Treatment of Port-wine Stains With a Noncoherent Pulsed Light Source

A Retrospective Study

Christian Raulin, MD; Careen A. Schroeter, MD; Robert A. Weiss, MD; Michael Keiner, MD; Saskia Werner, MD

Objective: We investigated whether a noncoherent intense pulsed light source (IPLS) would be effective in therapy of port-wine stains (PWSs).

Design: To evaluate the efficacy in treatment of PWSs with IPLS, a retrospective study was initiated.

Setting: The data were collected by physicians working in private practices and departments of university hospitals and medical centers, respectively.

Patients: A total of 37 randomly selected patients with a total of 40 PWSs were included in the study. Clinical PWS characteristics recorded were color and location of the PWS.

Interventions: All patients were treated with IPLS.

Main Outcome Measures: Data collected included treatment parameter (filters, pulse duration, fluence, and pulse sequencing), percentage of clearance, and side effects (purpura, blisters, crusting, altered pigmentation, and scarring).

Results: Good and complete (70%-100%) clearance was achieved in 28 of 40 PWSs treated with IPLS. The average number of treatment sessions in PWSs reaching 100% clearance included 4.0 for pink PWSs and 1.5 for red PWSs. The average number of sessions for purple PWSs reaching good clearance (70%-99%) was 4.2 sessions. Parameters used most frequently were 515- and 550-nm cutoff filters, pulse duration of 2.5 to 5.0 milliseconds, and fluences of 24 to 60 J/cm². Side effects included purpura in 133 (76%), superficial blisters in 14 (8%), and crusting in 35 (20%). Transient pigmentation changes were seen in 10.8% of patients (hypopigmentation in 3 [8.1%], hyperpigmentation in 1 [2.7%]). No scarring was observed.

Conclusion: Intense pulsed light source presents an effective and safe method for treating PWSs, especially purple PWSs.

Arch Dermatol. 1999;135:679-683

PORT-WINE STAINS (PWSs)—a congenital, progressive ectasia of the superficial cutaneous vascular plexus—appear in 0.3% to 0.5% of newborns. At birth, PWSs are typically flat, sharply delineated, light-red lesions, often occupying large surface areas. Facial PWSs often occur in the region of the first and second trigeminal nerves. With time, these superficial vessels become more and more ectatic resulting in a darkening and thickening of the PWS, occasionally progressing to the nodular type with increasing age.1-3

Previous methods of treating mature PWSs included surgical solutions such as excision and dermabrasion, carbon dioxide cryotherapy, sclerotherapy, irradiation, and radioactive implants.4-8 These treatments frequently result in associated complications, such as scars or pain. Irradiation-induced tumors as rare complications are known.

A variety of laser systems have been used, such as the argon, potassium-titanyl-phosphate, krypton, and copper vapor lasers and most recently, the flashlamp pulsed dye laser (FLPDL).6-10 On theoretical grounds alone, the wavelengths that would best match oxyhemoglobin’s absorption peaks are 418, 542, and 577 nm.11 The FLPDL at 577 nm and later modified to 585 nm (allowing a greater depth of penetration while maintaining vascular selectivity) has proven to be the therapy of choice because of high efficacy and low incidence of side effects such as scarring.3,12-15 However, efficacy for dark and particular nodular PWSs in adults is low most likely due to its relatively short-pulse duration (450 microseconds) and limited depth of penetration (maximum depth, 1.5 mm).6-10 New laser systems like the flashlamp–pumped pulsed tunable dye laser (ScleroPlus Laser; Candela Corporation, Wayland, Mass; Millenium; Cynosure, Bedford, Mass) that permit the choice of longer wavelengths (585-600 nm) and longer pulse widths (1.5 milliseconds) have become available for the treatment of vascular lesions such as leg telangiectasia.14,17-19 A long-pulsed potassium-titanyl-phosphate laser at 532 nm al-

From Laserklinik, Karlsruhe, Germany (Drs Raulin and Werner); Department of Lasertherapy, Medical Centre, Maastricht, the Netherlands (Dr Schroeter); Department of Dermatology, Johns Hopkins University, Baltimore, Md (Dr Weiss); and Center for Laser Therapy, Braunfels, Germany (Dr Keiner).
PATIENTS AND METHODS

From October 1994 to January 1997, 37 patients (25 females, 12 males), with 40 PWSs were treated using IPLS (Photoderm VL; Shasplan-ESC Medical System Ltd, Yokneam, Israel) emitting noncoherent light with a continuous wavelength ranging from 500 to 1000 nm (spectral output of the optical treatment head [see Figure 1]). By using cutoff filters (515, 550, 570, 590 nm), shorter wavelengths are filtered out. A single-, double-, or triple-pulse sequence can be administered. Pulse duration ranges from 0.5 to 25 milliseconds in the short-pulse mode and up to 30 milliseconds in the long-pulse mode. Delay between pulses can be adjusted between 10 and 500 milliseconds; fluences from 3 to 90 J/cm² are attainable, and the surface area is large: 2.8 cm² (8 × 35 mm).

The patients were randomly selected from our own treated populations. Patient demographics were as follows:

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No. of Patients or PWSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>12</td>
</tr>
<tr>
<td>Females</td>
<td>25</td>
</tr>
<tr>
<td>Age range, y</td>
<td>1-68</td>
</tr>
<tr>
<td>1-6 years</td>
<td>2</td>
</tr>
<tr>
<td>6-10 years</td>
<td>2</td>
</tr>
<tr>
<td>11-15 years</td>
<td>10</td>
</tr>
<tr>
<td>16-18 years</td>
<td>3</td>
</tr>
<tr>
<td>19-24 years</td>
<td>18</td>
</tr>
<tr>
<td>IV-VI</td>
<td>6</td>
</tr>
<tr>
<td>Localization of PWSs</td>
<td></td>
</tr>
<tr>
<td>Face</td>
<td>20 (no peri-orbital)</td>
</tr>
<tr>
<td>Neck</td>
<td>6</td>
</tr>
<tr>
<td>Trunk</td>
<td>6</td>
</tr>
<tr>
<td>Extremities</td>
<td>8</td>
</tr>
<tr>
<td>Previously treated PWSs</td>
<td>12 (5 red; 7 purple)</td>
</tr>
<tr>
<td>Argon and/or dye laser</td>
<td>11</td>
</tr>
<tr>
<td>Cryotherapy</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1

All treatments were performed using a clear, cooled, proprietary water-based gel (Coupling Gel; ESC Medical System Ltd) placed between the emitting crystal and the skin to decrease the heating of the epidermis. Following treatment, a cool compress was placed on the area for 20 to 30 minutes. Therapy with topical antibiotics or steroids was not required posttreatment. Patients were treated with IPLS intervals of 4 weeks and longer.

Due to the retrospective character of our study and different investigators, no uniform treatment parameters were used. The filters used were 515, 550, and 570 nm; total fluence ranged from 24 to 60 J/cm²; and energy was applied in single-, double-, and triple-pulse sequences. First the PWSs were treated in the single-pulse mode. In case of nonresponse, total fluence delivered was increased by using double and triple pulses, until an immediate response of erythema or purpura was seen. Intense pulsed light source was used in only 1 case (purple PWS) in the long-pulse mode (590 nm, triple pulse) with a high fluence of 70 J/cm². Photographs of all sites were taken under identical conditions. Identical cameras (Cannon EOS 100) with Agfa CTX 100 film were consistently used (except for Nikon N90 with Canfield flash system and Ektachrome 100 film at one site). Pretreatment and posttreatment photographs were reviewed by 3 nonparticipating physicians to evaluate lightening of the lesions independently. Using special colorboards the degree of clearance was determined as a percentage of reduction in color relative to normal skin. Results were ranked into 1 of 4 categories: complete, 100% clearance; good, 70% to 99% clearance; fair, 40% to 69% clearance; and poor, less than 40% clearance. Presence or absence of posttreatment blisters, purpura, crusting, hypopigmentation or hyperpigmentation, or scarring was recorded corresponding to data in patients’ documents. For statistical analysis the average parameters and SD were determined.

RESULTS

The mean (± SD) number of sessions was 2.9 ± 2.87 for pink PWSs, 2.0 ± 1.56 for red PWSs (SD), and 4.0 ± 1.87 for purple PWSs. It is noteworthy that the 70% to 99% clearance of pink PWSs occurred with an average wavelength and delivering sufficient energy within the thermal relaxation (cooling) time of the target chromophore (oxyhemoglobin in vessels in PWSs), it is possible to specifically damage selected targets within the tissue. By applying long pulses and multiple-pulse sequences, and by splitting up higher-energy densities, IPLS allows the treatment of larger blood vessels and cavernous vascular lesions. Longer wavelengths allow for the heating of deep-lying vascular structures.

Treatment of PWSs was performed using these principles during the multicenter clinical study of IPLS.

©1999 American Medical Association. All rights reserved.
The primary limiting factor of FLPDL is the small depth of penetration. Findings from histological studies demonstrated insufficient coagulation of dermal vessels.
below 1.16 mm in human skin. Vessels lying beyond the limited penetration depth may persist and determine the clinical response. In a PWS 577- or 585-nm laser treatment model, it has been shown that most energy is deposited in the superficial vessels. Multiple vessels mutually influence one another: the presence of overlying vessels decreases the amount of light available to be deposited in deeper vessels (shadowing effects). By this modeling the smaller effective depth at which vessel destruction occurs (maximum depth, 0.65 mm) by FLPDL may be explained. Our study corroborated this: 7 of 11 purple PWSs had been previously treated unsuccessfully with argon and/or FLPDL. The strong absorption of the 488- or 514-nm and the 577- or 585-nm wavelengths in blood prevents heating of the full wall diameter of large vessels and, therefore, only the top of the vessel is heated. Longer wavelengths penetrate deeper. However, the absorption of laser energy in blood vessels decreases dramatically. Concomitant increases in fluence are required to compensate for the decreased absorption. It has been shown that the use of 600-nm FLPDL with greater fluences (9.9 and 13.2 J/cm²) provides a higher degree of clearance compared with 585-nm FLPDL at 6.6 J/cm². The IPLS uses a broad spectrum of long wavelengths (515-1000 nm) and the necessary high fluences (up to 90 J/cm²). Thus, effectively heating the upper as well as the deeper vessels of PWSs could be obtained. Our data show that 6 of 11 purple PWSs achieved a good clearance (70%-99 %) within an average of 4.0 and 4.2 sessions when using IPLS.

It has been shown that the clinical response of lightening in PWSs following FLPDL (at 585 nm; 0.45-millisecond pulse length; fluence of 6.5 J/cm²) is dependent on vessel depth, diameter, and wall thickness. Port-wine stains with good responses were more superficially located (above 300 μm from the dermoepidermal junction) than those with moderate and poor responses. The moderate and good responding lesions consisted of moderate-sized vessels with diameters of 38 μm. The lesions showing poor blanching had smaller vessels (diameter, 19 μm). According to findings on histological examinations, there was also a tendency toward thicker vessel walls with increasing depth in the dermis. Analytic modeling of the influence of wavelength on PWSs with different dermal blood content confirms that 577 nm is the optimal wavelength for treatment of pink PWSs (small vessels, < 14 μm). This fact concurs with the studies of Tan et al, 2 that showed excellent results on pale pink lesions.

Ideally, the pulse duration should be compatible with the vessel diameter and be equal to the thermal relaxation time for that dimension. Dierickx et al discussed the benefits of longer-pulse duration and concluded that pulse durations of 1 to 10 milliseconds allow destruction of 30- to 150-μm vessels while sparing the capillaries. Using tunable FLPDL (585-600 nm; 1.5 milliseconds) (ScleroPlus Laser; Candela Corporation; Millenium; Cynosure) and long-pulse frequency-doubled Nd:YAG laser (532 nm) (VersaPulse; Coherent; Aura; Laserscope), good results could be achieved in the treatment of ectatic blood vessels encountered in PWSs, telangiectases, and leg veins smaller than 1 mm in diameter. The IPLS providing pulse durations up to 50 milliseconds enables delivery of laser energy to vessels over longer periods of time, resulting in either gentle, uniform heating or even coagulation across the entire vessel, while reducing vessel rupture and its associated purpura and hyperpigmentation. Therefore, IPLS can be seen as an additional mode of PWS therapy, particularly for dark and hypertrophic lesions. It has been shown in a case report that FLPDL-resistant PWSs showed notable improvement following a single IPLS treatment.

Using IPLS, splitting light into double and triple pulses is possible. Thus, larger and deeper vessels, such as in hypertrophic PWSs or venous malformations, which require higher fluences to reach sufficient coagulation, can be treated effectively by additive heating. The epidermis and smaller vessels cool down during the long delay between pulses (10–500 milliseconds) without reaching coagulation temperatures or causing necrosis. The ability to deliver multiple pulses to treat vascular lesions may have theoretical support since Dierickx et al were able to achieve multiple-pulse photocoagulation of blood vessels using lower fluences.

In the current study, adverse reactions included superficial blisters in 8% and transient crusting in 20%, especially in purple PWSs. The use of higher fluences seems to cause epidermal damage owing to absorption and backscattering of light from especially large vessels to the sur-
rounding tissue. Hypopigmentation (8.1%) and hyperpigmentation (2.7 %) were relatively infrequent. Finally, scar formation was not seen in our patients. This approximately corresponds to the references with regard to the application of IFLS for leg telangiectases (blisters, 2%-42%; hypopigmentation, 3%-20%; hyperpigmentation, 4%-50%; scarring, 0.5%-21%). In the treatment of PWSs, FLPDL caused comparatively frequent postinflammatory hyperpigmentation reported at a frequency of 9% to 57% (5,6,12,25,46-48) and postinflammatory hypopigmentation in 2% to 10%. 3,4,6,10,46 Hyperpigmentation and hypopigmentation were also the most common transient side effects of the long-pulsed FLPDL treatment of leg veins. 17,18

The rate of side effects, particularly with FLPDL-resistant dark types, combined with a relatively low incidence of side effects, makes IPLs a useful alternative for adjunctive or primary treatment of PWSs. Whether IPLs will find a firm place in the therapy of vascular lesions, especially of PWSs, still awaits large, critical, and especially prospective clinical studies, and better refined IPLS treatment parameters.

Accepted for publication March 11, 1999.

We are grateful to Thorsten Reinke, MS, Math, and his team for the statistical analysis of our data.

Reprints: Christian Raulin, MD, Kaiserstrasse 104 D-76133 Karlsruhe, Germany (e-mail: dres.raulin@t-online.de).

REFERENCES


