Seventy-six patients (51 females, 25 males) with port-wine stains (PWS) were treated with the flashlamp-pumped pulsed dye laser (585 nm, 450 μsec). The patients ranged in age from 1 month to 71 years (average, 14 yr). Forty-nine percent of all patients under study had a 90% or better (average, 94.6%) lightening response after an average of 9.0 (range, 4–15) laser treatments. Overall, there was a 79% clinical improvement seen after an average of 9.1 (range, 2–19) laser treatments. In contrast to previous studies, the number of treatments necessary to obtain PWS clearing in older children (9–15 yr) and adults (>16 yr) was not significantly greater than the number required to treat PWS in infants (0–2 yr) and younger children (3–8 yr). In fact, PWS in children aged 3 to 8 years required the greatest number of laser treatments, which may be due to continued abnormal growth of the ectatic blood vessels comprising the lesion during the growth of the child. In addition, there did not appear to be a significant difference in the number of laser treatments necessary to obtain clearing of PWS in different body locations. While the 585 nm pulsed dye laser continues to be the treatment of choice for removal of PWS in children and adults, the number of treatments necessary to obtain lesional clearing in all age groups is greater than previously reported.


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Port-wine stains (PWS) are benign, congenital vascular malformations histologically characterized by abnormally enlarged and ectatic blood vessels in the superficial dermis [1] and which occur in an estimated 3 per 1,000 births [2]. PWS present at birth as flat, pale pink patches that can be located anywhere on the body but are most commonly seen on the face and neck [3]. With advancing age, PWS appear darker in color (deep red or purple) and thicker and nodular in character due to the tendency for the abnormal blood vessels to become more ectatic with time [4].

Many treatments have been used in the past for PWS, including surgical excision and grafting [5], ionizing radiation [6, 7], cryosurgery [8], and tattooing [9, 10]. Results following these treatments were unpredictable and complications were common and potentially serious [11, 12]. Argon [13–17], carbon dioxide [18, 19], dye [20–26], and copper vapor [27] lasers have more recently been used as treatments for PWS as well as for other vascular lesions. The flashlamp-pumped pulsed dye laser at a wavelength of 585 nm and a pulse duration of 450 μsec has become the favored laser for treating benign vascular lesions due to its high specificity and safety profile in all age groups.

Previous studies involving the use of the flashlamp-pumped dye laser have focused primarily on treatment of PWS in children [23–26]. Based on these studies, it has been assumed that older children and adults require an increased number of laser treatments for total eradication of PWS when compared with infants and younger children (under the age of 7 yr). In addition, PWS of the trunk or extremities have generally been expected to require additional laser treatments than PWS of the face or neck. With continued clinical experience, however, it has become apparent that additional laser treatments may be necessary to obtain the degree of clinical improvement initially reported after 6 to 8 laser treatments.

This study was, therefore, undertaken to update information regarding the number of laser treatments required to clear PWS in children and adults and to report on differences in the clinical response in different anatomical areas. Comparison of before and after photographs were evaluated by the standard comparison of simultaneously projected images.
Table 1. Location and Size of Port-Wine Stains in Different Age Groups

<table>
<thead>
<tr>
<th>Age Groups (yr)</th>
<th>No. of Patients</th>
<th>PWS Size (mean, cm²)</th>
<th>No. of Patients</th>
<th>PWS Size (mean, cm²)</th>
<th>No. of Patients</th>
<th>PWS Size (mean, cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2</td>
<td>18</td>
<td>4–100 (38)</td>
<td>2</td>
<td>36–64 (50)</td>
<td>2</td>
<td>48–100 (74)</td>
</tr>
<tr>
<td>3–8</td>
<td>14</td>
<td>9–144 (61)</td>
<td>3</td>
<td>48–100 (83)</td>
<td>3</td>
<td>30–96 (66)</td>
</tr>
<tr>
<td>9–15</td>
<td>8</td>
<td>48–100 (71)</td>
<td>1</td>
<td>80 (80)</td>
<td>2</td>
<td>50–120 (85)</td>
</tr>
<tr>
<td>≥16</td>
<td>16</td>
<td>4–320 (84)</td>
<td>3</td>
<td>64–144 (109)</td>
<td>4</td>
<td>48–300 (133)</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>4–320 (62)</td>
<td>9</td>
<td>36–144 (84)</td>
<td>11</td>
<td>30–300 (95)</td>
</tr>
</tbody>
</table>

PWS = port-wine stain.

Materials and Methods

During the period of January 1991 through June 1993, 76 patients (51 females, 25 males) with PWS initiated therapy at the Washington Institute of Dermatologic Laser Surgery and had pretreatment and posttreatment photographs of comparable quality for use in this study. Ages ranged from 1 month to 71 years (mean, 14 yr). Lesional size varied from 4 cm² to 320 cm² (mean, 68 cm²). All patients had skin types I to II and none had received prior treatment of their lesions. Fifty-six (74%) patients had PWS localized to the face or neck, 9 (12%) had truncal involvement, and 11 (14%) had PWS on the extremities (arms/legs = 7:4) (Table 1). PWS color varied from pale pink to red and purple.

After informed consent was obtained, all patients were treated with the SPTL-1 flashlamp-pumped pulsed dye laser (Candela Laser Corp, Wayland, MA) with a 585-nm wavelength, 450-µsec pulse duration, and 5-mm spot size. Energy densities were measured with an energy meter (Ophir Optics Limited, Jerusalem, Israel) calibrated to ±10% accuracy. Energy densities ranged from 6.0 to 7.75 J/cm². The fluence used was determined by the patient’s age, skin color, and PWS color/thickness/location. In general, younger patients and fair-skinned patients were treated with the lowest energy densities. Subsequent fluences were adjusted contingent on patient response. Multiple nonoverlapping pulses were delivered to the entire PWS at each visit. The number of pulses administered ranged from 25 to several hundred during a treatment session. Laser treatments were delivered at 6 to 8-week intervals to allow for maximal vessel clearing.

All patients were treated in an outpatient setting without general anesthesia. Children aged 2 to 12 years had a topical anesthetic (30% lidocaine powder USP in velvacho cream base) [28] applied to their lesions and occluded with Tegaderm for 30 minutes prior to laser treatment. The Tegaderm and anesthetic cream were removed and the skin rinsed with tap water immediately before initiation of treatment.

Immediately after laser treatment, the PWS was covered with bacitracin ointment and a sterile nonstick pad. Each patient was instructed to gently rinse the treated area once to twice daily with tap water and then reapply bacitracin ointment and a nonstick bandage for 1 week or until healing was complete.

The degree of lightening of each PWS as a result of laser treatment was determined as the percent reduction in lesional color relative to the normal skin in gradations of 10%, with a 100% rating designated when the treated area had completely cleared to the normal surrounding skin color, a slight modification of the scale described by Garden and co-workers [22]. Pretreatment and posttreatment photographs were projected simultaneously and an assessment of the clinical response was made independently by two adult observers (TA and FW) as outlined above. All photographs were taken by a single photographer using the same camera, film type, lighting conditions, camera settings, and film processing technique.

Results

Seventy-six PWS patients, 1 month to 71 years of age, fulfilled the criteria for inclusion in this study. PWS ranged in color from a pale pink in 23
patients (30% of total) to a medium red in 44 patients (58%) and to a deep purple in 9 patients (12%). In general, paler lesions were seen most often in the youngest patients. The PWS were located on the face, trunk, and extremities in 74%, 12%, and 14% of the patients, respectively. No patient had received prior treatment to the PWS under investigation. All patients with preoperative and postoperative photographs of comparable quality with respect to camera angle and lighting were included in the study. No patients were excluded as a result of poor clinical response or inadequate treatment. Energy densities used ranged from 6.0 to 7.75 J/cm² (mean, 6.59 J/cm²). Laser treatments were delivered every 6 to 8 weeks.

Overall, a 79% PWS lightening was seen in all patients under study after an average of 9.1 laser treatments (range, 2–19) (Table 2). Forty-nine percent of patients had a 90% to 100% (average, 94.6%) clinical improvement after an average of 9.0 (range, 4–15) laser treatments.

The study group was divided further into the following age groups: 0 to 2 years, 3 to 8 years, 9 to 15 years, and ≥16 years (see Table 1). Favorable responses occurred in all age groups regardless of the lesional size or body location (Tables 2 and 3). No patients experienced crusting, blistering, infection, or scar formation following laser irradiation. Transient hyperpigmentation that resolved during the 6 to 8-week interval between treatments was reported by 34% of all patients but was most frequently seen in patients with extremity involvement.

### Discussion

The efficacy of the flashlamp-pumped pulsed dye laser at a 585-nm wavelength and 450-μsec pulse duration in the treatment of PWS has been clearly established in previous studies; however, the number of laser treatments necessary to achieve total eradication of these lesions has varied. Tan and colleagues [23] studied a population of 35 PWS patients between the ages of 3 months and 14 years who showed complete lesional clearance following an average of 6.5 laser treatments. Reyes and Geronemus [24] studied a population of 73 children aged 3 months to 14 years of whom 45% showed a 75% or better clearance rate after an average of 1.7 treatments. Only 3 of their patients achieved 100% clearing. Goldman and associates [26] reported on 43 children with PWS between the ages of 2 weeks and 14 years who had an average improvement of 69% after 3.7 laser treatments. Only 16% of the patients had >95% resolution after an average of 4.8 treatments.

The above studies all concluded that the therapeutic outcome of PWS to laser treatment correlates directly with the age of the patient; namely,
the younger the patient, the better the outcome with fewer laser treatments necessary to achieve maximum lesional lightening. This phenomenon has been explained by the fact that because skin thickness increases linearly with age up to the age of 20 years, laser irradiation may be better able to penetrate the deeper component of PWS in thin-skinned infants and children. In addition, the smaller vessel diameters seen in young children with pale pink PWS may be more amenable to laser treatment than the larger vessels seen in older children and adults.

Our study reports the results of flashlamp-pumped pulsed dye laser treatment on the largest group of PWS patients to date. In addition, a broader age range (1 mo to 71 yr) was included for a better representation of different sizes, colors, and locations of PWS. In all age groups, an average improvement of 79% was seen with 49% of patients showing a 90% to 100% lightening response after an average of 9 laser treatments. While a significant difference in the response of PWS to laser treatment in different body locations was not appreciated, differences in response rates became most evident in different age groups (see Tables 2 and 3).

As was to be expected, infants and young children below the age of 2 years achieved the highest average clearance (87.3%) after an average of 9.1 laser treatments. Fourteen of the 22 patients (64%) showed 90% to 100% clearance after 7.4 treatments. It is interesting that the range
in the number of treatments required (3 to 19) was much broader than in previously reported studies. In the 3- to 8-year-old age group, 78.5% average lightening occurred after a mean of 10.8 laser sessions. Forty-five percent of these patients demonstrated >90% clearance after 12 laser treatments.

Again the number of treatments is significantly higher than in previous reports. Patients in the 9- to 15-year age group showed a 77.3% improvement in the appearance of their PWS after 8.2 laser treatments and 45% had >90% lightening after 9.2 laser sessions. PWS patients >16 years of age demonstrated slightly less improvement (73.5%) after an average of 5.7 treatments, and only 9 of 23 patients (39%) had 90% to 100% clearing of their lesions.

While the number of laser treatments required for lesional lightening ranged from 2 to 19, every age group in this study required more laser treatments to achieve clinical improvement than reported in previous studies. The degree of lightening was greater overall than previously shown, which may account for the increased number of treatments necessary. It is interesting, however, that even children <8 years of age who in previous reports showed the best responses with the fewest treatments, required an average of 9.9 laser treatments for 83.1% clearance and an average of 9.6 laser treatments for 90% to 100% clearance.
Obviously, there were some children who required numerous laser treatments with slow improvement while other children demonstrated remarkable improvement (90–100%) in fewer laser sessions. It is interesting that those children with slow improvement did not necessarily have larger, darker, or nonfacial PWS, common explanations given for slow response rates.

PWS in the 3 to 8-year-old subgroup were even more difficult to clear, with an average of 10.8 laser treatments necessary to achieve 78.5% improvement overall and an average of 12 laser treatments required for 90% to 100% clearing. The number of laser treatments necessary were significantly higher \( (p < 0.01) \) than in the other age groups to achieve the same degree of clinical lightening. An explanation for this disparity is that children in the 3 to 8-year age group are growing rapidly and, quite possibly, may exhibit an associated growth in the residual blood vessels of the PWS in the interval between laser treatments. Therefore, the clinical response would be slower with PWS skin demonstrating less fading as residual blood vessels develop more ectasia between each treatment.

Surprisingly, older children (9–15 yr) and adults (>16 yr) required fewer laser treatments than the infants and children (6.5 treatments to achieve a 74.7% improvement). This, again, is in contradiction to other reports, which have conjectured that older patients require additional treatments because of the increased size, color, depth, and blood vessel diameter of the PWS with advancing age. Older children and adults with PWS may, in fact, have more stable lesions than infants and younger children, with less ectasia or resistance of the vessels to progressive treatments. The increased erythrocyte-to-surface area ratio seen in the darker and more nodular PWS in the adults may also account for the favorable response seen in these patients.

No complications, such as scarring or permanent pigmented changes, were encountered as a result of laser treatment by any patient during the course of the study. Transient hyperpigmentation was reported by 34% of the study patients, which was resolved within the 6 to 8-week interval between laser sessions in all patients. Those individuals with extremity involvement were more frequently affected.

The flashlamp-pumped pulsed dye laser remains the most acceptable method for treatment of PWS in patients of all ages. Removal of PWS is not simply a cosmetic consideration, but is important in preventing physical and psychological debilitation. This treatment method is safe, effective, and can be performed without general anesthesia. The end result is skin of normal color and texture. This study demonstrates that older children and adult patients can show clinical responses that fare equally with those of infants and younger children, thereby giving a more optimistic outcome to the older age group. Our study patients required an average of 9.0 laser treatments for 90% to 100% PWS clearing, but up to 19 treatments have been required. It is important to impart this information to PWS patients, as we may have been underestimating the number of treatments necessary for treatment of these lesions.

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