Plastic and Aesthetic Nursing

Fundamentals of Plastic and Aesthetic Nursing

NCPD 1.5 ANCC Contact Hours

Frostbite 101

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Plastic and Aesthetic Nursing (PAN), *the official journal of the International Society of Plastic and Aesthetic Nurses (ISPAN), publishes this column to provide accurate, evidence-based information about fundamental best practices for plastic and aesthetic nurses.*

Traditionally, frostbite injury was considered a military phenomenon; however, with the increased incidence of homeless individuals and people engaging in cold weather recreational activities, the occurrence of frostbite has become more common (Carceller et al., 2019; Heil et al., 2016; Murphy et al., 2000; Nguyen & Song, 2012). In a study to examine the incidence of frostbite in the general population, Mäkinen et al. (2009) found that the annual incidence of mild frostbite was 12.9% (men: 14.2%; women: 11.9%) and the annual incidence of severe frostbite was 1.1% (men: 1.6%; women 0.6%). The researchers also found that frostbite occurred more often in men than in women and less often in individuals older than 65 years. Frostbite occurs most frequently among occupational workers exposed to physical strain and cold (e.g., agricultural, fishery), but may also occur in individuals during leisure activities. In a retrospective study of 241 patients, Schellenberg et al. (2020) reported a 3% mortality rate, with debridement and/or amputation required in 20% of patients.

According to Basit et al. (2022), factors that increase the risk for frostbite are numerous and include:

- the winter season,
- a lack of or inadequate shelter from the cold,
- a high wind chill factor,
- exposure to cold at a high altitude,
- prolonged exposure to cold,
- prolonged exposure to a wet condition,
- having an altered mental status,
- abusing alcohol or drugs,
- being malnourished,
- being immobilized,
- being very young or very old,
- being homeless,
- having a medical disorder such as diabetes, hypothyroidism, peripheral vascular disease, stroke, or arthritis, and
- smoking.

Plastic surgeons have a critical role in the management of patients with frostbite and must work with an interdisciplinary team that includes skilled plastic surgical nurses to identify the best treatment route for optimal patient care. This column provides a review of the fundamentals of frostbite, including its pathophysiology, classification, and management. Using the search terms *frostbite* AND *management* AND *surgery*, Zaramo et al. (2022) conducted a literature review of 54 publications published before February 20, 2022, located in the PubMed and EMBASE databases. The majority of the information provided in this column was derived from this excellent review.

PATHOPHYSIOLOGY OF FROSTBITE

Frostbite occurs when the skin and tissues are exposed to temperatures beyond their freezing point (31.1 °F [–0.53 °C]). Exposure to extreme cold leads to peripheral vasoconstriction and intermittent cycles of vasodilation, which shunt the blood from the distal areas of the body to the central areas of the body (Regli et al., 2021; Rintamäki, 2000). This causes the feet, hands, ears, lips, and nose to freeze (Regli et al., 2021; Rintamäki, 2000).

As the tissue freezes, extracellular ice crystals form, resulting in cellular lysis and dehydration, electrolyte imbalances, and microvascular damage (Zaramo et al., 2022). These processes eventually lead to tissue ischemia and necrosis (Handford et al., 2017; McIntosh et al., 2019; Regli et al., 2021). As shown in Figure 1, frostbite injuries occur in three stages:

1. *Frostnip* is a mild form of frostbite (Mayo Clinic, 2022). Ongoing exposure to cold leads to numbness in the affected area. As the patient's skin begins to warm, they may complain of pain and tingling (Mayo Clinic, 2022). Frostnip does not cause permanent skin damage (Mayo Clinic, 2022).
2. *Superficial frostbite* causes slight changes in skin color (Mayo Clinic, 2022). The patient's skin may begin to feel

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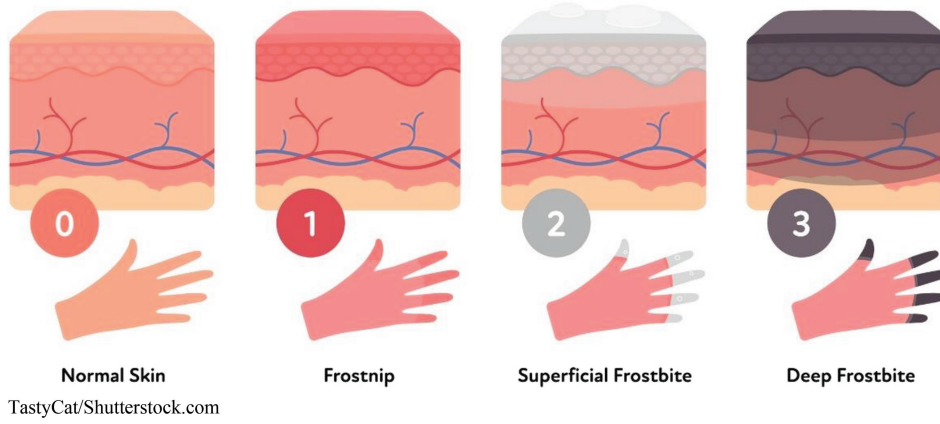

FIGURE 1. Stages of frostbite. This figure is available in color online (www.PANjournal.org).

warm and swollen and the patient may complain of stinging and burning (Mayo Clinic, 2022). This is actually a sign of serious skin involvement (Mayo Clinic, 2022).

3. *Deep frostbite* occurs as the frostbite injury progresses, affecting all of the layers of the skin as well as the tissues that lie below the skin (Mayo Clinic, 2022). The patient's skin turns white, yellow, blue or blue–gray, or mottled, and may also have a hard, waxy appearance (Handford et al., 2017; McIntosh et al., 2019; Murphy et al., 2000). The patient loses all sensation of cold, pain, or discomfort in the area and their joints and/or muscles may stop working (Zaramo et al., 2022). The tissue turns black and hard as it dies (Mayo Clinic, 2022).

After rewarming, the skin may be red and abnormally swollen with fluid (Zaramo et al., 2022). The appearance of clear, yellow, serosanguinous blisters is a late finding that typically indicates a favorable prognosis, whereas the appearance of small, dark, blood-filled blisters indicates a less favorable prognosis (Zaramo et al., 2022).

CLASSIFICATION OF FROSTBITE

The most current classification scheme for frostbite injuries was developed by Cauchy et al. (2001). This classification is based on the presence of lesions after rewarming and radioactive uptake on bone scans, which are helpful in predicting bone and tissue loss and the risk for amputation. Using this classification, frostbite injuries are classified as

- *Grade 1:* No cyanosis on the extremity; no risk of amputation or sequelae predicted
- *Grade 2:* Cyanosis on the distal phalanx only; amputation of soft tissue and fingernail/toenail sequelae predicted
- *Grade 3:* Cyanosis on the intermediate and proximal phalanges; amputation of digit bone and functional sequelae predicted
- *Grade 4:* Cyanosis on the carpal/tarsal bones; amputation of the limb and functional sequelae predicted

Notably, these classifications can be challenging to assign because frozen tissue is difficult to examine, and assessing the depth of tissue damage may not be possible for several days to weeks (McIntosh et al., 2019). Likewise, frostbite lesions evolve slowly and may change in appearance after rewarming (McIntosh et al., 2019).

MANAGING FROSTBITE INJURIES

As soon as a frostbite injury is identified, the individuals caring for the patient should remove the patient from cold exposure and take off the patient's wet clothing. Caregivers should avoid rubbing, massaging, and applying dry heat to the patient's frostbitten skin, as this can result in further injury to the tissue (McIntosh et al., 2019). To protect the patient against further injury, caregivers should immobilize the affected area and gently wrap it with dry gauze (Zaramo et al., 2022). To prevent refreezing, which can lead to reperfusion injury, caregivers should keep the patient warm (Cauchy et al., 2016; Lorentzen et al., 2020).

The foundation of effective frostbite injury management is rapid rewarming of the affected area in water (104 °F–107.6 °F [40 °C–42 °C]; Zaramo et al., 2022). Rewarming should continue until the skin appears red or purple (Zaramo et al., 2022). This usually takes approximately 15–60 min (Zaramo et al., 2022). To avoid fluctuating temperatures and cooling of the water, which may cause additional tissue damage, it is important to circulate the water used for rewarming (Zaramo et al, 2022). Caregivers should consider adding an antiseptic solution (e.g., chlorhexidine gluconate and povidone-iodine) to the water, as this will cause no harm and may help to reduce the bacterial load on the patient's skin (McIntosh et al., 2019). Notably, current literature does not recommend administering prophylactic antibiotics except in cases of severe trauma, exposure to infectious contaminants, or for treatment of cellulitis or sepsis (Handford et al., 2017; McIntosh et al., 2019).

The patient may experience severe pain during rewarming. Pain may be relieved by administering

12-mg/kg ibuprofen twice daily, with a maximum dose of 2,400 mg per day (Ibrahim et al., 2015). In addition to its analgesic and anti-inflammatory effects, ibuprofen reduces prostaglandins and thromboxanes associated with thrombosis and ischemia (Ibrahim et al., 2015). Caregivers should also consider giving the patient a tetanus vaccine (McIntosh et al., 2019).

After rewarming, blisters may form. If the blisters are filled with a clear or cloudy fluid, caregivers may use a sterile needle to drain the blisters (Heggers et al., 1987; McIntosh et al., 2019). This is desirable because the fluid may contain prostaglandins and thromboxanes that may damage the underlying tissue (Heggers et al., 1987; McIntosh et al., 2019). After draining the blisters, caregivers may apply topical aloe vera to decrease prostaglandins and thromboxanes, which may improve tissue survival (Golant et al., 2008; Imray et al., 2009; McIntosh et al., 2019). If the blisters are filled with blood, they should be left alone and not drained as this is a sign of deeper tissue damage (Heggers et al., 1987; McIntosh et al., 2019). Caregivers should loosely wrap the affected area with dry, sterile dressings and place padding or dressing material between the affected fingers or toes to prevent friction (McIntosh et al., 2019).

One major challenge in managing frostbite is determining the extent of injury and preserving as much tissue as possible (Zaramo et al., 2022). Multiple imaging techniques may be appropriate for this purpose (Zaramo et al., 2022). X-ray is useful for assessing for fractured bones, penetrating trauma, or foreign bodies (Cauchy et al., 2001; Murphy et al., 2000). Doppler imaging and angiography may be useful for assessing vessel patency (Zaramo et al., 2022). Bone scans using technetium 99m-labeled diphosphonate and single-photon emission computed tomography combined with conventional computed tomography can be used to assess the depth of injury, tissue viability, and the need for thrombolytics (Zaramo et al., 2022). Administering thrombolytics may improve tissue perfusion and decrease the need for amputation (Bruen et al., 2007; Cauchy et al., 2011; Ibrahim et al., 2015; Jones et al., 2017; Poole et al., 2021; Tavri et al., 2016; Twomey et al., 2005). Bone scans can also be used to guide surgical management and predict the need for amputation (Zaramo et al., 2022).

Grade 1 frostbite injuries should heal without a need for surgery; however, Grade 2, 3, and 4 frostbite injuries often require surgical repair (Hutchison, 2014). Reconstructive strategies must be tailored to each patient's situation (Zaramo et al., 2022). Surgical repair may involve debridement, fasciotomy for compartment syndrome, surgical salvage with revascularization, dermal tissue grafts, local flaps, or free flaps (Classen, 2000; Fisher et al., 2019; Handford et al., 2017; Leonard et al., 2001; Shenaq & Gottlieb, 2017). Notably, caregivers should suspect compartment syndrome in patients who complain of pain disproportionate to the injury (Zaramo et al., 2022). As compartment pressures increase, it causes further ischemic damage to the nerves and muscle (Brandão et al., 2018; Mohr et al., 2009).

Frostbite of the hand often requires complex reconstructive surgery with a goal of preserving digital length and restoring form and function (Brandão et al., 2018; Joshi et al., 2020; Shenaq & Gottlieb, 2017).

Frostbite injury most commonly occurs on the foot (Zaramo et al., 2022). To restore optimal form and function, surgical reconstruction of the foot is often necessary (Fodor et al., 2016). Surgical reconstruction of the foot is complex and often requires the use of flaps that have sufficient skin composition, turgor, and padding to maintain flexibility and support for walking (Classen, 2000; Simman & Abbas, 2021).

Patients who sustain frostbite injury may suffer from long-term complications including neuropathy, chronic pain, cold, hypersensitivity, hyperhidrosis, and functional impairment (Regli et al., 2021). Managing these long-term complications can be challenging; therefore, it is important to involve chronic pain specialists early in the treatment process (Handford et al., 2017; Hutchison, 2014). Likewise, medications such as amitriptyline, gabapentin, duloxetine, topical capsaicin, and onabotulinumtoxinA may be beneficial (Handford et al., 2017; Hutchison, 2014; Khan et al., 2008; Regli et al., 2021).

Plastic and reconstructive surgeons play a primary role in managing frostbite injuries. To improve patient satisfaction and outcomes, plastic surgical nurses must be well versed in frostbite management.

If you are a plastic or aesthetic nurse and would like to write about an issue of fundamental importance to plastic or aesthetic nurses, or if you would like to see your issue presented in a future* Fundamentals of Plastic and Aesthetic Nursing Practice *column of* PAN*, please contact Sharon Ann Van Wicklin, Editor-in-Chief at sharonvwrn@ispan.org.

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