Cold Injuries – Chilblains and Frostbite

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Abstract

The skin plays an important role in thermoregulation and there is ample evidence that a cold environment can be a threat to the skin, because of the low human capacity for physiologic adaptation to cold and due to prominent seasonal changes, physiological, behavioral and other environmental factors. Usually, there is no serious skin damage until tissue freezing occurs.

Frostnip is the mildest form of cold injury, whereas chilblains represent a more severe condition due to prolonged exposure to nonfreezing temperature and humidity. Trench foot, also known as immersion foot, occurs when the feet are wet, but not freezing, for long periods of time. Frostbite, the most serious peripheral cold injury, results in tissue necrosis, and usually occurs after exposure to freezing temperatures. The risk factors are represented by advanced age, substance abuse, mental impairment and injury.

The main treatment recommendations include methods of rewarming, NSAIDs and use of topical corticosteroids.

Keywords: Chilblains, frostbite, freezing temperature, rewarming, preventive measures

Introduction

Romania was faced in 2012 with one of the worst winters of the last century, being under orange code of alert (heavy snow, blizzards, temperatures below –10°C) for several weeks. Large amount of snow and high winds of over 100 km/h in speed led to the formation of drifts of 2-3 meters high.

Temperatures dropped to –28° C, and did not exceed –10^0 C. The 2012 winter was surpassed in magnitude only by the Great Blizzard of 1954, the worst winter in recent history of Romania. The weather forecast announcements permitted to prepare in advance and to take preventive measures. State Hospitals were informed and organized for the difficult conditions. After the winter months the statistcis showed that few patients were seeking for the treatment of cold induced lesions. There was a total of 16 cases of cold injuries in the 2nd Clinic of Dermatology, with ages between 32 and 46 years, with a mean age of 40 years. This number represents 0,37% of the total of patients recorded (n = 4269) in this period (01.Dec.2011 – 29.Feb.2012) in our Clinic. The most frequent cold injuries were pernio (n = 12; 75%) and frostbite (n = 4; 25%). A majority of patients were men (n = 13; 81,25%), and the urban/rural ratio was 3/1.

The winter conditions in 2012 were extremely difficult but cold induced injuries did not result in increased influx of patients to the dermatology department.

The profile of patients suffering from diseases caused by cold is that of man of working age. However, low demands and low number of patients from rural areas indicate that the addressability for this pathology is directed to hospitals with emergency profile.

Classification of skin cold injuries involves freezing and nonfreezing injuries, which may easily be recognised clinically and according to temperature values, duration and severity of chilling (Table 1) [1, 2].

Table 1

Classification of Cold Injuries	
Freezing cold injuries to the skin	Nonfreezing cold injuries to the skin
Frostbite	Vasoconstriction
	Hunting reaction
	Trench foot
	Pulling boat hands
	Acrocyanosis
	Chilblains
	Cold urticaria
	Cold panniculitis
	Erythromelalgia
	Raynaud phenomenon
	Sclerema neonatorum
	Subcutaneous fat necrosis of the newborn
	Livedo reticularis
	Cryoglobulinemia
	Cold agglutinins
	Cryofibrogenemia

Frostnip

Frostnip is the mildest form of cold injury and therefore doesn't cause any irreversible damage. Frostnip consists in a severe cold sensation which involves only the skin and may lead to numbness and even pain [1, 2].

Erythema of the cheeks, ears, nose, fingers and toes is the main clinical aspect of this condition and since there is no edema formation, frostnip is the only type of frostbite to be treated safely on the field using first aid measures (rewarming and use of aloe vera, a thromboxane inhibitor, which has proven to be a useful topical agent in superficial frostbite) [1, 2].

Pernio

Pernio (erythema pernio or chilblains), is an inflammatory skin condition presenting after exposure to cold as pruritic and/or painful erythematous-to-violaceous acral lesions. Pernio may be idiopathic or secondary to an underlying disease [1, 2]. Pernio is not necessarily related to very low external temperature, as it is to prolonged exposure to moderately low temperatures, humidity, air currents and sudden shift from hot to cold [1, 2, 5]. The true incidence of pernio is unknown because pernio frequently is unrecognized or misdiagnosed and because rates of pernio vary with climate.

Chilblains are most seen in young and middle-aged women and in children, and in terms of sex ratio,women are affected more frequently than men [2].

Most patients with pernio present with a history of recurrent painful and/or pruritic, erythematous, violaceous papules or nodules on the fingers and/or toes. Most cases of pernio resolve within 2–3 weeks without any adverse reactions. There is always a history of cold exposure or repeated episodes of cold exposure [1]. The direct cause of pernio is cold exposure, but exposure to both mild nonfreezing cold and humidity seems to be required. There are some categories of people who are prone to develop chilblains, such as people who exercise or work outdoors in wet and cold rooms (most common in spring and autumn), women, people who have suffered frostbite, acrocyanosis, hyperhidrosis of the extremities or erythrrocyanosis [4, 5]. Pernio may also be considered a professional condition most often found in fishermen, guards, pastors, frozen meat and fish vendors, street vendors in trade, as well as construction workers and workers in stone quarries [4].

Chilblains have been described in association with various systemic diseases, including chronic myelomonocytic leukemia, dysproteinemias, macroglobulinemia, cryoglobulinemia or cryofibrinogenemia, cold agglutinins and antiphospholipid antibody syndrome. A familial tendency can be found in some patients, while others suffer from peripheral vascular disease due to diabetes, smoking, hyperlipidaemia [1, 2, 3].

Other etiologic factors include low body weight, or poor nutrition due to anorexia nervosa, Raynaud disease and celiac disease. It was also postulated that hormonal changes influence erythema pernio, in terms of improvement of chilblains during pregnancy [1, 2].

Variants of pernio include kibes (equestrian cold panniculitis), chilblain lupus erythematosus and drug-induced pernio. Sulindac – a non-steroidal anti-inflammatory drug of the arylalkanoic acid class that is marketed in the UK & US by Merck as Clinoril – has been reported related to drug-induced pernio in some patients [1, 3]. In kibes, erythrocyanotic plaques occur on the upper lateral thighs of women who ride horses. Histology is characterized by an intense perivascular infiltrate extending into subcutaneous fat [1, 3].

Chilblain lupus erythematosus consist in violaceous "pernio" plaques appear prominent over dorsal interphalangeal joints, often with positive antinuclear antibody (ANA) or rheumatoid factor (RF). Histologic and immunofluorescent evidence of lupus is present in the skin lesions. Half of the patients have associated facial discoid lupus lesions, and 15% develop systemic lupus [1, 3].

Perniotic lesions consist in bluish-red skin discoloration of extremities (fingers, toes, heels, ears, nose, lower legs or thigh); lesions are usually painful and itchy, and patients may experience burning sensations. Other signs include skin swelling, acrocyanosis or ulcerating blisters (fig. 1) [1, 2, 4].

Figure 1. Chilblains in a male – erythema, cyanosis and edema (swelling)

Taking into account the clinical features of pernio differential diagnosis may be necessary, to distinguish between pernio and erythema multiforma, leukocytoclastic vasculitis and sometimes even sarcoidosis [2, 5].

The treatment regimen of the acute outburst consists of local applications with topical steroids (e.g. mometasone furoate), vasodilators, ichtiol, camphor, balsam of Peru and phlebocapillar tonics – Troxerutinum (Venuroton 0.2% gel produced by Novartis) [4, 5].

Systemic therapy is also necessary, and NSAIDs are most commonly used, but sometimes synthetic antimalarials (hydroxychloroquine) are also indicated [4, 5].

Prevention is the key to all cold-related problems as adequate treatment is often not possible out of the hospital setting.

Preventive measures during the first days of winter or sudden temperature changes include effective protection against low temperatures by hot and dry clothes and shoes, and the avoidance of exposure to cold and humidity [4, 5].

Patients should be warned to apply sunscreen to exposed skin even on dull days. In the morning, before leaving the house, a local application of vasodilators and reducers is also mandatory [4, 5].

Another preventive measure is to avoid medicines that might constrict blood vessels: these include caffeine and decongestants. Vasodilator medication such as nifedipine is best to be prescribed before the onset of cold weather and taken throughout winter. However, there may be some minor side effects which include flushing and headache [4, 5].

Trench foot

Trench foot is a nonfreezing cold injury that occurs when feet are wet, but not freezing (temperatures between +15^{0}C and their freezing point), for long periods of time [1, 4].

First described during World War I, trench foot lead to many casualties among soldiers using constrictive footware in wet conditions. Both trench foot and immersion foot, which is a similar condition found in shipwreck survivors in World War II, may lead to persistent hyperhidrosis or cold sensitivity, and therefore prevention is highly important in this cases [1, 2, 3].

Frostbite

Frostbite is a condition caused by the action of cold on the body. Appearance of frostbite not only depends on temperature but also on the duration of exposure to cold, humidity, airflow, possible pre-existing diseases (arterial circulatory disorders, chronic alcoholism) [4]. Usually, frostbite occurs after exposure to –5°C down, but when there are favorable conditions appear to +1°C. Frostbite is a growing problem in winter, but its incidence can not be determined accurately. It affects both sexes in similar percentages and is more frequently seen in children and elderly.

Both frostbite and hypothermia, the condition of developing an abnormally low body temperature, which may lead to death, are cold-related emergencies.

The main consequence of frostbite is permanent disability, due to finger and/or legs/arms amputation, but more than 65% of people will suffer long-term symptoms because of their frostbite. Common symptoms include pain or abnormal sensations in the extremity, heat or cold sensitivity, excessive sweating, and arthritis [1, 2, 3].

Frostbite is caused by two different means: cell death at the time of exposure and further cell deterioration and death because of a lack of oxygen.

Certain groups of people are at greater risk of getting frostbite than others, such as the homeless, winter and high-altitude athletes (mountaineers and skiers) or individuals stranded in extreme cold weather conditions. Soldiers, cold weather rescuers and labourers working in cold environments are also exposed [4].

The most important risk factors are extreme ages (very young and very old people, with thin skin), substance abuse, mental impairment and exhaustion or excessive dehydration [1, 2].

People with decreased blood flow to the extremities such as those with peripheral vascular disease or diabetes or those taking certain drugs that constrict blood vessels (e.g. nicotine or beta blockers) are also at risk to develop frostbite [1, 2].

In superficial frostbite the main symptoms include burning, tingling, stinging and numbness, as well as itching and pain. Patients may experience a cold sensation and excessive sweating. These area appear white and frozen and when pressed, they retain some resistance [1, 2].

As opposed to superficial frostbite, in deep frostbite there is an initial decrease in sensation that is eventually completely lost. Swelling and blood-filled blisters are noted over white or yellowish skin that looks waxy and turns a purplish blue as it rewarms. The area is hard, has no resistance when pressed on, and may even appear blackened and dead. A dull continuous ache transforms into a throbbing sensation in 2 to 3 days and it may last weeks to months until final tissue separation is complete [1, 4, 5].

It is highly important to note that at first the areas may appear deceptively healthy. Most people do not arrive at the doctor with frozen, dead tissue. Only time can reveal the final amount of tissue damage.

Frostbite has been classified under the following categories that relate to the degree of injury.

First-degree frostbite occurs in people who live in very cold climates or do a lot of outdoor activity in winter. It involves the top layer of skin (epidermis) and presents as numbed skin that has turned white in colour. The skin may feel stiff to touch, but the tissue underneath is still warm and soft. Blistering, infection or scarring seldom occurs if it is treated promptly [4, 5].

Second-degree frostbite is a superficial frostbite and presents as white or blue skin that feels hard and frozen. Blisters usually form within 24 hours of injury and are filled with clear or milky fluid. The tissue underneath is still intact but medical treatment is required to prevent further damage (fig. 2) [2, 3].

Third-degree frostbite, also known as deep frostbite, appears as blue skin alternating with white zones. The underlying skin tissue is damaged and feels hard and cold to touch. Blood-filled blisters form black thick scabs over a matter of weeks. Amputation may be required to prevent severe infection or when damage affects muscles, tendons, and bone, with resultant tissue loss (fig. 3) [4, 5].

Frostbite medical treatment includes methods of rewarming suitable to the extent of tissue damage. Therefore, in superficial frostbite thawing is essential and must take place in a warm area (warming and then re-exposing frozen parts to the cold cause permanent damage), using dry warm clothes. Dehydration can be prevented by using warm, nonalcoholic, noncaffeinated fluids to drink. A dry, sterile bandage may be applied, as well ihtyol or camphor creams [4, 5].

In case of deep frostbite after initial life threats are excluded, rewarming is the highest priority. This is accomplished rapidly in a water bath heated to 40-42°C and continued until the thaw is complete (usually 15 to 30 minutes). Narcotic pain medications should be administered because this process is very painful, and since dehydration is very common, IV fluids may also be given. Occasionally, oxygen therapy may be effective. However,when there is a great risk of damage enough to require amputation the patient is send to surgery departament [4, 5].

Post-thaw care is undertaken in order to prevent infection and if necessary, a tetanus booster is given. Dead tissue removal is essential, but only the clear blisters are debrided, leaving blood-filled blisters intact in order to reduce the risk of infection. Hospitalisation for at least 1 to 2 days is important as to determine the extent of injury and to receive further treatment [1, 2].

Long term complications (table 2) have a high impact on patient's life and therefore preventive measures are essential in people at risk for cold injuries [1, 2].

Figure 2. Second degree frostbite – purplish-blue area alternating with white zones, and necrotic patches

Figure 3. Third-degree frostbite – two weeks of evolution (scaling of yellow and black thick scabs)

Table 2

Sequelae of frostbite
• Permanent hipersensitivity to cold
• Hyperhidrosis
• Neuropathies
• Persistent Raynaud phenomenon
• Decreased nail and hair growth
• Loss of limbs
• Frostbite arthritis
• Squamous cell carcinoma
• Epiphyseal plate damage or premature fusion (in children: shortening of the digits, skin redundancy, joint laxity, distal interphalangeal joint radial deviation)
• Lymphedema
• Ulcerations
• Subcutaneous tissue atrophy

The first step to prevent frostbite is knowing which categories are at risk for the injury. Therefore people should avoid alcohol, smoking and additional risk factors such as fatigue, dehydration and improper clothing [1, 4, 5].

Preventive measures include dressing for the weather, using waterproof shoes, covering the head, nose, ears, and wearing gloves, as well as taking extra precautions for the very old, very young, or for people with diabetes [4].

Paraclinical investigations

Baseline laboratory tests in cold injuries should include a complete blood cell count, levels of blood glucose, electrolyte, phosphorus, creatinine, amylase, lactic dehydrogenase isoenzyme, and creatine kinase isoenzyme; prothrombin time; activated partial thromboplastin time (aPTT); and arterial blood gas values. Complete blood count is useful to exclude hemolytic anemia and myelomonocytic leukemia and the evaluation of cryoglobulin, cold-agglutinin and cryofibrinogen levels eliminates cold-sensitive dysproteinemia. Both serum protein electrophoresis and immunofixation electrophoresis are used to exclude a monoclonal gammopathy [1, 2].

Other investigations may include triple-phase bone scans, magnetic resonance imaging and magnetic resonance angiography in order to predict tissue loss and to establish the need of surgical intervention [1, 2].

Conclusions

Exposure to cold environment, due to either occupational or recreational activities may lead to cold-related injuries, such as frostbite and chilblains.

Fundamental therapeutic goals in cold injuries are thawing and rewarming, prevention of further cold exposure and restoration of circulation. However, preventive measures are highly important and include adequate clothing and avoidance of cold and damp, as well as avoidance of smoking or use of alchool.

References

1. Wolff, K., Goldsmith, L. A., Katz, S. I., Gilchrest, B. A., Paller, A. S., Leffell, D. J. *Fitzpatrick's Dermatology in General Medicine, 7th Edition,* New York: McGraw-Hill, 2008. Vol. I, Chapter 93 – Cold Injuries, p 844–852.

2. Bolognia, J. L., Jorizzo, J. L., Rapini, R. P. *Bolognia: Dermatology, 2nd ed,* Mosby-Elsevier, 2008. Vol II, Chapter 87 – Injuries due to cold exposure.

3. Burns, T., Breathnach, S., Cox, N., Griffits, C. *Rook's Textbook of Dermatology, 8th Edition,* Wiley-Blackwell, 2010. Vol. II, Chapter 28 – Mechanical and Thermal Injury, Reactions to cold, pp 28.63–28.70.

4. Bucur, G., Bucur, L., Salavastru, C., Tiplica, G. S. *Dermatoze Profesionale,* Niculescu, 2006. Chapter 2 – Occupational Dermatoses Caused by Physical Agents, p. 32–41.

5. Nicola, G. *Dermatologie si Infectii cu Transmitere Sexuala,* Ovidius University Press, 2006. Chapter 32 – Dermatoses Caused by Physical Agents, p. 241–243.