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ORIGINAL ARTICLE

Clinical analysis of port wine stains treated by intense pulsed light

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Abstract

Background: Port wine stains (PWS) are formed by dilation and malformation of dermal capillaries without endothelium proliferation. Despite the improvements in lasers and light therapy for PWS therapy in the past 10 years, the 'cure' rate is only about 10%. Intense pulsed light (IPL) is a non-coherent light based on the theory of selective photothermolysis. *Objective:* To evaluate the efficacy of a new IPL on PWS. *Methods:* Seventy-two patients with PWS treated with an IPL with synchronous cooling were retrospectively analyzed. According to AQ1: sentence re-punctuated in places. Please check through and confirm correct.the Fitzpatrick skin type, color, location of the lesion, and treatment reaction, light filters of 560 nm 590 nmor 640 nmwere used with a single pulse with a pulse width of 6–14 ms and a fluence of 16–29 J/cm2; a double pulse with a pulse width of 3.5–4.0 ms, a pulse delay of 20–30 ms, and a fluence of 17–23 J/cm2; or a triple pulse with a pulse width of 3.0–4.0 ms, a pulse delay of 20–40 ms, and a fluence of 18–22 J/cm2. The adverse effects and the relationships among the lesion type, treatments, ages and location were analyzed. *Results:* Most of the PWS lesions faded significantly and the response rate in this series was 76.4%. Patients resistant to other forms of therapy also showed good clinical results. Adult lesions were easier to remove than those in younger individuals. Further improvement did not occur after three treatments. We failed to find any relationship between efficacy and location of the PWS. *Conclusion:* The IPL treatment modality is safe and efficient for the treatment of PWS and for those which may be resistant to other therapies. The IPL is an alternative method for most PWS lesions.

Key Words: *Efficacy, intense pulsed light, port wine stains*

Introduction

Port wine stains (PWS) result from dermal capillary dilation and malformation. The incidence is reported to be between 0.3% and 0.5% in infants (1). Selim et al. (2) found that innervation was decreased in PWS lesions compared with the uninvolved 'normal' area. This observation suggested that the innervation may be an important factor in PWS pathogenesis. The PWS lesion shows dilated, clustering capillaries located in the middle and superior part of the dermis at approximately 100–1000 μm in depth and approximately 10–300 μm in diameter; the epidermis is usually normal (3) in these lesions. In general, the older the patient, the greater the quantity of capillaries without hyperplasia in blood vessel endothelium. When the lesion bulges or develops a nodule, dilated capillaries are noted in the deep dermis and subcutaneous tissue as well.

Traditional therapy for PWS has included cryotherapy, excision, skin grafting, dermabrasion, tattooing and radiation therapy. All have proven to be inefficient and are prone to scarring. Lasers including the pulsed dye laser, variable pulse frequency-doubled Nd:YAG laser, alexandrite laser, and the diode laser are clinically used more often today for PWS. All have demonstrated efficacy, but the 'cure' rate of the lesions is reported to be approximately 10% (4).

Here we report 72 patients with PWS treated by a new intense pulsed light (IPL) with synchronized cooling and analysis of its efficacy and safety in treating these lesions is presented.

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Patients and methods

Patients

Seventy-two patients with PWS aged from 2 months to 50 years old (average 16.7 years) were included in this study. There were 34 children (< 18 years) and 38 adults (⩾ 18 years); 27 were male cases and 45 were female cases. The lesions were located in 100 locations: 42 on the cheek, 17 on the neck, 12 on the temple, 13 on the midface, eight on the mental region, six on the forehead and two on the extremities. According to color and thickness, the lesions were divided into three types: (i) pink (31 cases); (ii) purple-red (32 cases); and (iii) thickening (nine cases). Among them, 25 of the lesions had been previously treated by either a variable pulse 532-nm laser, one by long pulse Nd:YAG 1064-nm laser, and one by isotope treatment.

Treatment procedure

The Lumenis One-IPL (Lumenis Inc, Santa Clara, CA, USA) with synchronous cooling technique was used for all the treatments in the retrospective analysis. According to the Fitzpatrick skin type, color, depth of the lesion, and treatment reaction, cut-off filters of 560 nm 590 nmor 640 nmwere used with a single pulse with a pulse width of 6–14 ms and fluence of 16–29 J/cm2; a double pulse with a pulse width of 3.5–4.0 ms, pulse delay of 20–30 ms, and a fluence of 17–23 J/cm2; or a triple pulse with a pulse width of 3.0–4.0 ms, each pulse delay 20–40 ms, and a fluence of 18–22 J/cm2. Before each treatment, the area was cleaned and a cool coupling gel with a 1–2-mm thickness was applied. The crystal light guide was placed parallel to the skin over the treatment area without pressure in order to avoid expelling blood from the PWS. Every light spot adjoined each other without overlapping.

The treatment endpoint occurred when the color of the treated cutaneous vessel showed darkening or slight purpura. After the treatment, cold compresses and ice were used for 20 minutes and an antibiotic ointment was applied to the treated area without the use of systemic medication. The interval between treatments was 1–2 months.

Photographs were taken before and after each treatment and at the follow-up visit in order to compare efficacy. The final evaluations of treatment results were performed by a trained dermatologist in a blinded fashion.

The criterion of the efficacy

Efficacy was evaluated according to the photographic analysis. Patient responses were divided into four groups according to the clearance rate of the lesion: excellent = 75–100%; good = 50–75%; fair = 25–50%; poor = < 25%. The response rate was determined via the following formula: (cases of excellent + cases of good + cases of fair)/total cases. Clinical effect was evaluated with photographs 1–2 months after the last treatment.

Statistical analysis

Data were analyzed with the chi-squared test or Fisher's exact probability.

Results

Efficacy of different clinical types

Most lesions faded significantly, with a response rate of 76.4%. Seventy-two patients were divided into three types according to their clinical manifestation. Efficacy was noted after one to five treatments. No statistical significance was found among the types as demonstrated in Table I.

Efficacy in adults versus children

Thirty-eight adult cases responded to therapy. Compared with children, adult PWS lesions showed better clinical results ($\chi^2 = 4.875$, $p = 0.0277$), as shown in Table II

Efficacy of treated lesions versus untreated lesions

The efficacy of the Lumenis-IPLAQ2: should this be the 'Lumenis One-IPL'? Amend accordingly. on the untreated lesions was compared with the treated lesions, including 25 cases by variable pulse 532-nm laser, one by long pulse Nd:YAG 1064 nmlaser and one by isotope therapy. Table III shows that no statistical significance was found by chi-squared test between the two groups.

Treatments and efficacy

Seventy-two patients received one to five treatments. They were divided into two groups: < 3 treatments and ⩾ 3 treatments. No statistical significance was found between the two groups by chi-squared test, as shown in Table IV

Locations and treatment efficacy

We evaluated the relationship between the PWS location and the treatment efficacy. Table V shows that the PWS lesions in different regions showed different efficacies without statistical significance.

Adverse effects and management

Seventy-two patients received one to five treatments (average 2.47). Topical antibiotic ointment was

Table I. Comparison of efficacy in different types.

Type	Excellent	Good	Fair	Poor	Total	Response rate
Pink type	4	7	13	7	31	77.4%
Purple-red type	2	10	10	10	32	68.8%
Thickening type	1	3	5	0	9	100%

routinely used after the IPL treatment. Blister formation (diameter approximately 0.2–0.5 cm) or moderate to severe purpura were found in 20 patients (27.8%) within 24 hours after the treatment and disappeared within 1–2 weeks. Mild to moderate hyperpigmentation was found in 10 patients (13.9%), mild hypopigmentation in 12 (16.7%) and slight atrophic scar formation in one (1.4%). All of the hyper- and hypopigmentation disappeared within 3–6 months following the last treatment and with the use of hydroquinone.

Discussion

An IPL source is different from laser technology but can be used clinically like lasers in many instances. The absorption spectrum generated from an IPL allows coverage from blue light to the infrared areas. The IPL is based on the theory of selective photothermolysis, which has the same characteristics of 'particle' (the energy of photon is freed with the unit of photon) and 'wave' (which has determinate frequency and amplitude of vibration) as laser technology. Different light filters are used to cut off the unnecessary shorter wavelength according to the demand of treatment. Heat is generated when the energy of light is absorbed by oxyhemoglobin and then conducted to the capillary to destroy it.

Traditional IPL systems have one limitation: the output spectrum can shift during the pulse due to the method of delivering the energy to the flash lamp. The output consists of a short, high-intensity 'spike' that gradually increases from zero to maximum intensity and decays back to zero. At the outset of the pulse, the spectrum is biased towards the red wavelengths. As the current increases, the spectrum shifts towards the blue. As the current decays, the spectrum moves back to the red light area. Traditional IPL technology has to produce high-intensity spikes to overcome the long intra-pulse periods where both the skin surface and target structure cool. In most instances, there is a need for the skin surface to cool to prevent epidermal damage; however, this

Table II. Comparison of efficacy in adults and children.

Type	Excellent	Good	Fair	Poor	Total	Response rate
Children	3	7	12	12	34	64.7%
Adult	4	13	16	5	38	86.8%

Table III. Efficacy of treated and untreated lesions.

Classification	Excellent	Good	Fair	Poor	Total	Response rate
Treated	0	8	10	9	27	66.7%
Untreated	7	12	18	8	45	82.2%

does increase the energy required to destroy the target. Spectral jitter can lead to variable tissue interactions, potentially resulting in ineffective treatment and increased incidents of adverse effects (5).

The Lumenis One-IPL is the newest IPL from Lumenis Inc. and delivers intense compound light in the 515–1200-nm wavelength with optimal pulsed technology. The pulse shape is uniform, increasing from zero to maximum intensity almost instantaneously, remaining at maximum for the entire duration of the pulse, then dropping to zero again instantaneously. An advantage of the uniform temporal profile is that the output wavelength is stable throughout the pulse. The epidermis is protected with synchronous cooling technology when the dilated capillary network is being treated. The development of synchronous cooling technology decreases the risk of epidermal burning and increases the clinical effect.

The abnormal vessels in PWS lesions consist of dilated blood vessels with different diameters and different depths. Video microscopy has revealed three patterns of vascular ectasia: ectasia of the vertical loops of the papillary plexus; ectasia of the deeper, horizontal vessels in the papillary plexus; and a mixed pattern with varying degrees of vertical and horizontal vascular ectasia (6). Most of the patients resistant to traditional laser therapy had smaller diameter and deeper vessels (2). Lasers with a single wavelength may have limited penetration depth, and the variable pulse width is relatively narrow. All of these factors inhibit the destruction of some of the deeper and smaller diameter blood vessels. The pulse width and the pulses in the Lumenis One-IPL are tunable, so a different pulse width can be chosen for different diameter vessels; a different wavelength and pulses for a different depth of the lesion. Another advantage of IPL therapy is that the large spot size increases the penetration and decreases the scattering of light. We believe that its merits may help the thermal effects of the IPL to reach vessels of different sizes and depths and destroy them to clear or improve the lesion.

The color of a PWS lesion is determined by the diameter and depth of the blood vessels within the

Table IV. Treatments and efficacy.

Frequency	Excellent	Good	Fair	Poor	Total	Response rate
< 3 Treatments	5	13	15	12	45	73.3%
⩾ 3 Treatments	2	7	13	5	27	81.5%

Table V. Locations and efficacy.

Location	Excellent	Good	Fair	Poor	Total	Response rate
Cheek	2	11	16	13	42	69.0%
Neck	3	5	5	4	17	76.5%
Temple	1	3	3	5	12	58.3%
Midface	0	4	5	4	13	69.2%
Mental region	1	1	3	3	8	62.5%
Forehead	2	1	1	2	6	66.7%
Extremities	0	1	1	0	2	100%

PWS. Usually, the vessel of a pink lesion is deeper in the skin and smaller in diameter, while the vessel of a purple lesion is deeper in the skin and bigger in diameter, and the vessel of a red lesion is usually shallower in the skin (7). As this was a retrospective study, we have no data on the diameter and depth of blood vessels for the different lesions treated. We divided the lesions into three types simply according to color and hyperplasia (8), which was easy to judge in clinical applications. Clinicians can select reasonable parameters to increase efficacy according to the different lesion types. For the pink lesions, longer wavelength light filters and shorter pulses can be selected. For the purple-red lesions, shorter wavelength light filters and longer pulses may be preferred. The IPL has a wavelength range of 515–1200 nm and can penetrate to the deeper vascular network found within a PWS. The diameter and depth of the vessels in different types of PWS are different. IPL can produce a series of different wavelengths that can treat different depth vessels, thus optimizing treatment efficacy.

It was previously reported that the children's responses to laser therapy were better than those of adults (9,10). Interestingly, in this study, the efficacy in adults was found to be better than in children. Possible reasons may be: (i) during treatment, no anesthesia was used, even when treating children, which may have limited the total treatment; or (ii) the PWS vessels of children with PWS may be smaller than those of adults, and thus the vessels of a child would respond less to the IPL; and (iii) the study's limited cases were not enough to achieve an unprejudiced result. In the future, we need a prospective, larger sample clinical trial to confirm our findings. To assure better efficacy, general anesthesia may be recommended when treating children in the future, as shown in Figure 1.

Some PWS lesions resistant to other therapy were included in our study and had satisfactory efficacy. Although the efficacy was almost the same between the treated and the untreated group, the cure rates of the untreated lesions were better than those of the treated lesions. Our results were similar to a previous finding (11): in this trial, 15 patients with PWS lesions resistant to multiple pulsed dye laser (PDL) treatmentsAQ3: re-worded. Confirm correct. were treated up to four times with IPL and

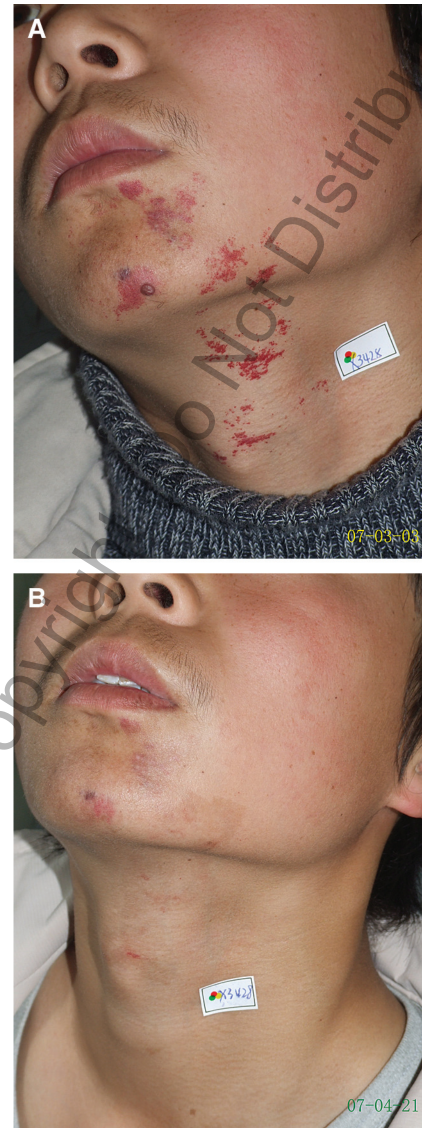

Figure 1. An 18-year-old man (A) before treatment and (B) 49 days after one treatment, with excellent response. Parameter settings: 560 nm single pulse with pulse width of 6 ms, fluence of 20–21 J/cm^2.

were divided into two groups – responders to IPL treatments (46.7%) and non-responders (53.3%). All responders obtained more than 50% reduction in their PWS, and 85.7% of the responders obtained between 75% and 100% reduction in their lesions.

The patients were divided into two groups in our study: < 3 treatments and $\geqslant 3$ treatments. Although patients who received more than three treatments demonstrated better efficacy, no statistical significance was found (the response rate was 81.5% vs 73.3%) by chi-squared test. This result suggested that the patients who had no response after two treatments of IPL may not respond to further IPL therapy.

A previous report suggested that there was a relationship between the location of the PWS and efficacy of the response (9). Some investigators have found that if the lesion is located in the central area of the face, the abnormal vessels are usually located deeper in the skin than in other anatomical areas (12–14). But in our study, we failed to find any relationship between PWS location and treatment efficacy. The possible reason was the merits of IPL, where the broad spectrum, large spot size, tunable pulse width and number of pulses used helped minimize the differences of location. But a larger sample trial is needed in the future to confirm our presupposition.

As the selectiveness of IPL is not as specific as that of the vascular laser, it would be very important to obtain a reasonable parameter to decrease possible adverse effects. A test treatment on a representative small and hidden area is recommendable before treatment; treatment parameters should then be adjusted according to the clinical reaction of the test treatment. The expected treatment reaction is a little darkening of the blood vessels and/or edema of the lesion but no blisters or burns in the epidermis. If no endpoint is seen, then adjust the parameters through any of the following: fluence, pulse delay and/or pulse width and/or pulse number and/or the filters directly.

Conclusion

The IPL treatment modality is safe and efficient for the treatment of PWS lesions resistant to other therapies. The Lumenis One-IPL is an alternative method for most PWS lesions.

Declaration of interest: Drs Guang Li, Tong Lin, Quiju Wu, Zhanchoo Zhou have no conflicts of interest and are responsible for the content and writing of the paper.

Dr Gold is a consultant to Lumenis.

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