telangiectasias and erythema: evaluation of a single purpuric pass versus multiple subpurpuric passes. *Dermatol Surg* 2005; **31**(8 Pt 1): 898–903.
72 Del Rosso JQ. Management of facial erythema of rosacea: what is the role of topical α-adrenergic receptor agonist therapy? *J Am Acad Dermatol* 2013; **69**(6 Suppl. 1): S44–S56.
73 Tan SR, Tope WD. Pulsed dye laser treatment of rosacea improves erythema, symptomatology, and quality of life. *J Am Acad Dermatol* 2004; **51**: 592–599.
74 Maxwell EL, Ellis DA, Manis H. Acne rosacea: effectiveness of 532 nm laser on the cosmetic appearance of the skin. *J Otolaryngol Head Neck Surg* 2010; **39**: 292–296.
75 Neuhaus IM, Zane LT, Tope WD. Comparative efficacy of nonpurpuragenic pulsed dye laser and intense pulsed light for erythematotelangiectatic rosacea. *Dermatol Surg* 2009; **35**: 920–928.
76 Papageorgiou P, Clayton W, Norwood S, Chopra S, Rustin M. Treatment of rosacea with intense pulsed light: significant improvement and long-lasting results. *Br J Dermatol* 2008; **159**: 628–632.
77 Kassir R, Kolluru A, Kassir M. Intense pulsed light for the treatment of rosacea and telangiectasias. *J Cosmet Laser Ther* 2011; **13**: 216–222.
78 Salem SA, Abdel FN, Tantawy SM, El-Badawy NM, Abd E-AY. Neodymium-yttrium aluminum garnet laser versus pulsed dye laser in erythematotelangiectatic rosacea: comparison of clinical efficacy and effect on cutaneous substance (P) expression. *J Cosmet Dermatol* 2013; **12**: 187–194.
79 Kim TG, Roh HJ, Cho SB, Lee JH, Lee SJ, Oh SH. Enhancing effect of pretreatment with topical niacin in the treatment of rosacea-associated erythema by 585-nm pulsed dye laser in Koreans: a randomized, prospective, split-face trial. *Br J Dermatol* 2011; **164**: 573–579.
80 Campolmi P, Bonan P, Cannarozzo G *et al.* Intense pulsed light in the treatment of non-aesthetic facial and neck vascular lesions: report of 85 cases. *J Eur Acad Dermatol Venereol* 2011; **25**: 68–73.
81 Moodley M, Ramdial P. Blue rubber bleb nevus syndrome: case report and review of the literature. *Pediatrics* 1993; **92**: 160–162.
82 Nahm WK, Moise S, Eichenfield LF *et al.* Venous malformations in blue rubber bleb nevus syndrome: variable onset of presentation. *J Am Acad Dermatol* 2004; **50**(Suppl. 5): S101–S106.
83 Moser CM, Hamsch C. Successful treatment of cutaneous venous malformations in a patient with blue rubber bleb naevus syndrome by Nd:YAG laser. *Br J Dermatol* 2012; **166**: 1143–1145.
84 Olsen TG, Milroy SK, Goldman L, Fidler JP. Laser surgery for blue rubber bleb nevus. *Arch Dermatol* 1979; **115**: 81–82.
85 Ng EK, Cheung FK, Chiu PW. Blue rubber bleb nevus syndrome: treatment of multiple gastrointestinal hemangiomas with argon plasma coagulator. *Dig Endosc* 2009; **21**: 40–42.
86 Ng WT, Kong CK. Argon plasma coagulation for blue rubber bleb nevus syndrome in a female infant. *Eur J Pediatr Surg* 2003; **13**: 137–139.
87 Morris L, Lynch PM, Gleason WA Jr, Schauder C, Pinkel D, Duvic M. Blue rubber bleb nevus syndrome: laser photocoagulation of colonic hemangiomas in a child with microcytic anemia. *Pediatr Dermatol* 1992; **9**: 91–94.

88 Salaria M, Taylor J, Bogwitz M, Winship I. Hereditary haemorrhagic telangiectasia, an Australian cohort: clinical and investigative features. *Intern Med J* 2014; **44**: 639–644.
89 Luk L, Mace JC, Bhandarkar ND, Sautter NB. Comparison of electrosurgical plasma coagulation and potassium-titanyl-phosphate laser photocoagulation for treatment of hereditary hemorrhagic telangiectasia-related epistaxis. *Int Forum Allergy Rhinol* 2014; doi:10.1002/alr.21328.
90 Halachmi S, Israeli H, Ben-Amitai D, Lapidoth M. Treatment of the skin manifestations of hereditary hemorrhagic telangiectasia with pulsed dye laser. *Lasers Med Sci* 2014; **29**: 321–324.
91 Fiorella ML, Lillo L, Fiorella R. Diode laser in the treatment of epistaxis in patients with hereditary haemorrhagic telangiectasia. *Acta Otorhinolaryngol Ital* 2012; **32**: 164–169.
92 Kluger PB, Shapshay SM, Hybels RL, Bohigian RK. Neodymium-YAG laser intranasal photocoagulation in hereditary hemorrhagic telangiectasia: an update report. *Laryngoscope* 1987; **97**: 1397–1401.
93 Ben-Bassat M, Kaplan I, Levy R. Treatment of hereditary haemorrhagic telangiectasia of the nasal mucosa with the carbon dioxide laser. *Br J Plast Surg* 1978; **31**: 157–158.
94 Lennox PA, Harries M, Lund VJ, Howard DJ. A retrospective study of the role of the argon laser in the management of epistaxis secondary to hereditary haemorrhagic telangiectasia. *J Laryngol Otol* 1997; **111**: 34–37.
95 Marglani OA, Bawazeer NA, Abu Suliman OA. Avastin and diode laser: a combined modality in managing epistaxis in hereditary hemorrhagic telangiectasia. *Am J Otolaryngol* 2013; **34**: 603–605.
96 Mahoney EJ, Shapshay SM. New classification of nasal vasculature patterns in hereditary hemorrhagic telangiectasia. *Am J Rhinol* 2006; **20**: 87–90.
97 Schroeter CA, Neumann HA. An intense light source. The photoderm VL-flashlamp as a new treatment possibility for vascular skin lesions. *Dermatol Surg* 1998; **24**: 743–748.
98 Nofal A, Salah E. Acquired poikiloderma: proposed classification and diagnostic approach. *J Am Acad Dermatol* 2013; **69**: e129–e140.
99 Batta K, Hindson C, Cotterill JA, Foulds IS. Treatment of poikiloderma of Civatte with the potassium titanyl phosphate (KTP) laser. *Br J Dermatol* 1999; **140**: 1191–1192.
100 Rusciani A, Motta A, Fino P, Menichini G. Treatment of poikiloderma of Civatte using intense pulsed light source: 7 years of experience. *Dermatol Surg* 2008; **34**: 314–319.
101 Meijs MM, Blok FA, de Rie MA. Treatment of poikiloderma of Civatte with the pulsed dye laser: a series of patients with severe depigmentation. *J Eur Acad Dermatol Venereol* 2006; **20**: 1248–1251.
102 Wat H, Wu DC, Rao J, Goldman MP. Application of intense pulsed light in the treatment of dermatologic disease: a systematic review. *Dermatol Surg* 2014; **40**: 359–377.
103 Tierney EP, Hanke CW. Treatment of Poikiloderma of Civatte with ablative fractional laser resurfacing: prospective study and review of the literature. *J Drugs Dermatol* 2009; **8**: 527–534.
104 Craig LM, Alster TS. Vascular skin lesions in children: a review of laser surgical and medical treatments. *Dermatol Surg* 2013; **39**: 1137–1146.
105 Lee J, Sinno H, Tahiri Y, Gilardino MS. Treatment options for cutaneous pyogenic granulomas: a review. *J Plast Reconstr Aesthet Surg* 2011; **64**: 1216–1220.
106 Pohl L, Karsai S, Raulin C. Recurrent pyogenic granuloma: treatment at difficult anatomic sites with the long-pulsed Nd:YAG laser (1064 nm). *Hautarzt* 2011; **62**: 46–50.
107 Raulin C, Greve B, Hammes S. The combined continuous-wave/pulsed carbon dioxide laser for treatment of pyogenic granuloma. *Arch Dermatol* 2002; **138**: 33–37.
108 Hammes S, Kaiser K, Pohl L, Metelmann HR, Enk A, Raulin C. Pyogenic granuloma: treatment with the 1,064-nm long-pulsed neodymium-doped yttrium aluminum garnet laser in 20 patients. *Dermatol Surg* 2012; **38**: 918–923.
109 Roncero M, Cañueto J, Blanco S, Unamuno P, Boixeda P. Multiwavelength laser treatment of venous lakes. *Dermatol Surg* 2009; **35**: 1942–1946.
110 Weiss J, Weiss KD, Ross AL, Weiss E. A simplified minimally invasive technique for the treatment of venous lakes. *Dermatol Online J* 2014; **20**: 21257.
111 Azevedo LH, Galletta VC, Eduardo Cde P, Migliari DA. Venous lake of the lips treated using photocoagulation with high-intensity diode laser. *Photomed Laser Surg* 2010; **28**: 263–265.
112 Wall TL, Grassi AM, Avram MM. Clearance of multiple venous lakes with an 800-nm diode laser: a novel approach. *Dermatol Surg* 2007; **33**: 100–103.
113 Bekhor PS. Long-pulsed Nd:YAG laser treatment of venous lakes: report of a series of 34 cases. *Dermatol Surg* 2006; **32**: 1151–1154.
114 Pancar GS, Aydin F, Senturk N, Bek Y, Canturk MT, Turanli AY. Comparison of the 532-nmKTP and 1064-nm Nd:YAG lasers for the treatment of cherry angiomas. *J Cosmet Laser Ther* 2011; **13**: 138–141.
115 Fodor L, Ramon Y, Fodor A, Carmi N, Peled IJ, Ullmann Y. A side-by-side prospective study of intense pulsed light and Nd:YAG laser treatment for vascular lesions. *Ann Plast Surg* 2006; **56**: 164–170.
116 Bernstein EF. The pulsed-dye laser for treatment of cutaneous conditions. *G Ital Dermatol Venereol* 2009; **144**: 557–572.
117 Eivazi B, Werner JA. Management of vascular malformations and hemangiomas of the head and neck – an update. *Curr Opin Otolaryngol Head Neck Surg* 2013; **21**: 157–163.
118 Püttgen KB. Diagnosis and management of infantile hemangiomas. *Pediatr Clin North Am* 2014; **61**: 383–402.
119 Herschthal J, Wulkan A, George M, Waibel J. Additive effect of propranolol and pulsed dye laser for infantile hemangioma. *Dermatol Online J* 2013; **19**: 18570.
120 Léauté-Labrèze C, Prey S, Ezzedine K. Infantile haemangioma: part II. Risks, complications and treatment. *J Eur Acad Dermatol Venereol* 2011; **25**: 1254–1260.
121 David LR, Malek MM, Argenta LC. Efficacy of pulse dye laser therapy for the treatment of ulcerated haemangiomas: a review of 78 patients. *Br J Plast Surg* 2003; **56**: 317–327.
122 Bédard MS, Boulanger J. Treatment of lobular capillary hemangioma with the Nd:YAG laser: retrospective case series of 25 patients. *J Cutan Med Surg* 2009; **13**: 181–182.
123 Alcántara-González J, Boixeda P, Truchuelo-Diez MT, Pérez-García B, Alonso-Castro L, Jaén Olasolo P. Infantile hemangiomas treated by sequential application of pulsed dye laser and Nd:YAG laser radiation: a retrospective study. *Actas Dermosifilogr* 2013; **104**: 504–511.
124 Su W, Ke Y, Xue J. Beneficial effects of early treatment of infantile hemangiomas with a long-pulse Alexandrite laser. *Lasers Surg Med* 2014; **46**: 173–179.
125 Alcántara González J, Boixeda P, TruchueloDíez MT, López Gutiérrez JC, Olasolo PJ. Ablative fractional yttrium-scandium-gallium-garnet laser for scarring residual haemangiomas and scars secondary to their surgical treatment. *J Eur Acad Dermatol Venereol* 2012; **26**: 477–482.
126 Brightman LA, Brauer JA, Terushkin V *et al.* Ablative fractional resurfacing for involuted hemangioma residuum. *Arch Dermatol* 2012; **148**: 1294–1298.
127 Raulin C, Greve B. Retrospective clinical comparison of hemangioma treatment by flashlamp-pumped (585 nm) and frequency-doubled Nd:YAG (532 nm) lasers. *Lasers Surg Med* 2001; **28**: 40–43.
128 Kessels JP, Hamers ET, Ostertag JU. Superficial hemangioma: pulsed dye laser versus wait-and-see. *Dermatol Surg* 2013; **39**(3 Pt 1): 414–21.
129 McCuaig CC, Cohen L, Powell J *et al.* Therapy of ulcerated hemangiomas. *J Cutan Med Surg* 2013; **17**: 233–242.
130 Bruscino N, Bonan P, Cannarozzo G, Moretti S, Lotti T, Campolmi P. Laser use in infantile hemangiomas, when and how. *Dermatol Ther* 2012; **25**: 314–321.

131 Di Maio L, Baldi A, Dimaio V, Barzi A. Use of flashlamp-pumped pulsed dye laser in the treatment of superficial vascular malformations and ulcerated hemangiomas. *In Vivo* 2011; **25**: 117–123.
132 Lorenz S, Maier C, Segerer H, Landthaler M, Hohenleutner U. Skin changes in newborn infants in the first 5 days of life. *Hautarzt* 2000; **51**: 396–400.
133 van Drooge AM, Beek JF, van der Veen JP, van der Horst CM, Wolkerstorfer A. Hypertrophy in port-wine stains: prevalence and patient characteristics in a large patient cohort. *J Am Acad Dermatol* 2012; **67**: 1214–1219.
134 Chapas AM, Eickhorst K, Geronemus RG. Efficacy of early treatment of facial portwine stains in newborns: a review of 49 cases. *Lasers Surg Med* 2007; **39**: 563–568.
135 Izikon L, Nelson JS, Anderson RR. Treatment of hypertrophic and resistant port wine stain with 755 nm laser: a case series of 20 patients. *Lasers Surg Med* 2009; **41**: 427–432.
136 Anolik R, Newlove T, Weiss ET *et al.* Investigation into optimal treatment intervals of facial port-wine stains using the pulsed dye laser. *J Am Acad Dermatol* 2012; **67**: 985–990.
137 Tomson N, Lim SP, Abdullah A, Lanigan SW. The treatment of port-wine stains with the pulsed-dye laser at 2-week and 6-week intervals: a comparative study. *Br J Dermatol* 2006; **154**: 676–679.
138 Bjerring P, Christiansen K, Troilius A. Intense pulsed light source for the treatment of dye laser resistant port-wine stains. *J Cosmetic & Laser Ther* 2003; **5**: 7–13.
139 Katugampola GA, Lanigan SW. Five years' experience of treating port wine stains with the flashlamp-pumped pulsed dye laser. *Br J Dermatol* 1997; **137**: 750–754.
140 Faurschou A, Olesen AB, Leonardi-Bee J, Haedersdal M. Lasers or light sources for treating port-wine stains. *Cochrane Database Syst Rev* 2011; CD007152.
141 Pençe B, Aybey B, Ergenekon G. Outcomes of 532 nm frequency-doubled Nd:YAG laser use in the treatment of port-wine stains. *Dermatol Surg* 2005; **31**: 509–517.
142 Faurschou A, Togsverd-Bo K, Zachariae C, Haedersdal M. Pulsed dye laser vs. intense pulsed light for port-wine stains: a randomized side-by-side trial with blinded response evaluation. *Br J Dermatol* 2009; **160**: 359–64.
143 van Drooge AM, Bosveld B, van der Veen JP, de Rie MA, Wolkerstorfer A. Long-pulsed 1064 nm Nd:YAG laser improves hypertrophic port-wine stains. *J Eur Acad Dermatol Venereol* 2013; **27**: 1381–1386.
144 Yang MU, Yaroslavsky AN, Farinelli WA *et al.* Long-pulsed neodymium:yttrium-aluminum-garnet laser treatment for port-wine stains. *J Am Acad Dermatol* 2005; **52**(3 Pt 1): 480–490.
145 Alster TS, Tanzi EL. Combined 595-nm and 1,064-nm laser irradiation of recalcitrant and hypertrophic port-wine stains in children and adults. *Dermatol Surg* 2009; **35**: 914–918.
146 Klein A, Szeimies RM, Bäumler W *et al.* Indocyanine green-augmented diode laser treatment of port-wine stains: clinical and histological evidence for a new treatment option from a randomized controlled trial. *Br J Dermatol* 2012; **167**: 333–342.
147 Ho WS, Ying SY, Chan PC, Chan HH. Treatment of port wine stains with intense pulsed light: a prospective study. *Dermatol Surg* 2004; **30**: 887–890.
148 Peters MA, van Drooge AM, Wolkerstorfer A *et al.* Double pass 595 nm pulsed dye laser at a 6 minute interval for the treatment of port-wine stains is not more effective than single pass. *Lasers Surg Med* 2012; **44**: 199–204.
149 Yung A, Sheehan-Dare R. A comparative study of a 595-nm with a 585-nm pulsed dye laser in refractory port wine stains. *Br J Dermatol* 2005; **153**: 601–606.
150 Frohm NM, Passian S, Wiegleb Edstrom D. Comparison of two dye lasers in the treatment of port-wine stains. *Clin Exp Dermatol* 2010; **35**: 126–130.
151 Woo WK, Jasim ZF, Handley JM. Evaluating the efficacy of treatment of resistant port-wine stains with variable-pulse 595-nm pulsed dye and 532-nm Nd:YAG lasers. *Dermatol Surg* 2004; **30**(2 Pt 1): 158–162.
152 Buscher BA, McMeekin TO, Goodwin D. Treatment of leg telangiectasia by using a long-pulse dye laser at 595 nm with and without dynamic cooling device. *Lasers Surg Med* 2000; **27**: 171–175.
153 Baumler W, Ulrich H, Hartl A *et al.* Optimal parameters for the treatment of leg veins using Nd:YAG lasers at 1064 nm. *Br J Dermatol* 2006; **155**: 364–371.
154 Bernstein EF, Noyaner-Turley A, Renton B. Treatment of spider veins of the lower extremity with a novel 532 nm KTP laser. *Lasers Surg Med* 2014; **46**: 81–88.
155 Fournier N, Brisot D, Mordon S. Treatment of leg telangiectases with a 532 nm KTP laser in multipulse mode. *Dermatol Surg* 2002; **28**: 564–571.
156 Woo WK, Jasim ZF, Handley JM. 532-nm Nd:YAG and 595-nm pulsed dye laser treatment of leg telangiectasia using ultralong pulse duration. *Dermatol Surg* 2003; **29**: 1176–1180.
157 Bernstein EF. The new-generation, high-energy, 595 nm, long pulse-duration, pulsed-dye laser effectively removes spider veins of the lower extremity. *Lasers Surg Med* 2007; **39**: 218–224.
158 Kono T, Yamaki T, Ercocen AR *et al.* Treatment of leg veins with the long pulse dye laser using variable pulse durations and energy fluences. *Lasers Surg Med* 2004; **35**: 62–67.
159 Schroeter C, Wilder D, Reineke T *et al.* Clinical significance of an intense, pulsed light source on leg telangiectasias of up to 1 mm diameter. *Eur J Dermatol* 1997; **7**: 38–42.
160 Trelles MA, Allones I, Martín-Vázquez MJ, Trelles O, Vélez M, Mordon S. Long pulse Nd:YAG laser for treatment of leg veins in 40 patients with assessments at 6 and 12 months. *Lasers Surg Med* 2004; **35**: 68–76.
161 Munia MA, Wolosker N, Munia CG, Chao WS, Puech-Leão P. Comparison of laser versus sclerotherapy in the treatment of lower extremity telangiectases: a prospective study. *Dermatol Surg* 2012; **38**: 635–639.
162 Ozden MG, Bahçivan M, Aydin F *et al.* Clinical comparison of potassium-titanyl-phosphate (KTP) versus neodymium: YAG (Nd:YAG) laser treatment for lower extremity telangiectases. *J Dermatolog Treat* 2011; **22**: 162–166.
163 Ross EV, Meehan KJ, Gilbert S *et al.* Optimal pulse durations for the treatment of leg telangiectasias with an alexandrite laser. *Lasers Surg Med* 2009; **41**: 104–109.
164 Trelles MA, Allones I, Alvarez J *et al.* The 800-nm diode laser in the treatment of leg veins: assessment at 6 months. *J Am Acad Dermatol* 2006; **54**: 282–289.
165 Eremia S, Li C, Umar SH. A side-by-side comparative study of 1064 nm Nd:YAG, 810 nm diode and 755 nm alexandrite lasers for treatment of 0.3–3 mm leg veins. *Dermatol Surg* 2002; **28**: 224–230.
166 Passeron T, Olivier V, Duteil L, Desruelles F, Fontas E, Ortonne JP. The new 940-nanometer diode laser: an effective treatment for leg venulectasia. *J Am Acad Dermatol* 2003; **48**: 768–774.
167 McCoppin HH, Hovenic WW, Wheeland RG. Laser treatment of superficial leg veins: a review. *Dermatol Surg* 2011; **37**: 729–741.
168 Klein A, Buschmann M, Babilas P, Landthaler M, Bäumler W. Indocyanine green-augmented diode laser therapy vs. long-Pulsed Nd:YAG Indocyanine green-augmented diode laser therapy vs. long-pulsed Nd: YAG (1064 nm) laser treatment of telangiectatic leg veins: a randomized controlled trial. *Br J Dermatol* 2013; **169**: 365–373.
169 Nanni C. Handling complications of laser treatment. *Dermatol Ther* 2000; **13**: 127–139.
170 Boixeda P, Núñez M, Pérez B, de lHM, Hilara Y, Ledo A. Complications of 585-nm pulsed dye laser therapy. *Int J Dermatol* 1997; **36**: 393–397.
171 Fisher DM, Chang CJ, Chua JJ, Chen YR, Achauer BM. Potential complications of intralesional laser photocoagulation for extensive vascular malformations. *Ann Plast Surg* 2001; **47**: 252–256.

172 Hammes S, Kimmig W. Side effects and complications of therapy with laser and intense light sources. *Hautarzt* 2013; **64**: 145–154.
173 Hirsch R. Iatrogenic laser complications. *Clin Dermatol* 2011; **29**: 691–695.
174 Alster TS, Khoury RR. Treatment of laser complications. *Facial Plast Surg* 2009; **25**: 316–323.
175 Willey A, Anderson RR, Azpiazu JL *et al.* Complications of laser dermatologic surgery. *Lasers Surg Med* 2006; **38**: 1–15.
176 Guyatt G, Gutterman G, Baumann MH *et al.* Grading strength of recommendations and quality of evidence in clinical guidelines. Report of an American College of Chest Physicians Task Force. *Chest* 2006; **129**: 174–181.

Appendix I : Abbreviations

Terms	Definitions
FLDL	Flashlamp pumped dye laser
IPLS	Intense pulsed light source
KTP	Potassium titanyl phosphate
LPDL	Long-pulsed dye laser
Nd:YAG	Neodymium yttrium aluminium garnet
PDL	Pulsed dye laser
PWS	Port-wine stains
SPDL	Short-pulsed dye laser
SPF	Sun protection factor
UV	Ultraviolet

Appendix II : Methodology and search strategy

MEDLINE/PubMed, EMBASE and Cochrane Library searches were performed from 2006 to May 2014 using different combinations of terms vascular laser, laser, intense pulsed light, cooling, blood vessel, leg, face, telangiectasia, erythema, rosacea, blue rubber bleb naevus, hereditary haemorrhagic telangiectasia, Ossler-Weber-Rendu disease, spider angioma, cherry angioma, angioma, haemagioma, infantile haemangioma, poikiloderma, pyogenic granuloma, granuloma telangiectaticum, venous lake, capillary malformation, port wine stain, naevus flammeus, leg veins. All retrieved abstracts were reviewed independently by two authors (MDP, MA) and selected those of the following article types: randomized controlled trial (controlled) clinical trial, case studies, comparative study, observational study, guideline, reviews, systematic review and meta-analysis. All the papers were then sent out to other members of the Consensus Panel (ATR, MEP, PB). The aim was to answer the following questions for each clinical vascular condition according to available evidence: (i) which vascular lasers and light sources are indicated for its treatment? (ii) what is the acceptable therapeutic efficacy and how was it assessed? (iii) is there any comparative studies between different lasers and light sources for this particular condition? (iv) what are side-effects of the treatment? The first two authors have formulated guideline draft on the basis of the first guideline published in 2007, and according to the GRADE system. In brief, the strength of the recommendation or the extent to which one can be confident that adherence to the recommendation will do more good than harm was divided into [1] strong (we recommend) and [2] weak (we suggest), with [1] favouring benefit over harm and [2] with benefits closely balanced by the risk. The 'quality of evidence' or the extent to which confidence in an estimate of effect is sufficient to support a particular recommendation was graded [A], [B] or [C] by standard evidence-based methodologic criteria (see table below). Then the draft was circulated among all members of the Panel who discussed the content, added comments and corrections. There were several rounds of discussion until the final agreement is reached. In cases where there were not high quality clinical studies available, expert opinions of the members of the Consensus Panel were taken into account.

American College of Chest Physicians Task Force recommendations on Grading Strength of Recommendations and Quality of Evidence in Clinical Guidelines[176]

Grade of recommendation/ description	Benefits vs. risk and burdens	Methodological quality of supporting evidence	Implications
1A/Strong recommendation; high quality evidence	Benefits clearly outweigh risk and burdens, or vice versa	RCTs without important limitations or overwhelming evidence from observational studies	Strong recommendation, can apply to most patients in most circumstances without reservation
1B/strong recommendation, moderate quality evidence	Benefits clearly outweigh risk and burdens, or vice versa	RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Strong recommendation, can apply to most patients in most circumstances without reservation
1C/strong recommendation, low quality or very low quality evidence	Benefits clearly outweigh risk and burdens, or vice versa	Observational studies or case series	Strong recommendation but may change when higher quality evidence becomes available
2A/weak recommendation, high quality evidence	Benefits closely balanced with risks and burden	RCTs without important limitations or overwhelming evidence from observational studies	Weak recommendation, best action may differ depending on circumstances or patients' or societal values
2B/weak recommendation, moderate-quality evidence	Benefits closely balanced with risks and burden	RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Weak recommendation, best action may differ depending on circumstances or patients' or societal values
2C/weak recommendation, low quality or very low quality evidence	Uncertainty in the estimates of benefits, risks and burden; benefits, risk and burden may be closely balanced	Observational studies or case series	Very weak recommendations; other alternatives may be equally reasonable