



Case report

Unusual both hands cryogenic burn caused by Freon gas and early treatment with hyperbaric oxygen therapy

Özay Özkaya*, Onur Egemen, Derya Bingöl, İ. Mithat Akan

Okmeydanı Training and Research Hospital, Department of Plastic Reconstructive and Aesthetic Surgery, Postal Code 34384 Okmeydanı, Şişli/Istanbul, Turkey

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1. Introduction

Frostbite may be defined as the acute freezing of the tissues when exposed to temperatures below the freezing point of intact skin. The refrigerant liquids and compressed gases may cause frostbite when sprayed on the skin. Cryogenic burns are uncommon and various etiologies were reported. Only a few Freon frostbite cases were reported and there is little information available in the medical literature that reports on emergency treatments for frostbite injuries from refrigerant liquids, gases and the effectiveness of the hyperbaric oxygen therapy within 24 h after injury. The aims of this paper are to present the frostbite of both hands caused by Freon gas injury and to discuss the management of the situation with early conservative treatment with hyperbaric oxygen therapy (HBOT) within 24 h which eliminates the need for surgical intervention.

2. Case report

A 58-year-old man was admitted to our emergency unit with frostbite injury involving both hands. He reported that the frostbite had been due to explosion of industrial cryogenic gas tube and contact of both hands with the Freon gas. He had held his both hands through the tube to prevent the gas leak. Both hands had been exposed to the gas for about 40–50 s. Immediately after the exposure, the skin had gone white and cold, followed by numbness and an increasing pain on the hands. The man had arrived at our institution 1 h after the injury. The initial physical examination demonstrated a second and a third degree frostbite on the both hands (Fig. 1). All the fingers and palm were severely edematous and skin colour was white. He had a partial lack of sensation in his fingers on both hands. The capillary circulation of the fingers was adequate. Upon arrival at our hospital, the patient was immediately cleaned in

a cleaning tank. His hands were irrigated with a 40 °C and sterile water for 30 min. As an antiedema treatment, extremity elevation, and high-molecular-weight dextran in saline (35 mL/h) were initiated. In addition, we decided to perform HBOT, which improves microcirculation, to prevent the venous and capillary thromboses which are the main causes of tissue damage. HBOT was repeated daily for 14 days according to the Marx-schema for problematic wounds (2,4 bar, total time at depth = 90 min, alternations of 100% O₂, and air breathing). Burn areas were dressed every day and intravenous antibiotics were administered. The blisters were not debrided but only the massive epidermal fluid collection was drained. After the first course of the therapy, we observed remarkable reduce of the oedema and an improvement on the frostbite area (Fig. 2). The burns were healed gradually over two weeks (Fig. 3). Early range of motion exercises were started to prevent contractures. At his last follow-up on the 6th months his hands were remarkably healed with a full range of motion.

3. Discussion

Cryogenic burns are uncommon and various etiologies were reported. Aerosol sprays, liquid ammonia, and liquefied propane have been described as a cause of cryogenic burns.^{2,10,13,7} Freon is a trade name for a group of chlorofluorocarbons (CFCs) used primarily as refrigerants in industry in the form of clear, colourless, and non-flammable gas or liquid. Various refrigeration equipments contain Freon gas, such as refrigerators, air conditioners, freezers and water coolers. CFCs are also occasionally used as dry-cleaning solvents, aerosol propellants, blowing agents, chemical excipients and topical anaesthetics.^{15,3} CFCs were first developed in the 1930s, it was thought that they were useful and nontoxic to human health. Decades later, it was discovered that CFCs harm the environment and human health. Freon gas has low toxicity, but exposure to relatively high concentrations may have adverse effects on health. Despite its widespread use, few reports of injuries involving Freon gas have been published.^{15,1} Freon gas produces rapid and profound cooling of the surrounding air, thus causing localised cold injury and cellular destruction in human tissue, and subsequent inactivation of sensory nerves results in numbness. Moreover, skin contact with Freon gas can lead to drying of the skin, contact dermatitis and mild skin irritation with discomfort or rash. The gas may also cause severe frostbite. Frostbite following exposure to cold gases is a recognised occupational hazard.⁹ Contact frostbite is common in young

* Corresponding author. Tel.: +90 212 2217777x5120; fax: +90 212 2217800.
E-mail address: oozozay@yahoo.com (Ö. Özkaya).



Fig. 1. Dorsal and volar photographs of the hands after exposure to Freon gas for 40 s showing the formation of massive blisters.



Fig. 2. Dorsal and volar photographs of the hands at 6 days after HBO therapy.



Fig. 3. View of the hands after epithelisation.

workers and typically involves the hands. The upper extremities, particularly the fingers are more susceptible to cold exposure, as the vascular structures are smaller and narrower and the tissue coverage is thinner in the upper extremities in contrast with the lower extremities.⁸ The extent of injury caused by liquid agents may be determined by the surface area of exposed tissue, the volume of liquid agent on the skin and the duration of exposure. The mechanism of refrigerant agents is unlike frostbite in that the damage occurs within seconds.^{11,14} However, there are some controversial discussions over the duration of exposure that may lead to such severe tissue damage. The appearance of the superficial tissue is often an unreliable indicator of the viability of the underlying tissue.⁹ The injury may be more severe compared to a thermal burn because the refrigerant liquids and gases rapidly and deeply penetrate through the skin; Freon gas has the potential to cause irreversible damage. There is little information available in the medical literature that reports the emergency treatments for frostbite injuries from refrigerant liquids, gases and effectiveness of HBOT in 24 h after injury. The first treatment step is to remove the patient from danger and minimize the duration of exposure. Unlike with thermal burn, the agent will continue to burn until the substance is inactivated or removed from the area. In the first-aid treatment, any clothing that has been splashed or soaked with

refrigerant agents should be removed immediately. The contaminated skin must be promptly washed using soap or mild detergent and water. For frostbite, immediate rewarming in a water bath between 40 °C and 42 °C is recommended.^{11,14} Adherence to this narrow temperature range is important; rewarming at lower temperatures is less beneficial to the tissue survival, whilst rewarming at higher temperatures may compound the injury by producing a burn wound. Rewarming should be continued for 15–30 min until thawing is complete. Heparinization for the prevention of thrombosis is still controversial. Active motion during rewarming is helpful, but massage should be avoided. Reconstruction has no role in the acute phase of frostbite. Escharotomy or fasciotomy may be indicated in the early phase, if circulation is impaired or compartment syndrome develops. Attempts on aggressive debridement in the early phase of frostbite and amputation may violate the viable tissues. The only indication for early operative intervention is to ameliorate a constricting eschar or to drain a subeschar infection that has not responded to topical antimicrobials. If tissue injury progresses to gangrene, amputation and coverage may be required. Thus, in the care of frostbite injury, patience in allowing demarcation of nonviable tissues is recommended, which may take as long as two to three months.

Surgery should be delayed until the area is thoroughly demarcated.

In frostbite a certain number of cells are injured irreversibly but a large number of cells are injured reversibly, and these may recover and survive with appropriate treatments.⁵ The aim of frostbite treatment must be to salvage the more irreversibly injured cells.⁴ Wegener et al. reported compartment syndrome and necrosis of two fingers at a case of cryogenic burn who administered to hospital at 14 h. In this case, to salvage the hand they had applied fasciotomy and they had to amputated the fingers.¹⁵ However, Sever et al. reported a case of Freon gas frostbite treated with HBOT after 96 h because of poor capillary circulation of the fingers and they observed rewarming and pink colour after the first course.¹² This report remarks the efficiency of HBOT for treatment of frostbite even in late onset of therapy. Our case was similar to the case reported by Sever et al, with the HBOT for the second and third degree cryogenic burns of both hands, but differently in our case with earlier onset of the therapy, a remarkable reduction of the oedema occurred and the hands were rewarmed. Hereby we think that antiedema effect of the HBOT, with early onset, also serves as a protective treatment modality against compartment syndrome and extremity sacrifice. In the early stages of freezing, HBOT can assist in the salvaging of a greater amount of tissue by increasing the viability of reversibly damaged cells adjacent to necrotic tissue by preventing tissue hypoxia and reducing tissue oedema. In the late stage it reduces the duration of hospitalization and the development of secondary infection by accelerating wound healing. At the same time, HBOT assists the surgeon by permitting the clarification of the demarcation line and increases the success of surgical interventions planned for tissue defects.⁶ In our case HBOT started in 24 h after injury. This provided us the salvage of more reversibly damaged tissue, avoided the necessity of any surgical intervention and favoured conservative therapy.

In conclusion, even a short contact with Freon gas can result in severe frostbite. Removal from exposure, followed by early transport of the victim to a burn centre, are the essential preliminaries of the treatment. Subsequently, prevention of severe

oedema and compartment syndrome has great importance, including close monitorization for deep tissue damage that might cause compartment syndrome and also for any vascular or neurological deficit. The adjunctive HBOT is an alternative treatment of frostbite injuries for its contribution to healing. For the favourable outcomes of HBOT, it is better to start the treatment within the first 24 h following the injury. HBOT was effective in the treatment of necrosis, infection and loss of tissues.

References

1. Astrom T, Jonsson A, Jarvholm B. Exposure to fluorocarbons during the filling and repair of air conditioning systems in cars: a case report. *Scand J Work Environ Health* 1987;13:527–8.
2. Camp DF, Ateaque A, Dickson WA. Cryogenic burns from aerosol sprays: a report of two cases and review of the literature. *Br J Plast Surg* 2003;56(December (8)):815–7.
3. Hanke CW, O'Brian JJ, Solow EB. Laboratory evaluation of skin refrigerants used in dermabrasion. *J Dermatol Surg Oncol* 1985;11:45–9.
4. Hegggers JP, McCauley RL, Phillips LG, Robson MC. Cold induced injury: frostbite. In: Herndon DN, editor. *Total burn care*. London: WB Saunders; 1996. p. 408–14.
5. Hurley LA. Angioarchitectural changes associated with rapid rewarming subsequent to freezing injury. *Angiology* 1957;8:19–28.
6. Jain KK. Hyperbaric oxygen therapy in wound healing, plastic surgery, and dermatology. In: Jain KK, editor. *Textbook of medicine*. 4th rev. ed., Germany: Hogrefe & Huber Publishers; 2004. p. 147–67.
7. James NK, Moss AL. Cold injury from liquid propane. *BMJ* 1989;299(October (6705)):950–1.
8. Koljonen V, Andersson K, Mikkonen K, Vuola J. Frostbite injuries treated in the Helsinki area from 1995 to 2002. *J Trauma* 2004;57:1315–20.
9. Kumar P, Chirayil PT. Helium vapour injury: a case report. *Burns* 1999;25:265–8.
10. Olive KE. Aerosol spray can induced cold injury in a patient with Raynaud's phenomenon. *J Rheumatol* 1990;17(April (4)):556–7.
11. Sever C, Ulkur E, Uygur F, Celikoz B. Hand burn caused by Freon gas. *Burns* 2008;34:1210–2.
12. Sever C, Kulahcı Y, Acar A, Karabacak E. Unusual hand frostbite caused by refrigerant liquids and gases. *Turk J Trauma Emerg Surg* 2010;16(5):433–8.
13. Sotiropoulos G, Kilagblian T, Dougherty W, Henderson SO. Cold injury from pressurized liquid ammonia: a report of two cases. *J Emerg Med* 1998;16(May–Jun (3)):409–12.
14. Uygur F, Sever C, Noyan N. Frostbite burns caused by liquid oxygen. *J Burn Care Res* 2009;30:358–61.
15. Wegener EE, Barraza KR, Das SK. Severe frostbite caused by Freon gas. *South Med J* 1991;84:1143–6.