Evaluation of optimal care provided to a patient with third- or fourth-degree frostbite presenting to a level II trauma center emergency department

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Abstract:

**Background**

Frostbite is a cold injury that occurs when patients are exposed to cold temperatures for a prolonged period of time. The Wilderness Medical Society has published clinical practice guidelines for the prevention and treatment of frostbite. Severe frostbite is uncommon and requires prompt attention. The purpose of this study was to evaluate the incidence of guideline concordant care of third- and fourth-degree frostbite presenting within 48 hours to an emergency department.

**Methods**

This was a retrospective chart review of assessing patients presenting to an ED with third- or fourth-degree frostbite. The primary outcome of this study was to evaluate the percentage of patients that received each component of optimal care as defined by the guidelines. Secondary outcomes included patients who received each component of optimal care, limb salvation, and in-hospital mortality.

**Results**

There were 26 patients included in the analysis. Five patients (26%) received all components of optimal care as defined by the guidelines. Hypothermia, systemic hydration, rapid rewarming of frozen tissues, and thrombolytic therapy when indicated occurred 100% of the time. Prophylactic antibiotics were avoided 73% of the time. Patients received tetanus prophylaxis that was guideline concordant 46% of the time. Fifteen percent of patients had limb salvation. In-hospital mortality occurred in 8% of the population.

**Conclusion**

There are opportunities for improvement in the emergence department for guideline concordant care of patients presenting with third- or fourth-degree frostbite. Institution specific guidelines or order sets are needed to help direct optimal care.

Keywords: Frostbite, thrombolytics, emergency department

1. Background

Frostbite is an injury that causes tissue damage that occurs due to cold exposure. Typically, injury occurs when the temperature is less than zero degrees Celsius1.Historically, it was most commonly identified in military personnel. However, recreational sports have become a more common contributing cause in civilian populations. There are several risk factors for the development of frostbite including exposure, clothing, acute intoxication, inadequate shelter, comorbidities, and dehydration1,2.Frostbite causes tissue damage by several mechanisms including direct cellular tissue injury by formation of extracellular ice crystals vascular inflammation, thrombosis, and ischemia. Frostbitten tissue cycles through phases of vasoconstriction and vasodilation, which further increases the inflammatory response1.

Classification of frostbite injuries includes a four-tier system, each characterizing progressively more damage. First-degree frostbite typically presents with a white plaque in the area of injury. Many patients will have edema, numbness, and erythema to the injury site. Second-degree frostbite causes superficial skin vesiculation with clear or milky white fluid. Patients will experience edema and erythema to the site of injury. Third-degree frostbite is characterized by deeper, hemorrhagic blisters. These blisters indicate the injury is deeper and can extend beyond the dermal vascular plexus. Lastly, fourth-degree frostbite is characterized by cyanotic, gangrenous tissue necrosis. This injury extends to the muscle and bone. The injury will eventually become dry, black, and mummified. Tissue loss and amputation are common for fourth-degree injuries2-5.

The goal of resuscitation in frostbite injuries is to maintain peripheral perfusion and prevent tissue loss and amputation. The Wilderness Medical Society has published clinical guidelines for the prevention and treatment of frostbite. Level I recommendations include treating patients that have moderate to severe hypothermia prior to addressing frostbite injury, hydration, rapid rewarming of frozen tissues, avoidance of systemic antibiotics for prophylaxis, tetanus prophylaxis, thrombolytic therapy, and prostacyclin analogue therapy. Adequate hydration also plays a vital role in frostbite recovery. Fluid status should be optimized to prevent dehydration. This can be accomplished via enteral fluids or warm intravenous fluids. Frozen tissue rewarming is recommended if spontaneous thawing has not previously occurred. This should be addressed by placing the frostbitten tissue in a tepid water bath until rewarming is completed. Rewarming is considered complete when the injured tissue changes color and becomes soft and pliable. Frostbite is not an infectious process and does not necessitate antibiotics for the prevention of infection. It is recommended to administer antibiotics for frostbite patients only if there are other infectious sources, trauma, or signs of cellulitis or sepsis. Frostbite injury can be a risk factor for tetanus; therefore, it necessitates that patients are up to date with their tetanus vaccinations. Thrombolytic therapy is recommended for frostbite injuries with potential for significant morbidity. Criteria for thrombolytic therapy include no improvement on rapid rewarming, absent doppler pulses in limbs, limited perfusion on bone scan, and less than 24 hours since rewarming has been completed. Patients are excluded from receiving thrombolytic therapy if they have severe hypertension, recent trauma, stroke, or bleeding disorder, pregnancy, mental incapacity, repeated freeze-thaw cycles or more than 24 hours of cold exposure6. Prostacyclin (PGI2) analogues should be considered if thrombolytics are contraindicated up to 48 hours after injury5.

Level II recommendations include application of topical aloe vera, non-steroidal anti-inflammatory drugs (NSAIDs), management of blisters, and low molecular weight dextran. Topical aloe vera is recommended to be applied at each dressing change. Aloe vera reduces formation of inflammatory mediators. NSAIDs are recommended to prevent further tissue damage and inhibit harmful prostaglandins. Low molecular weight dextran is recommended to decrease formation of microthrombi.Currently, low molecular weight dextran and Iloprost, the primary studied prostacyclin analogue, are not available in the United States; therefore, it was unable to be assessed in this study.

**2. Methods**

This was a retrospective chart review of patients presenting to the emergency department from January 2014 to December 2022. Patients were included in the study if they were identified as having third- or fourth-degree frostbite. Patient were excluded if they were determined to have first- or second-degree frostbite. The objective of this study was to evaluate the incidence of guideline concordant care of third- and fourth-degree frostbite presenting within 48 hours to an emergency department. This study was formally reviewed and approved by the institutional review board.

The primary outcome of this study was the percentage of patients that received all grade I recommendations as defined by the Wilderness Medical Society Clinical Practice Guidelines for the Prevention and Treatment of Frostbite: 2019 update. Grade II recommendations for frostbite were weak recommendations with low quality or very low quality of evidence and were excluded from this study’s definition of optimal care. Optimal care for this study was defined as treating hypothermia, systemic hydration, rapid rewarming, avoidance of systemic antibiotics for frostbite alone, guideline concordant tetanus prophylaxis, and thrombolytic therapy if indicated.

Secondary outcomes for this study included the percentage of patients that received each component of the optimal care definition, percentage of patients with limb salvation, and in-hospital mortality. Limb salvation was defined as not having any portion of an extremity amputated.

***2.1 Data Collection***

Data was collected via the electronic medical record. Data collected included age, sex, comorbidities, alcohol use, substance use, housing status, severity and location of frostbite, (NSAID) use, benzodiazepines and opioids given in hospitals, and consulted services.

***2.2 Data Analysis***

Data was analyzed using descriptive statistics.

**3. Results**

There were sixty-five patients initially identified with ICD-9 or ICD-10 diagnosis codes for frostbite. Thirty-nine patients were excluded for various reasons including the encounter was not a frostbite encounter, it was first- or second-degree frostbite, it was a subsequent frostbite visit and had already been managed, or the patient left against medical advice prior to examination. After exclusion, there were 26 patients that were analyzed for this study (Figure 1).



Figure 1: Diagram of the study population

The demographics for included patients are demonstrated in Table 1. The majority of patients were male (73%) and the mean age was 54 years old. Eighty-one percent of patients included in this study were unhoused. There was a higher percentage of patients with third-degree injury (54%) than fourth-degree injury (46%). The feet and toes were the area most often affected by frostbite injury. Most patients (89%) had an orthopedic surgery consult.

Five patients (19%) received all components of optimal care as defined by the current guidelines (Table 2). When indicated, all patients (100%) received treatment for hypothermia, systemic hydration, rapid rewarming of frozen tissues and thrombolytic therapy. Antibiotics for prophylaxis against frostbite wounds were appropriately avoided in 73% of the population. Forty-six percent of the population received guideline concordant tetanus prophylaxis. Fifteen percent of patients had limb salvation. In-hospital mortality occurred in 8% of the population (Table 3).

**4. Discussion**

This is the first study that these authors are aware of that addresses adherence to current guideline recommendations regarding frostbite management. In this study, optimal care was not provided in 81 % of patients enrolled. This demonstrates the need for a provider guideline or order set to direct optimal care for third- and fourth-degree frostbite in a level II trauma center.

Tetanus prophylaxis that is in concordance with Centers for Disease Control and Prevention was the largest opportunity to improve frostbite management with only 46% of the population adhering to this recommendation. In patients that did not meet this care metric, 7.7% received the vaccine when it was not indicated and 46% did not receive the vaccine when it was indicated. Pharmacy and nursing protocols have since been developed to improve tetanus guideline concordance.

There were initially eight patients identified as thrombolytic candidates, however, many of these patients met at least one exclusion criteria. The most common exclusion criteria were repeated freeze-thaw cycles and frostbitten tissue rewarmed more than 24 hours prior to initial presentation to the emergency department. The one identified thrombolytic candidate did receive the recommended treatment with alteplase.

***4.1 Limitations***

Limitations to this study include its retrospective design at a single institution. The sample size was small due to infrequency of severe frostbite incidence. There was inconsistent documentation regarding severity of injury, tetanus assessment, and need for antibiotics for true infection versus prophylaxis.

**5. Conclusion**

Optimal care for severe frostbite was provided infrequently at a level II trauma center emergency department; however, many components of care were provided frequently. Due to the rarity of severe frostbite presentation providers are unfamiliar with current guidelines. Order sets or provider guidelines should be developed to direct optimal care of frostbite within emergency departments.

Conflicts of Interest

The authors of this manuscript have nothing to disclose and no conflicts of interest.

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Table 1: Baseline Characteristics

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| --- | --- |
|  | Frostbite populationN=26 |
| Mean age, n (range) | 54 (34-84) |
| Male, n (%) | 19 (73.1) |
| Alcohol use, n (%) | 4 (15.4) |
| Substance use, n (%) | 5 (19.2) |
| Diabetes mellitus, n (%) | 3 (11.5) |
| Cancer, n (%) | 1 (3.8) |
| CAD/ PAD, n (%) | 6 (23.1) |
| Coagulopathy, n (%) | 1 (3.8) |
| Houseless, n (%) | 21 (80.8) |
| Degree of frostbite          Third-degree, n (%)          Fourth-degree, n (%) | 14 (53.8)12 (46.2) |
| Area of frostbite of third- or fourth-degree\*          Foot, n (%)          Toes, n (%)          Leg, n (%)          Finger, n (%)          Hand, n (%) | 15 (57.6)21 (80.8)1 (3.8)2 (7.7)1 (3.8) |
| NSAID given, n (%) | 8 (30.8) |
| Aloe vera given, n (%) | 1 (3.8) |
| Benzodiazepine given, n (%) | 4 (15.4) |
| Opiate given, n (%) | 12 (46.2) |
| Consulted services\*          Trauma, n (%)          Vascular surgery, n (%)          Orthopedic surgery, n (%) | 3 (11.5)5 (19.2)23 (88.5) |

\*Number does not add up to 100% due to patients included in multiple categories

Table 2: Optimal care

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|  | Frostbite PopulationN=26 |
| Percentage of patients with severe frostbite that received optimal care | 5 (19%) |

Table 3: Secondary Outcomes

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|  | Frostbite PopulationN=26 |
| Treat hypothermia, when indicated (n=4), n (%) | 4 (100) |
| Systemic hydration, when indicated, n (%) | 19 (73.1) |
| Rapid rewarming of frozen tissue, when indicated (n=8), n (%) | 8 (100) |
| Avoidance of systemic antibiotics for prophylaxis, n (%) | 19 (73.1) |
| Tetanus prophylaxis guideline concordant, n (%)          Indicated and given, n          Not indicated and avoided, n | 12 (46.2)102 |
| Thrombolytic therapy, when indicated (n=1), n (%) | 1 (100) |
| Percentage of patients with limb salvation, n (%) | 4 (15.4) |
| In-hospital mortality, n (%) | 2 (7.7) |