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Evaluation of Different Temperatures in Cold Air Cooling With Pulsed-Dye Laser Treatment of Facial Telangiectasia

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Background and Objectives: Cold air cooling is widely used in dermatological laser therapy. We investigated the influence of cold air cooling at different skin temperatures on therapeutic outcome and side effects of pulsed dye laser treatment of facial telangiectasia.
Study Design/Materials and Methods: From September 2002 to February 2003, 17 patients with previously untreated facial telangiectasia underwent a single treatment session with flash-lamp pulsed dye laser (3.5 J/cm^2, 585 nm, 0.45 milliseconds pulse length, 10 mm beam diameter, Cynosure® V). The treatment area was divided into three sub-areas: no cooling, cold air cooling to 20°C and to 17°C skin temperature. The skin temperature was monitored by a prototype infrared sensor system which controlled the temperature of the cold air stream (Cryo5®). In a prospective study, we collected data on purpura, pain, clearance, and patient satisfaction on numerical analog scales (NAS) from 0 (meaning "no") to 3 (meaning "high").
Results: Without cooling, purpura (2.53), pain (2.41), and clearance (2.35) were rated medium to high. Cooling to 20°C reduced purpura (1.12) and pain (1.06), whereas the clearance (2.12) was only slightly affected. Cooling to 17°C reduced purpura (0.88) and pain (0.76) even more, the clearance (2.06) was lowered marginally. Most patients preferred cooling to 20°C skin temperature.
Conclusion: In dermatological laser therapy of facial telangiectasia, the use of cold air cooling can significantly reduce side effects and increase patient satisfaction while only slightly affecting clearance. Cooling to 20°C skin temperature proved to be a well-balanced middle course. For the practical use of cold air cooling, we thus recommend cooling to a level which the patient can tolerate without problems and to try to increase the energy densities. Lasers Surg. Med. 36:136–140, 2005. © 2005 Wiley-Liss, Inc.

Key words: laser; cooling; cold air cooling; telangiectasia; dye laser

INTRODUCTION

Analgesic cooling methods have become an integral part of dermatological laser therapy [1–6]. Contact cooling has been used in different instances for a long time [7–9]. A more recent development is cryogen spray cooling, a technology in which a liquid contact phase and a gaseous evaporation phase can be differentiated. There are a number of studies as to its effectiveness in terms of analgesia, epidermal protection, and influence on clearance and side effects [1,4,10,11].

Complete contactless cold air cooling has been in use for some years now. Several studies have already demonstrated its good analgesic potency, reduction of the rate of side effects, and improvement of patient satisfaction [6,12–14]. The effect on clearance has been only very sparsely documented [13], whereas the impact of different cooling temperatures on clearance and side effects has up to now not been evaluated.

We therefore conducted a prospective comparative study in which we investigated the influence of cold air cooling at different skin temperatures on therapeutic outcome and side effects of pulsed dye laser treatment of facial telangiectasia. We chose this indication because it occurs frequently, the effect of the therapy is readily assessable and because the superficial position of the blood vessels is a challenge for an epidermally effective cooling technology. We selected the pulsed dye laser because it represents an approved therapy for this indication.

MATERIALS AND METHODS

Seventeen patients (15 females, 2 males, mean age 45.2 years, median age 45 years) of Fitzpatrick skin types I–III with previously untreated facial telangiectasia were enrolled in a prospective study which was conducted from September 2002 to February 2003. Informed consent following full explanation was obtained from all patients before therapy. They underwent a single treatment session with a flash-lamp pulsed dye laser (3.5 J/cm^2, 585 nm, 0.45 milliseconds pulse length, 10 mm beam diameter, Cynosure® V, Chelmsfort, CA).

For cooling, we used the cold air machine "Cryo5®" (Zimmer Elektromedizin, Ulm, Germany). This machine uses a compressor system similar to that in a refrigerator to generate from room air a permanent stream of cold air with a flow rate of 500–1,000 L/minute and a temperature as low as −30°C, depending on the cooling delivery system and the desired cooling level. The skin temperature was monitored using a prototype infrared sensor system ("Cryotherm®", Zimmer Elektromedizin, Ulm, Germany, Fig. 1) which

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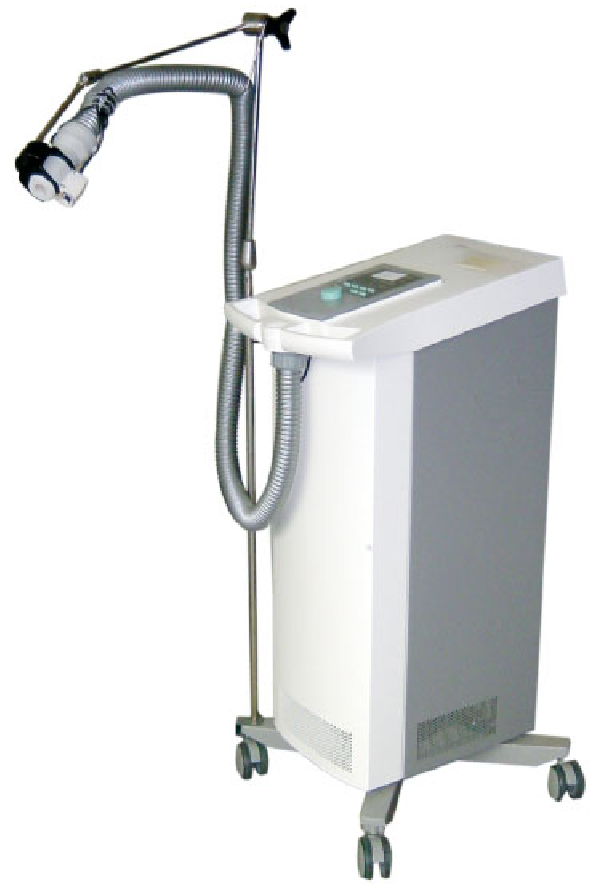


Fig. 1. The prototype cooling handpiece with integrated temperature sensoring and regulation (“Cryotherm®”, Zimmer Elektromedizin, Ulm, Germany).

controlled the cold air stream in the following way. Because the cooling power of the compressor system cannot be modulated quickly, we used a constant cooling level (4) for all treatments. The cooling handpiece had a built-in electrical heating unit which could increase the temperature of the cold air stream rapidly (like an electric hair dryer). The infrared sensor electronics modulated the power of the heating unit, which in turn modulated the temperature of the air stream to achieve the desired skin temperature which can be preselected via a control unit.

The treatment area was divided into three sub-areas which were outlined with a white eyeliner: no cooling, cold air cooling to 20°C and to 17°C skin temperature. These areas were treated in sequence. The target temperatures were determined in a pilot study with five test persons (pleasant or painful/uncomfortable cooling).

The skin temperature dropped to 28°C after 1 second (at an initial skin temperature of 32°C), to 20°C after 3 seconds and to 17°C after 7 seconds [6]. After treatment, the patients applied gel cooling packs to the treated areas.

We collected data about pain (day 1), purpura (days 1, 3, 28), patient satisfaction (days 1, 3, 28), clearance (days 3, 28) using numerical analog scales (NAS): 0 (meaning “no”), 1 (meaning “low”), 2 (meaning “medium”), 3 (meaning “high”). With the exception of the clearance rate, qualitative assessments of all the parameters were made using the aforementioned scales. The degree of clearance was evaluated by means of quantitative and simple blind assessment of the photographic documentation (0–100% with a granularity of 33% which maps to the NAS of 0–3). All of the parameters were evaluated both by the patients themselves and by two independent physicians who were not otherwise involved in the study. Photographic documentation was carried out on day 1 (pre- and post-op), day 3 and day 28 (EOS100 [Canon USA, Inc, Lake Success, NY] with Agfa-chrome CT× 100 films [Agfa Corp, Ridgefield Park, NJ]). The photographs were standardized by using the same type of film, the same camera, the same photographic angle, the same ring-flash and the same ambient light. It was not possible to use the same distance or magnification because the regions to be treated were of different sizes.

RESULTS

In the following we give the mean values of the data collected using the NAS (see Table 1). Without cooling, purpura (2.53), pain (2.41), and clearance (2.35) were rated medium to high. Cooling to 20°C reduced purpura (1.12) and pain (1.06), whereas the clearance (2.12) was only slightly affected. Cooling to 17°C reduced purpura (0.88) and pain (0.76) even more and the clearance (2.06) was lowered marginally (Figs. 2 and 3). We did not observe any formation of crusts.

Thirteen patients preferred cooling to 20°C skin temperature, cooling to 17°C was preferred by three patients, and one patient preferred no cooling at all. The overall patient satisfaction (2.41) was rated medium to high. No patient was completely dissatisfied.

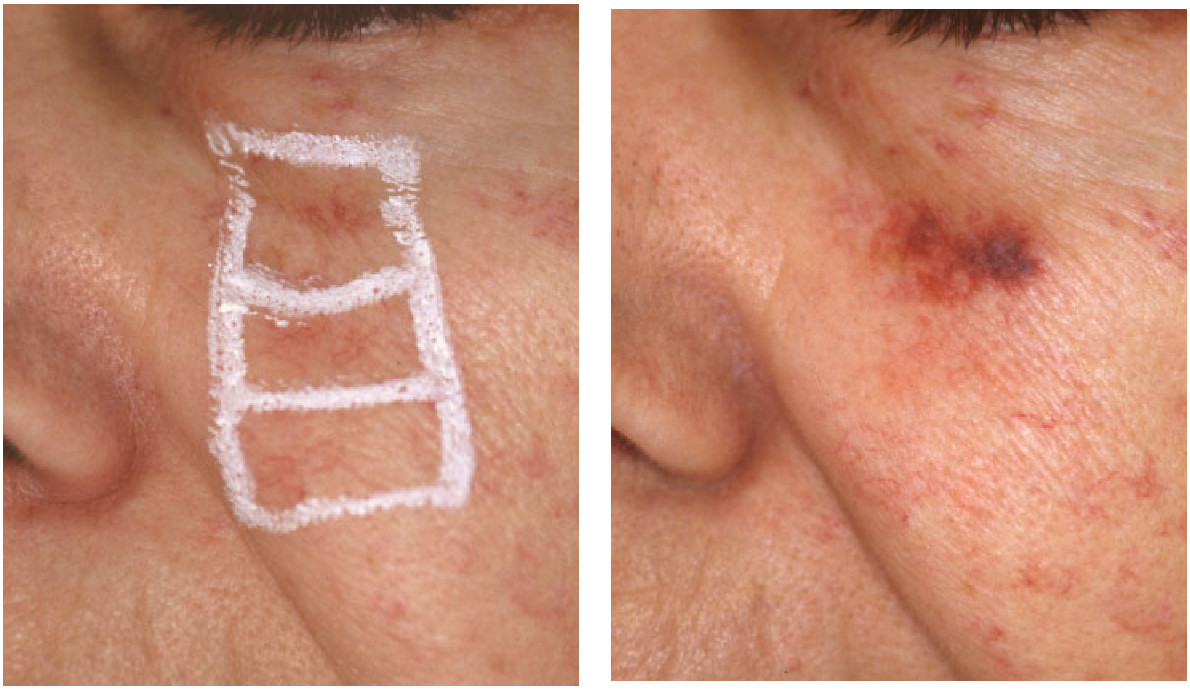
With respect to the clearance, we found that in most patients there was no drop of the clearance rate through cooling (Figs. 4 and 5). In one patient, the clearance rate in the cooled areas was definitely lower than in the non-cooled area. In two other patients, the clearance rate in the cooled areas was slightly lower than that in the non-cooled area. On the other hand, in one patient we had much better clearance in the cooled areas.

DISCUSSION

Facial telangiectasia are a very common skin problem for which there are effective therapeutic options. A current standard is treatment with the flash-lamp pumped pulsed dye laser [15]. We chose the 450 microseconds pulsed dye

TABLE 1. Treatment Results (Mean Values, Scales: 0–3 (0: no, 1: Little, 2: Medium, 3: High))

	No cooling	20°C skin	17°C skin
Purpura	2.53	1.12	0.76
Pain	2.41	1.06	0.88
Clearance	2.35	2.12	2.06



Figs. 2 and 3. Facial telangiectasia pre-op (day 1) and at day 3. There is no purpura in the cooled areas although the clearance is very good (no cooling, cooling to 20°C, cooling to 17°C; top to bottom).

Figs. 4 and 5. Facial telangiectasia pre-op (day 1) and at day 28. The clearance in all three treated areas (no cooling, cooling to 20°C, cooling to 17°C; top to bottom) is identical.

laser because in many practices and hospitals, there are conventional 450 microseconds pulsed dye lasers, but only in the best equipped practices there are long-pulsed dye lasers. Another reason why we chose the 450 microseconds dye laser is that there is the largest number of publications and most experience for this laser for the indication of facial telangiectasia. This is important because the results are thus better comparable to existing standards. Thirdly, by using a laser with obligate purpura we were able to demonstrate the reduction of especially this side effect which would not have been possible if we had chosen a non-purpuric laser.

Analgesic and epidermoprotective cooling methods in combination with this type of laser have been the subject of several studies. They focused mainly on cryogen spray cooling. It has been demonstrated in all the studies that cryogen spray cooling reduces the rate of side effects and improves the patients' tolerance of the treatment [1,4,10,11]. Evaluations of the effects of cryogen spray cooling on clearance mostly did not show any reduction [11]. In individual cases, a negative influence, e.g., because of too long cryogenic spurts, has been documented [16–18]. In other cases, there was improvement of the clearance rate because it was possible to use higher therapeutic energy densities [10].

Cold air cooling as a completely contact-less cooling method has been shown to be equal to cryogen spray cooling and contact cooling in terms of side effect rate and patients' tolerance [5,6,12]. Advantages are its good environmental performance, low running costs, the lack of influence on the laser beam and its continuous cooling effect (lasts from before to after the laser pulse) [6,13]. So far, the effect on clearance has only rarely been evaluated [13]. There were similar results as with cryogen spray cooling. In the therapy of port wine stains with the pulsed dye laser it has been proved that, in 84% of cases, the use of cold air did not decrease the clearance rate and in 15% of cases even increased it [13].

In the present study, the effects of different temperatures in cold air cooling have been evaluated for the first time. As was expected, the rate of side effects and the painfulness were reduced with falling temperatures. The clearance stayed the same in most cases. In three cases, there was poorer clearance because of the cooling. One possible explanation for this may be provided by the ratio of the temperature gradient ΔT of the target structure to the temperature decrease T_k produced by the cooling method [19]. The higher the quotient $\Delta T/T_k$, the lower the potentially negative effect of additive cooling. In the treatment of tattoos, for example, ΔT amounts to about 1,000°C. A T_k of about 20°C is, compared with ΔT, very low and can thus be neglected. In the therapy of vascular lesions, which we evaluated in the present study (ΔT approx. 40°C), the quotient $\Delta T/T_k$ is very small, thus we may have to expect a negative effect on the result. Another factor influencing the evaluation of the clearance is the position of the target structure in the skin. The more superficially it is situated, the more it is susceptible to temperature changes. Superficial vessels, for example in the form of facial telangiectasia, are far more temperature-sensitive than, for example, deep-lying hair follicles.

In one patient, there was even an increase of the clearance rate in the cooled areas. The reason may be a temperature-induced vasoconstriction with reduction of an increased blood flow to normal, which would have facilitated a better photothermolytic effect of the laser pulse [20]. Alternatively, local factors may be responsible for the described effect (different vessel configuration or localization).

The considerable reduction of purpura through cold air cooling is, on the one hand, a desired effect but, on the other hand, shows a certain sparing of the vessels, which, theoretically, could contribute to a reduced therapeutic effect. In view of the marginal reduction of the clearance, this aspect cannot be very important.

In order to be able to clearly compare the effect in the treated areas, we applied a constant energy density. The epidermal protection would have allowed considerably higher energy densities with additional cooling. This would have likely resulted in a measurable increase of the clearance rates in the cooled areas. Similar results have been presented for cryogen spray cooling [10,14].

We were able to show a continuous reduction of the rate of side effects with decreasing skin temperature. However, after a longer period of application, the cooling to 17°C was considered to be too cold by most patients. Thus, cooling to 20°C can be regarded as a fair compromise between a slightly better effect and a more pleasant feeling during treatment sessions. There was, however, only a slight reduction of clearance with greater cooling.

In our study, we used a prototype device for monitoring and regulating the skin temperature. For a potential commercial use, it may have to be optimized, but it was appropriate for our scientific requirements. The size of the prototype handpiece is rather large for a convenient application of the cold air stream, but it certainly can be miniaturized. At the end of the year there will be a much smaller and less noisy Zimmer cooling device on the market which we currently evaluate.

The technical realization of the modulation of the cooling power is not a simple problem. The compressor's power cannot be modulated quickly enough. For this reason we used a constant stream of cold air, the temperature of which can, if required, be increased by using a rapidly variable, electronically controllable electric heating element (like an electric hair dryer). From the point of view of energy requirements, this is not optimum, but still a necessity due to the prevailing technical conditions. A technical alternative would be a mechanical mixing valve which could mix a stream of cold air with ambient air in variable ratios and could drain excess cold air. With this, there would be no possible warming effect which, however, might be necessary when the temperature of the skin surface cools down too much.

Some patients may be bothered by the velocity of the cold air stream. This can, in most cases, be avoided by applying appropriate shielding measures (e.g. by using tight goggles, protecting ears and nose with one hand, using a cooling handpiece which forces the air stream into only one direction). Using these techniques, no patient in our study complained about the air stream. If there is still discomfort, it is possible to reduce the velocity of the cold air for the price of a longer cooling phase.

There are problems with the practical application because of the necessity for a quite long cooling phase, which is needed to achieve the initial target temperature. During treatment, however, the duration of cooling is shorter because of neighboring effects. All in all, movement artefacts make it difficult to maintain a constant skin temperature; it is more realistic and sufficient for practical purposes to define a target temperature corridor.

CONCLUSION

In dermatological laser therapy of facial telangiectasia, the use of cold air cooling can significantly reduce side effects and increase patient satisfaction. Cooling to 20°C skin temperature proved to be a well-balanced middle course. We demonstrated that greater cooling considerably reduced the rate of side effects, and only slightly reduced the clearance rate. For the practical use of cold air cooling we thus recommend cooling to a level which the patient can tolerate without problems and to try to increase the energy densities.

Further prospective studies are necessary in order to evaluate the therapeutic impact of additive cold air cooling on other target structures. A technical challenge would be the optimization of the currently experimental temperature control for commercial use.

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