A retrospective cohort study examining treatments and operative interventions for frostbite in a tertiary care hospital

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ABSTRACT

Background: Frostbite is a common yet challenging injury to both diagnose and treat. McCauley's frostbite treatment protocol consists of 12 treatments that might well represent the standard of care. However, its effectiveness in preventing operative intervention has yet to be examined. Our objectives were to characterize frostbite injuries in Eastern Ontario, identify risk factors for deep injuries, and assess the protocol's efficacy in preventing operative outcomes.

Methods: This cohort study examined patients with frostbite over ten years at a tertiary care hospital. Demographics and predisposing factors were recorded. Frostbite severity was categorized into superficial or deep. Treatments were recorded, including adherence to protocol and operative outcome.

Results: Of the 265 frostbite patients identified, deep frostbite accounted for 56 (21.1%, 95% CI: 16.2–26.1%), of whom 20 (35.7%) had an operative outcome. Amputation occurred in 16 (28.6%) of deep injuries and debridement in 5 (8.9%). Risk factors for deep frostbite were older age ($p = 0.002$), smoking ($p < 0.001$), male sex ($p = 0.056$) and alcohol abuse ($p = 0.056$). None of the patients with deep frostbite had all 12 treatments performed. Adherence to protocol ranged from 0.0% to 48.2% per treatment. The rate of operative intervention was 7.7% in patients with deep frostbite who did not have any McCauley's frostbite treatments and ranged from 0.0% to 100.0% per treatment in those who did receive treatments.

Conclusions: The frostbite protocol was not regularly followed and therefore its efficacy in preventing operative intervention could not be determined. Further, none of the individual treatments in the protocol were associated with preventing operative intervention. We recommend that future research focus on identifying effective individual treatments.

RÉSUMÉ

Contexte : Les gelures sont des accidents fréquents, qui présentent des difficultés tant sur le plan du diagnostic que sur celui du traitement. Le protocole de traitement des gelures de McCauley consiste en 12 interventions thérapeutiques et il pourrait bien devenir la norme de soins en la matière. Toutefois, il reste à examiner son efficacité dans la prévention des opérations. L'étude décrite ici visait à caractériser les gelures observées dans l'Est de l'Ontario, à cerner les facteurs de risque de gelure profonde et à évaluer l'efficacité du protocole quant à la prévention des opérations.

Méthode : Il s'agit d'une étude de cohorte portant sur des patients ayant subi des gelures, sur une période de 10 ans, dans un hôpital de soins tertiaires. Ont été consignés des données démographiques et des facteurs prédisposants. La gravité des gelures a été divisée en deux catégories : superficielle et profonde. Les interventions ont également été enregistrées, y compris le respect du protocole et les résultats des opérations.

Résultats : Au total, 265 patients ayant subi des gelures ont été recensés; sur ce nombre, 56 (21,1 %, IC à 95 % : 16,2-26,1 %) souffraient de gelures profondes, dont 20 (35,7 %) ont été opérés. On a procédé à l'amputation dans 16 (28,6 %) cas de lésion profonde et au débridement dans 5 (8,9 %) cas. Les facteurs de risque de gelure profonde comprenaient un âge avancé ($p = 0,002$), l'usage du tabac ($p < 0,001$), le sexe masculin ($p = 0,056$) et l'abus d'alcool ($p = 0,056$). Aucun des patients ayant subi des gelures profondes n'a été soumis aux 12 interventions thérapeutiques. Le respect du protocole variait de 0,0 % à 48,2 % par intervention. Le taux d'opération s'élevait à 7,7 % chez les patients ayant subi des gelures profondes qui n'avaient été soumis à aucune des interventions de McCauley et il variait de 0,0 % à 100,0 % par intervention chez ceux qui avaient été soumis à l'une ou l'autre d'entre elles.

Conclusions : Le protocole de traitement des gelures a été plus ou moins suivi; aussi a-t-il été impossible de déterminer son efficacité au regard de la prévention des opérations. De plus, aucune des interventions prévues au protocole, considérées individuellement, n'a été associée à la prévention des opérations. Les auteurs recommandent donc que la recherche d'interventions efficaces en elles-mêmes fasse l'objet de futures études.

Keywords: Frostbite, Amputation, Treatment-protocol

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INTRODUCTION

Frostbite is a prominent cause of morbidity for patients in cold climates. To help preserve injured tissue, McCauley created a frostbite treatment protocol in 1983 based on the pathophysiology of frostbite and observational data from the 1960s.[1-3] This protocol consists of 12 treatments that aim to suppress local inflammation, provide analgesia, and prevent secondary infection.[1]

More recent literature focuses on new treatments that have developed since the creation of the McCauley protocol. These include anticoagulant therapy, hyperbaric oxygen, and improved imaging modalities that quantifies non-viable tissue.[4–9] Although these new treatments are promising, the McCauley protocol might be considered the standard of care. Importantly, the evidence supporting the protocol or the individual treatments within it is lacking.

Our objectives were to examine the prevalence of frostbite in the emergency departments (EDs) of two Eastern Ontario tertiary care hospitals. We also sought to determine associated predisposing factors, current physician treatment practices, and determine if adherence to McCauley's frostbite treatment protocol was associated with improved patient outcomes (i.e., less operative intervention).

METHODS

A retrospective chart review was performed using The Ottawa Hospital patient records database. This hospital is a tertiary care referral centre, with two emergency departments, that serves a local population of over 1 million people. Hospital records were used to generate a list of all patients diagnosed with frostbite between April 1, 2002 and February 27, 2013. The inclusion criteria were: age greater than or equal to 16 years old, and diagnosed at The Ottawa Hospital with frostbite. To ensure no frostbite injuries were missed, all charts of patients given a diagnosis of frostbite or hypothermia according to the obligatory National Ambulatory Care Reporting System were reviewed. Only patients with documented frostbite in their charts were included in the study. The chart review included both paper and computer charts. Data was collected by the primary author with the guidance and supervision of the co-author (JP). The primary author utilized a standardized data extraction form. Charts were reviewed with coauthor (JP) after the first 10 charts for consistency. All documents containing physician notes, nursing notes, and order sheets were reviewed to ensure that all treatments were included. Data from encounters in the ED, during any admissions as well as during subsequent hospital visits were included. To determine if any operative intervention was performed, charts were followed prospectively until the time of review (June 2013). The Ottawa Health Science Network Research Ethics Board approved this study.

Our primary outcome was the rate of operative intervention. This was defined as: any operating room debridement, skin graft, amputation, or reconstructive surgery at the site of a frostbite injury. Secondary analysis included characterization of frostbite injuries, risk factors for deep frostbite, and treatments performed that are a part of the McCauley protocol, and treatments applied that were not included in the protocol (e.g., hyperbaric chamber, wound dressing, or topical antibiotics).

Demographic data and predisposing factors were recorded on a standardized data extraction form and then input into a database by one reviewer. Severity of frostbite was categorized into superficial (1st and 2nd degree) or deep (3rd and 4th degree) (Figure 1).[1,10-13] Distribution of predisposing factors were compared between superficial and deep injuries using student *t*-tests for continuous variables and chi-squared or Fisher's exact tests for categorical variables. Patient encounters were reviewed to determine if the protocol was followed (Figure 2). For each patient, protocol adherence, in terms of the number of treatments that were followed, was recorded. Using chi-squared or Fisher's exact tests, the operative intervention rates

Superficial Frostbite		Deep Frostbite	
1st Degree	2nd Degree	3rd Degree	4th Degree
- central area of pallor - white, waxy appearance - cold or burning pain - paresthesia - surrounded by edema	- clear / milky blisters - erythema - surrounded by edema	- blood filled blisters - black eschars develop over several weeks	- firm, woody tissue - muscle, tendons, and/or bone affected - complete tissue necrosis - sloughing of tissue

Figure 1. Classification of frostbite.

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1. Admit frostbite patient to a specialist unit, if possible
2. Correct hypothermia
3. Rapidly rewarm the affected areas in warm water at 40–42°C for 15 to 30 minutes or until thawing is complete
4. Debride white blisters and institute topical treatment with aloe vera every 6 hours
5. Leave hemorrhagic blisters intact and institute topical aloe vera every 6 hours
6. Elevate the affected part(s) with splinting as indicated
7. Administer anti-tetanus prophylaxis
8. Analgesia: opiate, intramuscularly or intravenously as indicated
9. Administer ibuprofen 400 mg orally every 12 hours
10. Administer benzyl penicillin 600 mg every 6 hours for 48 to 72 hours
11. Perform daily hydrotherapy for 30 to 45 minutes at 40°C
12. Prohibit smoking

Excluded: For documentation obtain photographic records on admission, at 24 hours and serially every 2 to 3 days until discharge.

Figure 2. Frostbite treatment protocol (adapted from McCauley).

Table 1. Patient characteristics and predisposing factors

	Superficial n = 209 (%)	Deep n = 56 (%)	All n = 265 (%)	*p*-value
Age (years) (mean, SD)	38.9 (16.8)	46.7 (16.9)	40.5 (17.1)	0.002
Presentation to ED within 24 hrs	64 (30.6)	30 (53.6)	94 (35.5)	0.001
Male sex	149 (71.3)	47 (83.9)	196 (74.0)	0.056
Smoker	15 (7.2)	13 (23.2)	28 (10.6)	<0.001
Alcohol	27 (12.9)	13 (23.2)	40 (15.1)	0.056
Illicit drug use	12 (5.7)	5 (8.9)	17 (6.4)	0.37
Any psychiatric illness	40 (19.1)	15 (26.8)	55 (20.8)	0.21
**Schizophrenia*	*19 (9.1)*	*5 (8.9)*	*24 (9.1)*	*0.97*
**Drug induced psychosis*	*4 (1.9)*	*1 (1.8)*	*5 (1.9)*	*1.00*
**Mood disorder*	*13 (6.2)*	*3 (5.4)*	*16 (6.0)*	*1.00*
**Suicide attempt*	*1 (0.5)*	*2 (3.6)*	*3 (1.1)*	*0.11*
**Other psychiatric illness*	*9 (4.3)*	*5 (8.9)*	*14 (5.3)*	*0.18*
Motor vehicle collision	3 (1.4)	1 (1.8)	4 (1.5)	1.00
Skidoo use	1 (0.5)	1 (1.8)	2 (0.8)	0.38
Winter sports	18 (8.6)	4 (7.1)	22 (8.3)	1.00
Inadequate clothing	63 (30.1)	22 (39.2)	85 (32.1)	0.19

*Note: some patients had more than one psychiatric diagnosis

were compared between those who received treatment according to protocol and those who did not. Similarly, treatments observed that fell outside the treatment protocol were recorded and the operative intervention rates were compared between those who did and those who did not receive these treatments. Those treatments that fell outside the treatment guidelines were compared using chi-squared or Fisher's exact tests as well. Associations were expressed as odds ratio (ORs) with 95% confidence intervals (CIs).

RESULTS

Over the course of ten years, we identified 265 patients with frostbite; 209 (78.8%) of patients were classified as having superficial frostbite and 56 (21.1%) as having deep frostbite (Table 1). The most prevalent predisposing factors for frostbite were similar for superficial and deep frostbite. These included inadequate clothing/footwear (32.1%), alcohol abuse (15.1%), and psychiatric illness (20.8%). Among patients with deep frostbite, smoking was significantly more prevalent (23.2% v. 7.2%, $p < 0.001$), and patients were significantly older (mean 46.7 v. 38.9 years, $p = 0.002$). While not statistically significant, male sex (83.9% v. 71.3%, $p = 0.056$) and alcohol abuse (23.2% v. 12.9%, $p = 0.056$) were more common among patients with deep frostbite injuries.

Of those with deep frostbite, 20 (35.7%) had an operative intervention for their injury. Amputation

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occurred in 16 patients (28.6%) and debridement occurred in 5 patients (8.9%). One patient received both an amputation and debridement.

Adherence to the treatment protocol is presented in Table 2. Adherence to each treatment ranged from 0.8% for daily hydrotherapy to 32.8% for analgesia across all patient groups. For patients with deep frostbite, the most common treatments included: admission to hospital (48.2%), analgesia (37.5%), antibiotics (19.6%), and prohibition of smoking (12.5%). These were also the most common treatments for patients with superficial frostbite; however adherence was generally worse among those with superficial frostbite. None of the 265 patients received all 12 treatments in the protocol. Adherence to other therapies that fell outside of the treatment protocol are also indicated in Table 2, specifically use of wound dressings (24.5%), hyperbaric chamber (3.4%), antibacterial cream (13.6%) and aloe vera (not associated with blister treatment) (8.3%).

Table 3 presents the operative intervention rates among deep frostbite patients adherent and non-adherent to the treatment protocol. The rate of operative intervention was 7.7% in patients with deep frostbite who did not receive any treatments listed in the protocol and ranged from 0.0% to 100.0% per treatment for those who did receive some treatments in the protocol. Patients who were admitted had significantly higher rates of operative intervention than those who were not admitted (56% v. 17%, $p = 0.003$), but there were no other significant differences in operative interventions among patients adherent and non-adherent to treatments.

None of the other therapies were associated with an operative intervention in deep the frostbite group. While not statistically significant, operative interventions were more common among those not using a hyperbaric chamber (30.6% v. 8.9%, $p = 0.085$). We also examined whether presentation to the ED within 24 hours of injury was associated with the rate of operative treatment. We found that the rate of operative intervention was higher among these patients (46.7 v. 23.1%, $p = 0.066$), but again, no definitive association could be made.

Table 2. Protocol and non-protocol treatments: superficial versus deep frostbite

	Superficial n = 209 (%)	Deep n = 56 (%)	All n = 265 (%)
Protocol treatments			
Admit	31 (14.8)	27 (48.2)	58 (21.9)
Hypothermia treatment	18 (8.6)	5 (8.9)	23 (8.7)
Rapid rewarming	6 (2.9)	1 (1.8)	7 (2.6)
Debride clear blisters	22 (10.6)	3 (5.4)	25 (11.7)
Leave hemorrhagic blisters	0 (0.0)	3 (5.4)	3 (1.1)
Immobilize	4 (1.9)	3 (5.4)	7 (2.6)
Tetanus	24 (11.5)	8 (10.7)	32 (12.1)
Analgesia	66 (31.6)	21 (37.5)	87 (32.8)
Ibuprofen	4 (1.9)	2 (3.6)	6 (2.3)
Antibiotics	26 (12.4)	11 (19.6)	37 (14.0)
Hydrotherapy	2 (1.0)	0 (0.0)	2 (0.8)
Prohibit smoking	12 (5.7)	7 (12.5)	19 (7.2)
Non-protocol treatments			
Aloe vera	18 (8.6)	4 (7.1)	22 (8.3)
Hyperbaric chamber	2 (0.8)	7 (12.5)	9 (3.4)
Antibacterial cream	31 (14.8)	5 (8.9)	36 (13.6)
Wound dressing	53 (25.4)	12 (21.4)	65 (24.5)

LIMITATIONS

As with any retrospective study, our study was limited by missing information in the form of lack of documentation of risk factors, severity of injuries, and treatments provided. Further, our sample size was arguably small despite examining years of data from two high volume EDs. Finally, we only had one investigator review the data.

Another of the limitations of our study was that we assumed that the McCauley protocol provided a reasonable approach to frostbite injuries. However, there are several limitations to the original McCauley study, including a small sample size (38 patients, of which only 3 had deep frostbite), a lack of control patients, and the derivation of treatments based on observations, expert opinion, and limited animal studies.[1] Despite these limitations, the McCauley protocol is frequently referenced in frostbite literature and medical textbooks as a standard guideline for frostbite treatment.[13,24,27] It should also be noted that as a guideline, it has undergone slight modifications since the original publication in 1983, and is now often quoted as "Treatment protocol for frostbite (after McCauley et al.)"[13] or "Treatment protocol for frostbite (adapted from McCauley et al.)"[24]. Smoking cessation, and regular ibuprofen (rather than aspirin) were not included in the original paper but are now generally accepted to be part of the protocol and were therefore included

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Table 3. Patients with deep frostbite: operative intervention rates in patients adherent versus non-adherent to treatment

	Operative intervention (%)			
	Adherent	Non-adherent	Odds ratio (95% CI)	*p*-value
Protocol treatments				
Admit	15/27 (55.6)	5/29 (17.2)	6.0 (1.8-20.5)	0.003
Hypothermia treatment	2/5 (40.0)	18/51 (35.3)	1.2 (0.2-8.0)	1.00
Rapid rewarming	1/1 (100.0)	19/55 (34.6)	-	0.36
Debride clear blisters	1/3 (33.3)	19/53 (35.9)	0.9 (0.1-10.5)	1.00
Leave hemorrhagic blisters	0/3 (0.0)	20/54 (37.9)	-	0.53
Immobilize	2/3 (66.7)	18/53 (34.0)	3.9 (0.3-45.8)	0.29
Tetanus	3/8 (37.5)	17/48 (35.4)	1.1 (0.2-5.2)	1.00
Analgesia	10/21 (47.6)	10/35 (28.6)	2.3 (0.7-7.0)	0.15
Ibuprofen	1/2 (50.0)	19/54 (35.2)	1.8 (0.1-31.1)	1.00
Antibiotics	5/11 (45.5)	15/45 (33.3)	1.7 (0.4-6.4)	0.50
Hydrotherapy	0/0 (0.0)	20/56 (35.7)	1.4 (0.3-7.1)	0.69
Prohibit smoking	3/7 (42.9)	17/49 (34.7)	1.4 (0.3-7.1)	0.69
Non-protocol treatments				
Aloe vera	0/4 (0.0)	20/52 (38.5)	-	0.29
Hyperbaric chamber	5/7 (8.9)	15/49 (30.6)	5.7 (0.99-32.57)	0.085
Antibacterial cream	2/5 (3.6)	18/51 (35.3)	1.2 (0.2-8.0)	1.00
Wound dressing	5/12 (41.7)	15/44 (34.1)	1.4 (0.4-5.1)	0.74
Presented to ED within 24 hr	14/30 (46.7)	6/26 (23.1)	2.9 (0.9-9.3)	0.066

in our study.[13,24,27] We used the McCauley protocol in our primary objective because we wanted to determine if a common, protocolled approach to treatment led to improved outcomes. Recognizing these limitations prior to beginning our study and the fact that physicians may use treatments outside of the protocol for frostbite injuries, we decided to include any treatments ordered for frostbite and whether they had an impact on operative interventions. We felt that there would be value in knowing how frostbite is treated, and whether any associations with outcomes could be made.

Prior to initiating the study, we had identified several predisposing factors to frostbite from previous studies. We assumed that documentation was complete and that lack of documentation of risk factors meant that they were not present. This may have resulted in an under reporting of predisposing risk factors.

The severity of frostbite related injuries may have been difficult for physicians to evaluate because the signs of more severe injury can sometimes take days to weeks to appear. Given that we followed all frostbite patients prospectively, it is unlikely that we missed any severe injuries that may have appeared less severe on initial presentation to hospital. Although patients diagnosed with frostbite at the hospital in our study would have been referred to specialists at the same hospital, it is possible that they may have chosen to seek follow-up care at another hospital. Given that the hospital in this study is the referral center for Eastern Ontario, it is unlikely that this would have occurred for patients with severe injuries.

Treatments provided, as well as treatments omitted, may not have been documented. We assumed that all treatments provided were documented and that lack of documentation of a treatment meant that it was not performed. Further, not all treatments in the protocol are applicable to each patient; including rapid rewarming, blister treatment, and smoking cessation. We assumed that documentation of consideration of providing these treatments meant that the treatment was provided as per protocol.

DISCUSSION

In our study, rates of adherence to most treatment protocol elements were low, and therefore we were unable to determine whether adherence to protocol was associated with lower rates of operative intervention. When comparing superficial frostbite to deep frostbite, the number of protocol treatments in the deep frostbite group was higher, but still relatively low. No charts outlined the treatments in the protocol completely.

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Although physicians provided some treatments that coincided with McCauley's frostbite treatment protocol, it was more likely that this was due to chance rather than a conscious effort to follow the protocol. A trend was observed where those who received treatments tended to have more operative interventions. This might be because more severe injuries received more aggressive treatment and documentation was more stringent.

Our study differed from previous studies in that we identified that patients with deep frostbite were more likely to be smokers, male, older, and abuse alcohol. Similar to previous studies, we found that inadequate clothing/footwear, alcohol abuse, psychiatric illnesses, and winter sports were predisposing factors for developing frostbite; however these were not statistically significant.[12,14,15,17]

Admission to hospital was associated with a significantly higher operative intervention rate. However, this may reflect the severity of the injury, rather than adherence to treatment protocol. In McCauley's study, the goal of admission to hospital was to ensure patients received regular frostbite treatment in an attempt to salvage injured tissue. Previous studies have shown a low rate of hospital admission.[17] In our study, rates of admission were somewhat higher, but we also found admissions occurred for reasons other than treatment of frostbite; including treatment of co-morbidities and for social reasons. This is in contrast to preventive therapy goals stated in the original paper.

It is generally accepted that patients with frostbite injuries should have their hypothermia corrected, and have their injuries rewarmed in a water bath between 40 °C to 42 °C for 15 to 30 minutes or until thawed.[1,10,12,18-22] In keeping with previous studies, hypothermia correction and rapid rewarming treatments were not common.[14] This may be because patients were presenting late after their initial frostbite injury and had passively warmed themselves at home or in the hospital while waiting to be seen. Only 53.6% of patients presented within 24 hours of their initial injury. Further, hypothermia was not a common finding because often frostbite developed in patients who only had one area of their body that was improperly sheltered from the cold (e.g., hands, feet, face).

Blistering of frostbite injuries was common. Previous studies found elevated levels of prostaglandin and thromboxane in clear frostbite blister fluid.[13,23] These metabolites of arachidonic acid have been heavily implicated as mediators of progressive dermal ischemia in burn, frostbite, or ischemia/reperfusion injuries.[24] Debridement of clear blisters is included in the protocol as a means to remove these inflammatory agents and improve wound healing. However, these benefits must be weighed against the risk of wound desiccation and infection. Current practice varies widely with regards to whether physicians debride blisters or not. Hemorrhagic blisters are at higher risk of desiccation, although practice remains variable as to whether these should be debrided or left intact. The lack of clinical data supporting either approach to treatment of clear of hemorrhagic blisters may be the reason that physicians in our study frequently chose the more conservative approach of leaving all blisters intact.

Tissues injured by frostbite are fragile, and although there is no evidence to support immobilization, it may prevent further tissue damage.[10,12] Given the extreme pain associated with frostbite, it is likely that many patients avoided using an affected limb, even without specific physician orders (e.g., not walking on a frostbitten foot). Further, immobilization is only applicable to frostbite to a limb, and no other parts of the body. This may account for the reason why only 3 out of 56 patients received a physician's order to immobilize the affected limb.

Frostbite injuries should be considered open wounds that are at risk of exposure to tetanus, and should therefore receive tetanus toxoid. Case reports of tetanus in patients with frostbite do exist[25] and most reviews promote the use of tetanus toxoid prophylaxis.[10,24] The low rates of tetanus vaccination seen in our study were in keeping with previous findings, and may be due to the lack of recognition of frostbite as an open wound at the time of presentation or the lack of recognition of their potential to become an open wound should the blisters burst at a later time.[15]

Analgesia is promoted in frostbite treatment reviews[10] and had a relatively good rate of adherence in our study compared to other interventions.[12,24,26] This is likely because frostbite injuries can be extremely painful, and probably not due to a conscious effort to follow the treatment protocol.

Regular ibuprofen was originally included in the protocol because of its potential to improve outcomes via its anti-thromboxane and anti-platelet effects.[16,19,24] We found that orders for regular ibuprofen were not common. This may be due to lack of awareness of its use in frostbite treatment. More recent studies examining reperfusion of frostbite injuries have had some success

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with the use of local thrombolytics,[7,11,19] however, this was not observed in our study.

Antibiotics (either oral, intravenous, or topical) were one of the most frequently given treatments. This may have been because frostbite often resemble cellulitis and because any wounds is considered at risk for developing infection.[14,24] Although previous studies have observed trends between frostbite and infection there is no evidence with regards to how antibiotic prophylaxis affects patient outcomes in frostbite.

Regular hydrotherapy helps with wound debridement of devitalized tissues and helps preserve function by promoting range of motion.[24] In our study only two patients received hydrotherapy. We speculate that this may have been due to advances in wound care, however there are no studies which have specifically examined frostbite wound care with regards to dressings or hydrotherapy.[12]

Smoking's deleterious effects on wound healing are well known. Smoking has been found to be a predisposing factor for frostbite in previous studies and 'prohibit smoking' is included in the McCauley protocol.[13-15,24-27] In our study, any patients where a physician specifically prohibited smoking or provided a prescription for smoking cessation were considered to have provided the 'prohibit smoking' treatment. Although smoking was identified in our study as a risk factor for developing deep frostbite, rates of operative intervention were similar regardless of whether patients had smoking prohibited or not.

In our study we made observations of treatments for frostbite that were not part of the protocol. Some of which have been studied previously in frostbite. These included aloe vera (alone),[24] hyperbaric oxygen,[8,28,29] topical antibiotics,[24] and wound dressing. None of these therapies were associated with operative intervention in deep frostbite, although operative intervention was more common among those not using a hyperbaric chamber. Although wound dressing was one of the more common treatments, we expected a higher rate of wound dressings in this patient population. We speculate that this may have been due to incomplete documentation of both physician orders for wound dressings and the dressing changes performed by nurses.

Aloe vera is used as a topical inhibitor of thromboxane and, when used in conjunction with ibuprofen and prophylactic penicillin, it has been shown to result in less tissue loss.[16,24,27] Aloe vera is described in the McCauley protocol as an adjunct to blister treatment. However, we did not document any cases where aloe vera was used specifically as an adjunct to blister treatment. In some cases, the use of aloe vera was described as a separate treatment, but this was not associated with lower rates of operative interventions.

Presentation to the ED within 24 hours of injury was not associated with lower rates of operative interventions. The tissue injury that occurs from frostbite is partially due to ischemia secondary to poor vascular supply. This suggests that early treatment of a frostbite injury is more likely to result in more tissue saved. As in previous studies, we found that few patients presented within 24 hours from their time of injury.[14,15] Using 24 hours as a marker of early versus late presentation may have been too late a time frame. Time of initiation of treatments would have been a more useful marker; however, these times were not documented well enough to obtain adequate data to make any conclusions.

CONCLUSION

This was the first study of frostbite in Eastern Ontario and the first that attempted to determine if adherence to a previously developed frostbite treatment protocol decreased the rate of operative interventions. This study found that older age, smoking, male sex, and alcohol abuse were potential risk factors for deep frostbite. Adherence to the existing frostbite treatment protocol was poor and therefore we were unable to determine if adherence to the protocol lowered the rate of operative intervention. Further, none of the individual treatments in the protocol were associated with a reduced rate of operative intervention. We recommend that future research efforts focus on identifying effective individual frostbite treatments prior to endorsing a specific treatment protocol.

Competing Interests: None declared.

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