The Effect of Cold Air Cooling on 585 nm Pulsed Dye Laser Treatment of Port-Wine Stains

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BACKGROUND. **The use of cryogen spray cooling in the course of dye laser treatment of port-wine stains has established itself in recent years because of its good analgesic and epidermally protective effects. The disadvantages of this kind of evaporative cooling are the cost and, in the case of dichlorodifluoromethane, the effects on the ozone layer. Cold air is an innovative cooling method that costs nearly nothing to use, is environmentally friendly, and can be easily adapted to existing laser systems.**

OBJECTIVE. **To examine and evaluate cold air cooling as an alternative method of cooling in laser treatment.**

METHODS. **In a prospective study, 13 patients (9 female, 4 male) with port-wine stains were treated with a pulsed dye laser (λ = 585 nm, τ_p = 450 μsec). In every case, either the entire area or a sample area of the port-wine stain was treated with cold air cooling on 50% of the surface and without on the other 50%. Clearance, analgesia, and adverse and concomitant effects were assessed.**

RESULTS. **In nine patients (69%) there were similar results in terms of clearance. In four cases, better lightening results (in two patients) and worse lightening results (in two other patients) were achieved in the area treated with cold air. Nine of the patients (69%) felt that the laser impulses accompanied by cold air were significantly less painful. Adverse effects (purpura, erythema, edema) and concomitant effects (hypopigmentation, hyperpigmentation, scars) were much less marked in the cooled areas.**

CONCLUSION. **Cold air is a safe and effective alternative to cryogen spray cooling. It is easy to use, economical, and environmentally friendly. Continuing studies are necessary to determine if there are interactions which affect the tissue.**

THE USE OF cryogen spray cooling during dye laser therapy of port-wine stains was first described by Nelson et al.[1] In comparing patients who were treated with cryogen spray cooling and those who were not, a decrease in epidermal damage was observed and clearance was unchanged. In addition, the cooling spurts during treatment have an analgesic effect. In the years that followed, the application of cryogen spray has repeatedly been a topic of discussion,[2–7] and its use was expanded to include treatment of such indications as hemangiomas and wrinkles.[8–10]

Cold air cooling is an innovative procedure that generates a continual air current of 500–1000 L/min at a minimal temperature of −30°C. A first evaluation in terms of its use with lasers was pursued on 166 patients by our workgroup in 2000.[11] This system proved itself to be safe, analgesic, and epidermally protective in the treatment of port-wine stains, hemangiomas, telangiectasias, tattoos, and hypertrichosis. We then had an adapter custom developed for the pulsed dye laser and the long-pulsed alexandrite laser. This adapter is now commercially available, and adapters are being prepared for other laser systems as well. The effect of cold air on the clearance of the treated areas, however, was not examined in the pilot study described here.

It is for this reason that we have focused our attention in this prospective comparative study on the degree of lightening in port-wine stains with and without the application of cold air.

Materials and Methods

All patients were included who had previously untreated port-wine stains and began dye laser treatment in our clinic between January and June 2000. The results of 13 patients (9 female, 4 male; Table 1) were assessed based on a prospective study design. For forensic reasons, only untanned patients or patients with Fitzpatrick skin types I–III were evaluated. The mean patient age was 31.7 years (range 6 months–65 years). The port-wine stains were located on the head (54%), arm and shoulder (23%), leg (15%), and hand (8%) (Tables 1 and 2). The classification of Fitzpatrick skin types was as follows: type I, 1 (8%); type II, 11 (84%); type III, 1 (8%). Three (23%) of the port-wine stains were less than 10 cm^2, 4 (31%) were 10–100 cm^2, and 6 (46%) were larger than 100 cm^2.

Either the entire area or a sample area (10 cm × 10 cm) of the port-wine stain was treated; 50% of the surface was treated with cold air and 50% without. The pulsed dye laser Photogenica V (Cynosure, Chelmsfort, CA; λ = 585 nm, τ_p =

B. Greve, MD, S. Hammes, MD, and C. Raulin, MD have indicated no significant interest with commercial supporters.

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Table 1. Demographic Data

Sex	
Female	9 (69%)
Male	4 (31%)
Age	
Range	6 months–65 years
Mean age	31.7 years
Fitzpatrick skin type	
I	1 (8%)
II	11 (84%)
III	1 (8%)
IV–VI	—
Size of the port-wine stain	
<10 cm^2	3 (23%)
10–100 cm^2	4 (31%)
>100 cm^2	6 (46%)
Localization	
Pileous head, face, and neck	7 (54%)
Hand	1 (8%)
Arm, shoulder	3 (23%)
Leg	2 (15%)

450 μsec) and the cooling device Cryo 5 (Zimmer, Ulm, Germany) were used. Treatment was always performed with a fluence of 6.0 J/cm^2, an impulse spot size of 7 mm, and level 6, the highest cooling level.

Cryo 5 uses a compressor system as in a refrigerator to generate from room air a permanent stream of cold air with a flow of 500–1000 L/min and a temperature as low as −30°C, depending on the cooling delivery system and the desired cooling level (range 1–6). At cooling level 6, a temperature of −15°C is measured at our custom-made adapter. The skin temperature drops to 28°C after 1 second (at an initial skin temperature of 32°C) and to 15°C after 8 seconds.[11]

Immediately after treatment (day 1) and days 3 and 28 thereafter, the following parameters were determined: analgesia (day 1), purpura (days 1 and 3), erythema (days 1 and 3), edema (days 1 and 3), hypopigmentation (day 28), hyperpigmentation (day 28), blisters (days 1 and 3), crusts (days 1 and 3), and scars (day 28). With the exception of the clearance rate, qualitative assessments of all of the parameters were made using the following scales: unchanged, stronger, weaker (analgesia, purpura, erythema, edema, hypopigmentation/hyperpigmentation, blisters, crusts) with/without cooling. The degree of clearance was evaluated by means of quantitative and simple blind assessment of the photographic documentation. The degree of lightening was indicated on a scale of 0–100%. All of the parameters were evaluated by both the patients themselves as well as by two independent physicians who were not otherwise involved in the study.

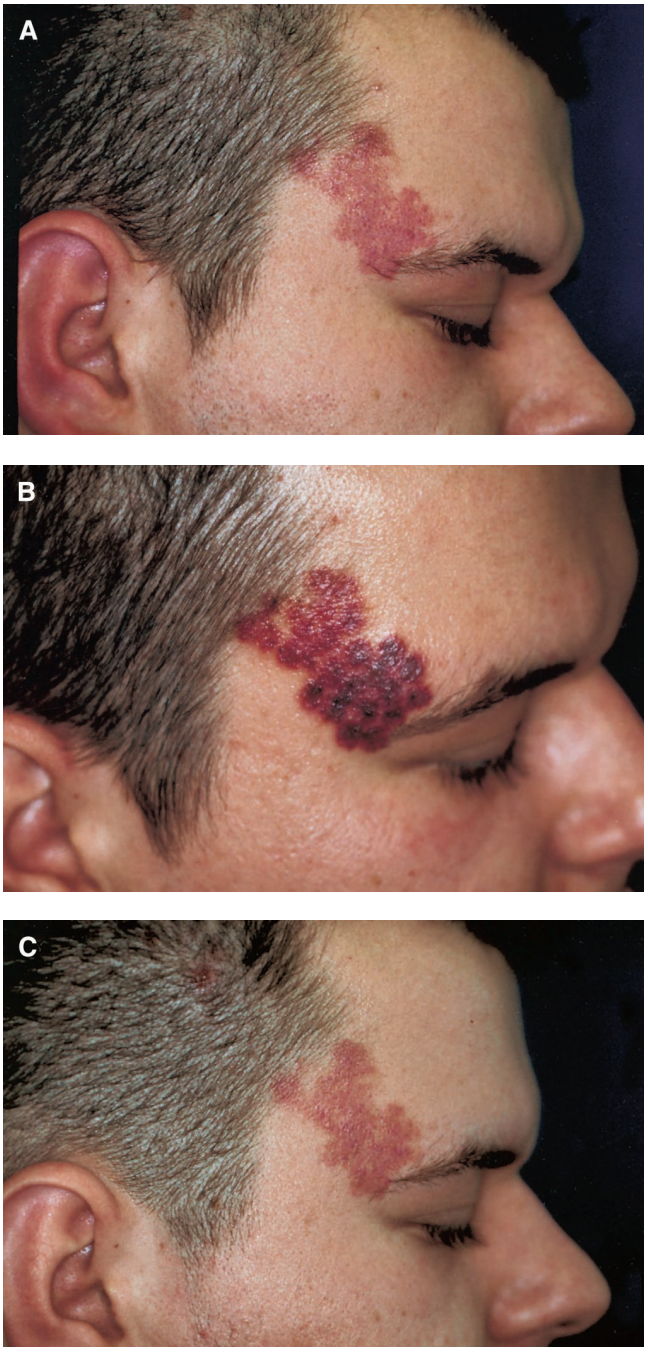

Figure 1. A) Port-wine stain immediately after treatment with the pulsed dye laser. The upper part was treated with cold air; the lower part, without. B) Patient after 3 days. Note the markedly less pronounced purpura in the cooled area. C) The patient after 4 weeks. There was no difference in results.

Results

Similar clearance results were determined in the comparison areas in nine patients (69%) (Figure 1, Table 2). In two cases each, a lower/higher clearance rate was attained in the area treated with cold air (Table 2). Nine patients (69%) stated that the analgesic effect was stronger when cooling was used and three patients (23%) indicated no difference (Table 3). In one case, no evaluation of this parameter could be made due to the patient's age (6 months). In six patients

Table 2. Localization and Clearance

Patient No.	Localization	Improvement	
		Without cooling	With cooling
1	Neck	83%	Same
2	Lip	10%	Same
3	Shoulder	33%	Same
4	Face	30%	Same
5	Calf	50%	Same
6	Shoulder blade	63%	33%
7	Hand	73%	Same
8	Face, neck, cleavage	37%	Same
9	Chin	77%	27%
10	Leg	27%	Same
11	Face, neck, pileous head	30%	70%
12	Temple	13%	Same
13	Arm	40%	57%

(46%, Table 3), purpuric maculae were weaker in the half that was additionally cooled; in another seven patients (54%) this was unchanged, and it was not more strongly pronounced in any of the patients. Erythema and edema were weaker when treated with cold air in 38% and 31% of patients, respectively, and at no time were they stronger. Blisters were only observed in one case in which cooling was not applied. Fine crusting formed in a total of nine patients (69%), although in three patients (23%) it was clearly minimized by the application of cold air. Hypopigmentation was not observed; hyperpigmentation occurred in 23%, although it was less marked when cold air was used. There was no scar formation.

Table 3. Analgesia, Adverse and Concomitant Effects

	Comparison with/without cooling
Analgesia	
Unchanged	3 (23%)
Stronger	9 (69%) with cooling
Other	1 (8%) could not be evaluated due to age (6 months)
Purpura	
Unchanged	7 (54%)
Weaker	6 (46%) with cooling
Erythema	
None	1 (8%)
Unchanged	7 (54%)
Weaker	5 (38%) with cooling
Edema	
None	2 (15%)
Unchanged	7 (54%) unchanged
Weaker	4 (31%) with cooling
Hypopigmentation	
None	13 (100%)
Hyperpigmentation	
None	10 (77%)
Weaker	3 (23%) with cooling
Blisters	
None	12 (92%)
Stronger	1 (8%) without cooling
Crusting	
None	4 (31%)
Unchanged	5 (38%)
Weaker	3 (23%) with cooling
Stronger	1 (8%) with cooling
Scars	
None	13 (100%)

Discussion

Cold air is a means of cooling that has been used for approximately 10 years in orthopedics, rheumatology, and sports medicine to treat painful and inflamed muscle conditions. It is distinguished by its simple application technique, environmentally benign factors, and low costs of use.[12] Moreover, Kröling and Mühlbauer[13] were able to prove that in comparison to ice compresses and liquid nitrogen, cold air improved the pain threshold on the elbow joint most quickly and intensely.

In numerous studies, the application of cryogen spray during dye laser therapy of port-wine stains has already been demonstrated to be analgesic and have a protective epidermal effect.[1,5,7] Waldorf et al.[7] and Chang and Nelson[5] used fluences that were approximately 10–20% higher in the cryogen spray-cooled areas they treated. In terms of clearance, Waldorf et al.[7] could not determine any difference in their study (a direct comparison on the same patient); Chang and Nelson,[5] on the other hand, observed a better lightening of port-wine stains in the group that received additional cooling (comparison of two independent groups of patients). Nelson et al.[1] did not change the fluence in the comparison groups (direct comparison on the same patient) and were also unable to determine a difference in lightening.

None of the authors mentioned above has reported a decrease in clearance when cryogen spray was applied. We, on the other hand, were able to observe two cases in our cohort in which there was a lesser degree of lightening in the cooled area. It is possible that the continuous cooling of the cold air leads to a larger drop in dermal temperature, unlike the spurts of cryogen spray, which are in the millisecond range. Nelson et al.[1] were able to use an infrared detector (fast-imaging infrared detector) to show that an 80-msec spurt at a skin temperature of 30°C leads to a decrease down to −10°C, only to be raised by 80°C by the dye laser impulse of 10 J/cm^2. In the noncooled area, the laser impulse raised the skin temperature to 110°C. An 80-msec cryogen spurt accomplishes a constant cooling effect of 100 msec in duration, according to Nel-

son et al.[1] Apparently the cooling does not exceed a depth of 0.4 mm.

Cold air is a continual procedure that apparently affects both epidermal and dermal structures. The depth and intensity of the cooling leads to a drop in temperature; the heat developed by the laser impulse is thus neutralized and only partial or no coagulation of the vessels may occur. A cold-induced contraction of the vessels is also plausible; this would lead to incomplete or no coagulation in the blood vessels. This theory is supported by our observation that erythema visibly decreases during treatment of essential telangiectasias.

Furthermore, differences in the vessel size and depth of the port-wine stains and variables in ambient temperature, skin temperature, and the body temperature of the patient can influence the process as well. The patient cohort assessed in this study is also not sufficient to exclude randomness of results. The lower rate of lightening of the two port-wine stains in our study could be a factor of the differences in the spot size of the impulse and the extent of the fluences (7 mm, 6.0 J/cm^2). In contrast to our work group, Chang and Nelson[5] used an impulse spot size of 7 mm and a fluence of 8–10 J/cm^2, Nelson et al.[1] used 5 mm and 10 J/cm^2, and Waldorf et al.[7] used 5 mm and 7–8 J/cm^2. In spite of the fact that the fluence was unchanged, the reason for a better result in the cooled area in two cases may also be related to the issues listed above.

The analgesic effect of concomitant cryogen cooling can also be confirmed for the cold air procedure. Adverse effects and concomitant reactions were also greatly reduced among our patients, as was the case after the use of cryogen spray.[1,5,7]

The ecological aspects and the significantly greater costs of using cryogen spray cooling versus cold air cooling should be noted as well. In particular, dichlorodifluoromethane, which was initially used as a cooling gas, has been shown to damage the ozone layer. For this reason, as was outlined in the Montreal protocol, it was taken out of circulation altogether as of 2000 and may only be used in exceptional cases. Currently the most widely used substance is 1,1,1,2-tetrafluoroethane; no health-related threats or hazards to the ozone layer have been determined.[14,15] One disadvantage of using this gas, however, is the fact that it contributes to the greenhouse effect.[16,17] The costs of use vary considerably depending on the manufacturer and the length of the cryogen spurts.

In summary, the application of cold air is a safe and simple procedure. However, it has yet to be determined which temperature profile in the skin is achieved by cold air, which tissue interactions may be induced, which treatment parameters are considered ideal, and to what extent the clearance rates are influenced. In cooperation with the Institute of Laser Technologies in Medicine and Quantitation of the University of Ulm, we are currently working on resolving these questions.

Dedication We dedicate this article to Professor Dr. D. Petzoldt, head of the university clinic for dermatology in Heidelberg, on the occasion of his 65th birthday in April 2001. He has always been an extraordinary teacher for us and an excellent doctor for his patients, and he has always focused on scientific innovation.

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