# Treatment of Port Wine Stains With a Non-Coherent Pulsed Light Source (PhotoDerm® VL) - A Retrospective Study

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**Abstract**

*Objective:* The flashlamp pulsed dye laser (FLPDL) is currently the treatment of choice for port-wine stains (PWS). We recently investigated whether a non-coherent intense pulsed light source (IPLS) would be effective in the therapy of PWS.

*Design and Patients:* In order to evaluate the efficacy in treatment of PWS (especially adult-type dark and hypertrophic), a retrospective study of 37 patients (randomly selected) with a total of 40 PWS treated with IPLS was initiated. Clinical PWS characteristics recorded were color and location of the PWS. Data collected included treatment parameters (filters, pulse duration, fluence and pulse sequencing), % clearance, and side effects (purpura, blisters, crusting, altered pigmentation and scarring).

*Results:* Good and complete (70-100 %) clearance was achieved in 28 of 40 PWS treated with IPLS. Average number of treatment sessions in PWS reaching 100 % clearance included 4.0 for pink PWS and 1.5 sessions for red PWS. Average number of sessions in purple PWS reaching good clearance (70-99%) was 4.2 sessions. Parameters used most frequently were 515 and 550 nm cut-off-filters, pulse duration of 2.5-5.0 ms and fluences of 24 to 60 J/cm$^2$. Side effects included purpura in 76%, superficial blisters in 8% and crusting in 20%. Transient pigmentation changes were seen in 10.8% of patients (hypopigmentations in 8.1%, hyperpigmentation in 2.7%). No scarring was observed.

*Conclusion:* IPLS presents an effective and safe method for treating PWS, especially dark and facial PWS.

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**Introduction**

Port wine stains (PWS) - a congenital, progressive ectasia of the superficial cutaneous vascular plexus - appear in 0.3-0.5% of newborns. At birth, PWS are typically flat, sharply delineated light red lesions, often occupying large surface areas. Facial PWS often occur in the region of the 1st and 2nd trigeminal nerve. 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 (1-5).

Previous methods of treating mature PWS included surgical solutions such as excision and dermabrasion, carbon dioxide cryotherapy, sclerotherapy, radiation and radio-implants (2, 6). These treatments frequently result with associated complications, such as scars or pain. Radiation-induced tumors as rare complications are known.

A variety of laser systems have been used, such as the argon, KTP, krypton, copper vapour laser 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 (5, 12-15). However efficacy for dark and particular nodular PWS in adults is low most likely due to its relatively short pulse duration (450 µsec) and limited depth of penetration (max. 1.5 mm) (6,16). New laser systems like the flashlamp- pumped tunable dye laser (ScleroPlus Laser, Candela Corporation; Millenium, Cynosure) that permit the choice of longer wavelengths (585 - 600 nm) and longer pulse widths (1.5 ms) became available for the treatment of vascular lesions such as leg telangiectasia (14, 17, 18, 19). A long-pulsed KTP laser (potassium-titanyl-phosphate) at 532 nm allows for the application of variable pulse widths in the 1-50 millisecond range (Aura™ , Laserscope; Versapulse, Coherent) (10, 19, 20, 21, 22). A deeper penetration can be reached and with longer pulse durations, which lie closer to the thermal relaxation times of larger vessels (23), a more effective thermal coagulation can be achieved.

IPLS has been thought to present another alternative for vascular lesions comprised of larger vessels. This high energy flashlamp, emitting non-coherent light and providing a wide range of various treatment parameters (wavelength, pulse duration, pulse sequences) has been used effectively in the treatment of cavernous hemangiomas, venous malformations, facial and leg telangiectasias, spider nevi, poikiloderma of Civatte and hypertrichosis (24-30).

IPLS functions are also based on the principle of selective photothermolysis (11). By using the appropriate wavelength and delivering sufficient energy within the thermal relaxation (cooling) time of the target chromophore (oxyhaemoglobin in vessels in PWS), it is possible to specifically damage selected targets within tissue. By applying long pulses and multiple pulse sequences, and by splitting up higher energy densities, IPLS allows for the treatment of larger blood vessels and cavernous vascular lesions. Longer wavelengths allow for the heating of deep lying vascular structures.

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

**Patients and Methods**

From October 1994 to January 1997, 37 patients (25 female, 12 male), with 40 PWS were treated using IPLS (Photoderm VL, ESC Medical System Ltd, Yokneam, Israel) emitting non-coherent light with a continuous wavelength ranging from 500 to 1000 nm (spectral output of the optical treatment head - see Fig.1). By using cut-off 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 ms in the short pulse mode and up to 30 ms in the long pulse mode. Delay between pulses can be adjusted between 10 and 500 ms. Fluences from 3 to 90 J/cm$^2$ are attainable. Surface area is large: 2.8 cm$^2$ (8x35 mm).

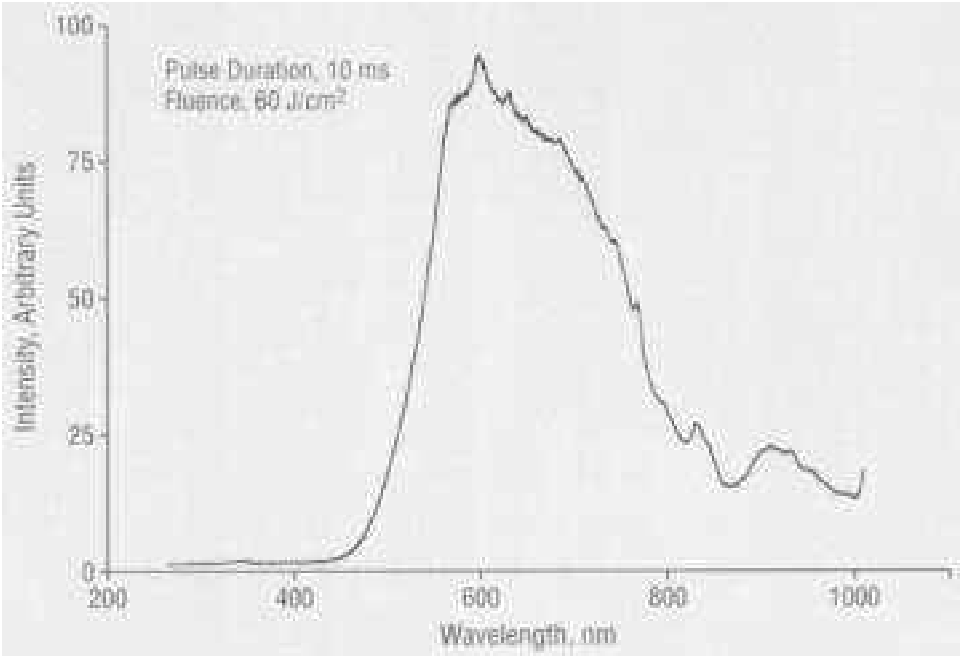


Fig. 1: Emission spectrum at the optical treatment head without cut-off filter only including a fixed mandatory blocking filter (pulse duration: 10 ms, fluence: 60 J/cm$^2$); Source: Dr. H. Lubatschowski, Laser Zentrum Hannover e.V.

The patients were randomly selected from the treated populations of the authors. Table 1 provides data of the patients.

Table 1. Patient demographics

| | |
|---|---|
| number of patients<br>male<br>female | 37<br>12<br>25 |
| age<br><12 years | 1 - 68 years<br>2 (1 and 4 years) |
| Fitzpatrick skin type I<br>II<br>III<br>IV-VI | 3<br>22<br>12<br>- |

| | |
|---|---|
| number of PWS<br>pink<br>red<br>purple | 40<br>14<br>15<br>11 |
| localisation of PWS<br>face<br>neck<br>trunk<br>extremities | 20 (no periorbital PWS)<br>6<br>6<br>8 |
| previously treated PWS<br>argon and/or dye laser<br>kryotherapy<br>localisation: face<br>neck<br>trunk<br>extremities | 12 (5 red, 7 purple)<br>11<br>1<br>6<br>1<br>2<br>3 |
| local anaesthesia (EMLA - 2.5% lidocain/2.5% prilocain cream) | 6 patients<br>(among 2 children) |

All treatments were performed using a clear cooled proprietary water based gel (Coupling Gel, ESC Medical System Ltd., Yokneam, Israel) 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 20-30 minutes. Topical antibiotic or steroids were not required post-treatment. Patients were treated with IPLS in intervals of four weeks and longer.

Due to the retrospective character of our study and different investigators, no uniform treatment parameters were employed. 515, 550, and 570 nm filters werde used, total fluence ranged from 24 to 60 J/cm$^2$, and energy was applied in single, double, and triple pulse sequences. First the PWS were treated in the single pulse mode. In case of non-response, total fluence delivered was increased by using double and triple pulses, until an immediate response of erythema or purpura was seen. In only one case (purple PWS) IPLS was employed in the long pulse mode (590 nm, triple pulse) with high fluence of 70 J/cm$^2$.

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). Pre and post-treatment photographs were reviewed by 3 non-participating 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: 100% clearance (complete), 70-99% clearance (good), 40-69% (fair) and less than 40% clearance (poor). Presence or absence of post-treatment blisters, purpura, crusting, hypo- or hyperpigmentation or scarring was recorded corresponding to data in patients´documents. For statistical analysis the average parameters and standard deviation were determined.

**Results**

The average number of sessions was 2.9 for pink PWS (SD ± 2.87), 2.0 for red PWS (SD ± 1.56), and 4.0 for purple PWS (SD ± 1.87). It is noteworthy that 70-99 % clearance of pink PWS occurred with an average of 2.8 sessions (SD ± 2.13), red with 1.4 sessions (SD± 0.53), and purple with 4.2 sessions (SD ± 2.59). In 5 of 14 pink PWS a 100 % clearance was observed after 4.0 sessions (SD ± 4.69). Two of 15 red PWS showed an complete clearance after 1.5 sessions (SD ± 0.70). There was no 100 % clearance in purple PWS.

The majority of the pink and red PWS (48 and 53% respectively) were treated mostly with the 550 nm filter while dark PWS (46%) required the 515 filter. The latter was very often used by two of the authors. In 77.7% of the total sessions a single pulse was applied. For single pulses, the 515 nm filter with a 2.5 ms pulse duration was most frequent (48.5%). The 550 nm filter with a 5 ms duration was required in 38.9%. Double pulses and triple pulses were employed but less frequently (14.3% and 14.8% respectively). Energy density ranged from 24 to 60 J/cm$^2$. The mainly used fluence in the single pulse mode was 28-30 J/cm$^2$.

Treatment results for previously untreated PWS (n=28) included 7 completely cleared (5 pink and 2 red), good clearance in 14 PWS (6 pink, 6 red and 2 purple) and fair clearance in 6. One case of previously untreated red PWS demonstrated poor results (Table 2).

Table 2. Degree of clearance in previously untreated PWS (n=28) in relation to their color

| Clearance (%) | Pink PWS | Red PWS | Purple PWS | Total | % |
|---|---|---|---|---|---|
| 100/complete | 5 | 2 | 0 | 7 | 25.0 |
| 70-99/good | 6 | 6 | 2 | 14 | 50.0 |
| 40-69/fair | 3 | 1 | 2 | 6 | 21.4 |
| <40/poor | 0 | 1 | 0 | 1 | 3.6 |
| Total | 14 | 10 | 4 | 28 | 100.0 |

Previously treated PWS (n=12) showed 100 % clearance in one case of red PWS. Good clearance was recorded in 6 cases (2 red and 4 purple), while 4 PWS (1 red and 3 purple) demonstrated fair results. One red PWS showed poor clearance (Table 3).

Table 3. Degree of clearance in previously treated PWS (n=12) in relation to their color

| Clearance (%) | Pink PWS | Red PWS | Purple PWS | Total | % |
|---|---|---|---|---|---|
| 100/complete | 0 | 1 | 0 | 1 | 8.3 |
| 70-99/good | 0 | 2 | 4 | 6 | 50.0 |
| 40-69/fair | 0 | 1 | 3 | 4 | 33.4 |
| <40/poor | 0 | 1 | 0 | 1 | 8.3 |
| Total | 0 | 5 | 7 | 12 | 100.0 |

In summary, complete and good clearances (70-100 %) were recorded in 75 % of previously untreated PWS in contrast to 58.3 % of previously treated PWS.

Side effects included immediate erythema in all sessions and immediate purpura in 76% of sessions, persisting for a maximum of 7 days, typically 24-72 hours. Immediate post-treatment swelling lasting only some hours was common. Swelling persisting longer than 24 hours and blisters were rarely observed following treatment with higher fluences (1.1% and 8%, respectively). In 20% of sessions, crusting was noted which resolved within 1 to 2 weeks (Table 4). Hypopigmentation was seen in 8.1% of patients, and hyperpigmentation in 2.7% of patients. These resolved within 2-4 months. No scarring or textural change resulted.

Table 4. The frequency of side effects following PhotoDerm VL treatment

| | Pink PWS | Red PWS | Purple PWS | Number of side effects | % of total number of treatments, n=175 |
|---|---|---|---|---|---|
| purpura | 38 | 38 | 57 | 133 | 76 |
| long-term swelling | 0 | 2 | 0 | 2 | 1 |
| blisters | 2 | 5 | 7 | 14 | 8 |
| crusting | 4 | 8 | 23 | 35 | 20 |
| Hypopigmentation | 1 patient | 2 patients | - | 3 patients | 8.1% of patients |
| Hyperpigmentation | - | 1 patient | - | 1 patient | 2.7% of patients |

Illustrative case is shown in Figure 2.

Fig 2A: A 56 year old woman with a slightly raised purple PWS on the right temple.

Fig 2B: 99% clearance following 6-time therapy with IPLS (1x515,2x550,2x570,1x590nm; pulse duration 2.5 - 8.5 ms; 28 -70 J/cm$^2$)

**Discussion**

The application of light in blue-green to yellow wavelengths results in selective damage of cutaneous vascular structures secondary to heating of hemoglobin as illustrated by most successful use of FLPDL (577/585 nm, pulse duration 0.45 ms) for PWS elimination (3, 4, 31-33).

The primary limiting factor of FLPDL is the small depth of penetration. Histologic studies demonstrated insufficient coagulation of dermal vessels below 1.16 mm in human skin (34-36). Vessels lying beyond the limited penetration depth may persist and determine clinical response. In a PWS 577/585 nm laser treatment model, it has been shown that most energy is deposited in the superficial vessels. Multiple vessels mutually influence one other: the presence of overlying vessels decreases the amount of light available to be deposited in deeper vessels (shadowing effects). By this modelling the smaller effective depth at which vessel destruction occurs (max. 0.65 mm) by FLPDL may be explained (37). Our study corroborated this: 7 out of 11 purple PWS had been previously treated unsuccessfully with argon and/or FLPDL. The strong absorption of 488/514 nm and 577/585 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 (18, 36, 38). Concomitant increases in fluence are required to compensate for the decreased absorption. (18). It has been shown that the use of 600 nm FLPDL with greater fluences (9.9 and 13.2 J/cm$^2$) provides a higher degree of clearance compared to 585 nm FLPDL at 6.6 J/cm$^2$ (39). IPLS utilizes a broad spectrum of long wavelength (515-1000 nm) and the necessary high fluences (up to 90 J/cm$^2$). Thus, effectively heating the upper as well as the deeper vessels of PWS could be obtainable. Our data shows that 6 out of 11 purple PWS achieved a good clearance (70-99 %) within an average of 4.0 and 4.2 sessions using IPLS.

It has been shown that the clinical response of lightening in PWS following FLPDL (585 nm; 0.45 ms pulse length; fluence of 6.5 J/cm$^2$) is dependent on vessel depth, diameter, and wall thickness. PWS with good responses were more superficially located (above 300 µm from the dermoepidermal junction) than the moderate and poor responders. 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 histologic examinations, there was also a tendency toward larger vessel-wall thickness with increasing depth in the dermis (34, 40). Analytic modeling of the influence of wavelength on PWS with different dermal blood content confirms that 577 nm is the optimal wavelength for treatment of pink PWS (small vessels < 14µm) (38). This fact concurs with the studies of Tan et al., showing excellent results on pale pink lesions (5).

Ideally, the pulse duration should be compatible with the diameter of vessel and be about equal to the thermal relaxation time for that dimension (23, 24, 41). Dierickx et al. discussed the benefits of longer pulse duration and concluded that pulse durations of 1-10 ms allow destruction of 30-150-µm vessels while sparing the capillaries (23). Using tunable FLPDL (585-600 nm; 1.5 ms: *ScleroPlus LaserÔ , Candela Corporation; MilleniumÔ , Cynosure*) and long-pulse frequency-doubled Nd:YAG laser (532 nm; *VersaPulseÔ , Coherent*; *AuraÔ , Laserscope*) good results could be achieved in the treatment of ectatic blood vessels encountered in PWS, telangiectases (10, 19, 20, 21, 22), and leg veins smaller than 1 mm in diameter (17, 18). IPLS providing pulse durations up to 50 ms 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 ist associated purpura and hyperpigmentation (24, 27, 37, 42, 43). Therefore, IPLS can be seen as an additional mode of PWS therapy, particularly for dark and hypertrophic lesions (26). It has been shown in a case report that FLPDL resistant PWS showed a significant improvement following a single IPLS treatment (42).

Using IPLS, splitting light into double and triple pulses is possible. Thus, larger and deeper vessels, such as in hypertrophic PWS or venous malformations, requiring higher fluences to reach sufficient coagulation, can be treated effectively by additive heating (27, 44). The epidermis and smaller vessels cool down during the long delay between pulses (10-500 ms) without reaching coagulation temperatures or causing necrosis (24). 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 (23).

In the current study, adverse reactions included superficial blisters in 8% and transient crusting in 20%, especially in purple PWS. The utilization of higher fluences seems to cause epidermal damage due to absorption and back scattering of light from especially large vessels to the surrounding 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 IPLS for leg telangiectases (blisters 2-42%, hypopigmentation 3-20%, hyperpigmentation 4-50%, scarring 0.5-21%) (24,25). In the treatment of PWS, FLPDL caused comparatively frequent postinflammatory hyperpigmentation reported at a frequency of 9 to 57 % (5,6,32, 35,46,47,48) and postinflammatory hypopigmentation in 2 to 10 % (3,4,6, 16,46). Hyper- and hypopigmentation were also the most common transient side effects of the long-pulsed FLPDL treatment of leg veins (17,18).

The success rate with PWS, 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 PWS. Whether IPLS will find a firm place in the therapy of vascular lesions, especially PWS, still awaits large, critical and, especially prospective clinical studies, and possibly more refined IPLS treatment parameters.

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*(For references please contact authors)*

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