Does dye laser treatment with higher fluences in combination with cold air cooling improve the results of port-wine stains?

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Abstract

Background and objective The use of cold air cooling (CAC) and cryogen spray cooling during dye laser treatment of port-wine stains (PWS) has become a standard in recent years. Still unsolved is the question of which fluences are necessary in combination with CAC in order to achieve an optimum clearance and the lowest possible rate of side-effects.

Study design In a prospective study, we treated 11 patients with PWS with pulsed dye laser (Photogenica V®, Cynosure, λ = 585 nm, τp = 0.5 ms, spot size = 7 mm). Each PWS was partitioned into three areas: (area 1) 6 J/cm² without CAC, (area 2) 6 J/cm² with CAC (level 4), (area 3) 9 J/cm² with CAC (level 4).

Results Area 3 (mean, 59%) showed a slightly better clearance than area 1 (mean, 57%); in area 2, we observed a reduced clearance (mean, 45%). Compared with area 1, we achieved a reduction of pain through CAC in areas 2 and 3. The healing periods as well as the rate of side-effects were comparable in all areas.

Conclusion We observed a slight but not statistically relevant increase in clearance with the use of higher fluences and CAC compared with lower fluences without CAC. Because pain is lowered significantly when using CAC, and because this makes the treatment more comfortable for the patients, we tend to recommend the use of higher fluences (9 J/cm²) with simultaneous CAC for treating PWS.
patients with Fitzpatrick skin types I to III. The sizes of the PWS ranged from 13 to 3600 cm$^2$.

Two of the PWS were pink, six were red, and three were purple. They were located on the cheek, neck, back, and legs.

The treatment was done in one session with pulsed dye laser (Photogenica V®, Cynosure, Chelmsfort, CA; $\lambda = 585$ nm, $t_p = 0.5$ ms) and a spot size of 7 mm. Small PWS were partitioned into three areas; with bigger ones, we selected an area of $10 \times 10$ cm and partitioned it into three areas: (area 1) 6 J/cm$^2$ without cooling, (area 2) 6 J/cm$^2$ with cooling, (area 3) 9 J/cm$^2$ with cooling. For CAC, we used the device Cryo® 5 (Zimmer-Elektromedizin, Ulm, Germany) with cooling level 4. This cooling device generates from ambient air a continuous stream of air of 500 to 1000 L/min and a possible minimum temperature of $-30^\circ$C. Given an initial temperature of 32 $^\circ$C, this temperature yields a skin temperature of 15 $^\circ$C within 8 s.\textsuperscript{17}

The side-effects were assessed by the treating doctors and the patients themselves after 10 min, 3 days, and 6 weeks. The extent of pain was evaluated with a numerical scale (1, slight; 10, strong pain), other side-effects (purpura, blisters, crusting, hypopigmentation, and hyperpigmentation) by healing time in days.

After 6 weeks, clearance was evaluated by the patients themselves and by four independent medical doctors (0%, 10%, 20%, ... 100%). Photos were taken before and 6 weeks after treatment with a Canon EOS100 camera and an Agfa Ctx100 film.

**Results**

Side-effects like crusting, purpura and, in one case, hypopigmentation, occurred in all areas.

Slight crusting occurred without cooling in four cases and with cooling in two cases. With one patient, hypopigmentation was observed in all three areas. Blisters or scar formation did not occur at all.

The average healing times were 11 days in area 1, 10 days in area 2, and 12 days in area 3 (Table 1).

Compared with area 1, we achieved a considerable reduction of pain in areas 2 and 3 by using CAC (Table 2). Regarding the extent of pain, area 1 showed an average value of 6.6, area 2 showed 4.3, and area 3 showed 5.3. According to a Wilcoxon signed rank statistical test, treatment in area 2 was significantly less painful than in area 1 at $P = 0.05$.

A comparison of areas 1 and 2 shows that clearance in area 2 is lower with five patients (on average from 64%
to 34%, Table 3), the same with five patients (average clearance 54%) and higher with one patient (from 40% to 60%).

A comparison of areas 1 and 3 shows higher clearance for area 3 in three cases (on average by 13%), lower clearance (by 20%) in one case, and no change in seven cases (average clearance of 69%).

When comparing areas 2 and 3, we observed higher clearance for area 3 in seven cases, no difference in three cases, and lower clearance in area 3 in one case.

On average, we had the best clearance rate in area 3, directly followed by area 1, and the worst clearance in area 2 (area 1, 57%; area 2, 45%; area 3, 59%; fig. 1a–c).

It seemed that clearance was dependent on the colour of the PWS. Red PWS showed the best (68–73%), pink ones medium (30–85%), and purple ones the worst clearance rates (13–20%).

### Discussion

The treatment with the 585-nm pulsed dye laser has been an accepted standard therapy of PWS for many years; it is based on the effects of selective photothermolysis and thermal relaxation time. Accompanying cooling methods (cryogen spray and cold air) have also become part of the standard therapy; they help to reduce pain and side-effects.

In many cases, there is still an incomplete or unsatisfactory lightening of PWS. Thus, it is necessary to conduct more studies to evaluate the use of different parameters; the most suitable method is the direct side-by-side comparison. Another open question is the safety and efficacy of higher fluences in combination with the use of CAC.

In a retrospective study, Chang and Nelson evaluated a total of 196 patients with PWS; each PWS was treated with only one set of parameters (8–10 J/cm², 0.5 ms, 7 mm, with CSC or 5–7 J/cm², 0.5 ms, 7 mm, without cooling). Significant improvement of clearance due to fluence increase was observed only in those PWS that had severity score 2 (well-defined borders, uniform lesion with no areas of normal skin, plus raised or thickened lesion, plus modularity or hypertrophy of involved anatomic structure). The question of why patients with PWS with severity score 1 (faint, barely discernible

### Table 3 Average clearance and localization of PWS

<table>
<thead>
<tr>
<th>Patient</th>
<th>Localization</th>
<th>6.0 J/cm² without cooling</th>
<th>6.0 J/cm² with cooling</th>
<th>9.0 J/cm² with cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Back</td>
<td>90</td>
<td>50</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>2 Cheek</td>
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<td>3 Cheek</td>
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<td>4 Cheek</td>
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</tr>
<tr>
<td>5 Neck</td>
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<td>90</td>
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</tr>
<tr>
<td>6 Lumbar</td>
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<td>9 Leg</td>
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<td>10 Neck</td>
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<td>10</td>
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<td></td>
</tr>
<tr>
<td>11 Leg</td>
<td>40</td>
<td>60</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Average clearance in percentage 57 45 59

![Fig. 1](a) Before therapy. (b) Ten minutes after therapy (left area, 6 J/cm² without cooling; centre area, 6 J/cm² with cooling; right area, 9 J/cm² without cooling). (c) Six weeks after therapy.
Dye laser and cold air cooling for PWS

Chiu et al. too evaluated in a prospective study whether higher fluences can augment PWS clearance rates.\(^1\) To this aim, they treated each PWS with two different sets of parameters (585 nm, 7 mm, 1.5 ms, average fluence 10.7 \(\text{J/cm}^2\) plus CSC and 585 nm, 7 mm, 1.5 ms, average fluence 6.5 \(\text{J/cm}^2\), no cooling). They found that PDL-CSC was more effective than PDL alone for blanching of PWS in Chinese patients. Moreover, PDL-CSC was better tolerated and resulted in a lower incidence of acute adverse effects such as blistering.

In our study, we observed a slight but not statistically relevant increase of clearance by using higher fluences and CAC compared with lower fluences without CAC. We think that the following reasons may explain this.

First, the vascular architecture changes, even in the same lesion. Optimal treatment settings are predicated on vessel diameter and vessel depth.

Second, CAC is a bulk mechanism for cooling. Thus, it is likely that, when cooling the vessels to be treated and the surrounding tissue, we do two things to them: (i) we make them smaller targets, because vessels contract when cooled. This mainly affects the deeper vessels that have autonomic innervation and ‘feed’ the PWS. Their contraction decreases the perfusion in the PWS and thus the target vessel size. Due to an absolute or relative deficiency in autonomic innervation of the PWS post-capillary venules in the papillary plexus, these vessels do not react to temperature changes; (ii) we make them colder, thus increasing the amount of heating required to heat them to a damage temperature. Both of these work against successful treatment because higher fluences are required in order to reach efficacy. This can be discounted to a certain extent because the purpura lasted about as long under all conditions, which suggests that the energy was high enough to heat 10- to 40-\(\mu\)m capillaries enough to cause purpura. In addition, it is likely that the surrounding tissue was heated well enough as well, at least superficially. It can be speculated that the PWS that responded poorly to the treatment with 6 \(\text{J/cm}^2\) and cooling were PWS with more deep vessels, so that bulk cooling, contraction, and scatter reduced the effect of the fluence of 6 \(\text{J/cm}^2\) with cooling to the point where it could not treat the bulk of the lesion that was located under the purpura. In the two studies mentioned above, CSC was used; therefore, they are not directly similar to the present study.

Third, Ackermann et al. showed that PWS on the neck, trunk, arms, or legs yielded a higher mean grade of fading compared with PWS on the head.\(^10\) This corresponds in general with our results, except for the PWS on the legs and, in one patient, at the neck, which may be due to the above mentioned reasons.

In the study of Chang and Nelson,\(^20\) only PWS with severity score 2 responded better to higher fluences. A possible explanation may be the fact that they have deeper vessels that are not as affected by superficial cooling as less deep vessels.

Due to the relatively small number of participants and standardized fluence parameters, our study merely indicates a tendency. A larger patient population and more elaborate examination methods are necessary to substantiate our assumptions. Differently from Chang and Nelson, we have chosen a prospective, direct side-by-side study design.

In the present study, as in our former studies, we had a nearly unchanged rate of side-effects with 9 \(\text{J/cm}^2\), which was due to CAC. The painfulness of the laser pulses was lowered from 6.6 (without cooling) to 4.3 (with cooling) using the same fluence and to 5.3 (with cooling) using a higher fluence (9 \(\text{J/cm}^2\)). The healing period of postoperative purpura and crusting was 10 to 12 days for all areas. Thus far, we can say that the extent and the duration of purpura and crusting decreased with the use of CAC.\(^14,15,17\) In deviation of the study protocol of 2001, we chose a cooling level of 4 instead of 6, which can be mentioned as an explication for the slightly prolonged healing period of purpura and crusting, especially in area 3.

It is interesting that the augmentation of the fluence to 9 \(\text{J/cm}^2\) led to an improved clearance mostly with red PWS. Maybe, other pulse durations, wavelengths, and spot sizes are necessary for other PWS colours.

Conclusion

In our study, we observed a slight but not statistically relevant increase of clearance when using higher fluences and CAC compared with lower fluences without CAC. Because the pain is lowered significantly by using CAC, and because this makes the treatment more comfortable for the patients, we tend to recommend the use of higher fluences (9 \(\text{J/cm}^2\)) with simultaneous CAC for treating PWS.

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