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# Distal limb pathologic conditions in horses treated with sleeve-style digital cryotherapy (285 cases)

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ABSTRACT

Digital cryotherapy (DC) is frequently used as laminitis prophylaxis for horses. While DC with ice-water slurries is reported to be safe for up to 48 h, the safety of sleeve-style digital cryotherapy (SSDC) with ice in direct contact with the distal limb has not been evaluated. Our objective was to determine the incidence of distal limb pathologic conditions (DLPC) among horses treated with SSDC. A retrospective study of cases from 2011 to 2015 identified 285 horses treated with SSDC for a minimum of 12 h. Data collected from medical records included demographic, treatment, diagnostic, and SSDC treatment parameters. Bivariate statistics and a generalized linear regression model were created to evaluate risk factors associated with increased incidence of DLPC. Among horses treated with SSDC, 7% had tissue injury of the distal limb. Increasing duration of SSDC was associated with increased incidence of DLPC. Lesions observed included dermatitis, cellulitis, alopecia, coronitis, tissue necrosis, and distal limb edema. These lesions were similar to frostbite, non-freezing cold injury, and prolonged water immersion injuries seen in other species. While the incidence of DLPC was low, the authors recommend that horses undergoing SSDC with ice in direct contact with the skin should be monitored closely for injury when prolonged cryotherapy is clinically indicated. Further studies to improve safety, efficacy, and convenience of alternative methods of DC for horses are warranted.

## 1. Introduction

Digital cryotherapy (DC) is the only evidence-based prophylaxis for sepsis associated laminitis (Kullmann et al., 2014; Pollitt and van Eps, 2004; van Eps, 2010; van Eps et al., 2014; Van Eps and Pollitt, 2009) and is routinely used in horses suffering from conditions in which laminitis is a common sequela (Divers, 2010). Cryotherapy is theorized to induce vasoconstriction and prevent hematogenous spread of toxins to the digit, decrease inflammatory signaling, and reduce lamellar metabolic rate (Divers, 2010; Pollitt and van Eps, 2004). Two reports have concluded that DC using immersion in ice water or 1 °C water for up to 48 h is safe and well tolerated by horses (Kullmann et al., 2014; Pollitt and van Eps, 2004). While all but one study have used experimental models of sepsis, and clinical trials have not been performed to date, current clinical recommendations for prophylactic DC include application of DC prior to or at onset of Obel Grade 2 lameness and cooling of the hoof wall to 5–10 °C for 48 to 72 h or until the resolution of clinical signs of sepsis (Kullmann et al., 2014; Reesink et al., 2012; van Eps et al., 2014; Van Eps et al., 2004). DC methods incorporating the hoof and distal limb with ice and water in direct contact with the limb (wet DC) (Reesink et al., 2012; van Eps et al., 2014) and advanced dry methods (van Eps and Orsini, 2016) result in the most consistent decrease in hoof wall surface temperature. Both described methods have some challenges in implementation, restriction of patient mobility, or cost of equipment. As a result, some hospitals, practitioners, and owners use sleeve-style boots that hold ice directly on the limb from the pastern to distal carpus or tarsus[2] and allow the water to drain through a foam cuff at the pastern. While this method of sleeve-style digital cryotherapy (SSDC) is advantageous in ease of use, cost, and patient ambulation during treatment, the safety of continued application of ice

*Abbreviations:* DC, digital cryotherapy; SSDC, sleeve-style digital cryotherapy; DLPC, distal limb pathologic conditions; NFCI, non-freezing cold injury; SIRS, systemic inflammatory response syndrome

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in direct contact with skin has not been evaluated.

Cold injuries such as non-freezing cold injury (NFCI) and frostbite are a relevant concern during DC treatment in other mammalian species (Guard and Murrish, 1975; Horwitz et al., 1953; Ungley et al., 2003). In humans, NFCI occurs at temperatures above freezing when in the presence of prolonged moisture (Ungley et al., 2003). Prolonged cold causes nerve sheath edema, which progresses to ischemic nerve damage and loss of vascular tone (Ungley et al., 2003). In humans and small mammals, NFCI is characterized by initial anesthesia with red-to-pale skin and absence of digital pulses (Horwitz et al., 1953; Montgomery et al., 1954; Ungley et al., 2003), which progresses to hyperemia, edema, palpable digital pulses, and the absence of reflexes after rewarming (Montgomery, 1954). The occurrence and clinical signs of NFCI are not documented in horses, and treatment of horses with ice-water immersion of the distal limb for 48 h did not result in detectable signs of cold injury such as distal limb edema (Pollitt and van Eps, 2004).

In contrast to NFCI, frostbite only occurs at temperatures below freezing. In humans, repeated freeze/thaw cycles increase the risk of severe damage (Golant et al., 2008; Imray et al., 2009; Imray and Oakley, 2005; Irwin et al., 1997). Clinical signs of frostbite in horses include pale to erythematous, edematous skin leading to hair loss and tissue necrosis (Thomsett, 1984). We hypothesized that horses treated with SSDC are at risk of frostbite and/or NFCI due to direct contact between the skin and 0° to −20 °C ice for extended periods. This study evaluates the incidence and type of distal limb pathologic conditions (DLPC) that develop in horses treated with SSDC to determine if lesions consistent with frostbite or NFCI occur. Additionally, clinical parameters to determine risk factors associated with the development of DLPC were assessed.

## 2. Materials and methods

### 2.1. Inclusion criteria

This was a retrospective study of horses admitted to 2 large animal teaching hospitals between January 2011 and July 2015. Billing records were used to identify horses that underwent SSDC with sleeve-style ice boots[i]. Cases were included if the complete medical record was available and SSDC was applied for 12 h or longer. No contemporary control group was available because horses with similar primary conditions that did not undergo DC during this time period were infrequent and generally had extenuating circumstances such as severe financial restriction or less severe disease. In cases where only the forelimbs were treated with DC, the hindlimbs serve as an internal control and DLPC between treated and non-treated limbs are compared.

### 2.2. Data collection

Demographic information gathered from the medical record included: signalment, date of admission, duration of hospitalization, final diagnoses, and signs or history of laminitis. Physical examination parameters were recorded at presentation and conclusion of SSDC. The presence and duration of Systemic Inflammatory Response Syndrome (SIRS) was documented. Patients were determined to have SIRS if they exhibited the classical criteria of any 2 of the following at a given time: heart rate > 50 bpm, respiratory rate > 24 bpm, WBC < $5 \times 10^9$ cells/uL or > $14.5 \times 10^9$ cells/uL, or temperature > 101.5 °F (39 °C) (Smith, 2014a). Packed cell volume, total solids, and lactate were recorded from the point of care testing at presentation. All treatments and diagnostic tests, including bacterial, viral, and parasitic results were documented.

Outcome measures included DLPC occurring within 14 days of SSDC, survival, and necropsy findings when applicable. DLPCs were identified based on clinical signs, need for related treatment during hospitalization, and necropsy findings. Specific pathologic conditions of the distal limb were recorded as diagnosed by the attending clinicians and included dermatitis, tissue necrosis, distal limb edema during and after SSDC, alopecia, coronitis, cellulitis and intolerance such as kicking, stomping, resentment of ice replacement, or destruction of the boots. Distal limb edema was not recorded as a DLPC if ventral edema of the thorax or abdomen was also present. Diagnosis of laminitis was determined based on ≥ Obel grade 1 lameness or radiographic evidence of sinking or rotation of the third phalanx. If horses were only treated with SSDC on the forelimbs, then DLPC of the hindlimbs were noted and are reported separately, but were not included as DLPC of treated horses. Justification for ice boot removal, treatments for any DLPC, and duration of care required for each DLPC were recorded. Survival, reason for euthanasia, and pathologic findings in the distal limbs of euthanized horses were collected.

### 2.3. Method of digital cryotherapy

Prophylactic SSDC was performed in a similar manner at both universities. Sleeve style nylon boots with a foam cuff around the pastern were filled with ice at least to the level of the mid-cannon bone, and ideally to the level of the distal carpus or tarsus. At University A, the boots were modified by removing half of the width of the foam at the distal cuff and applying the cuff around the hoof wall to allow ice to be in contact with the coronary band. University A exclusively used crushed ice to fill the boots. University B applied the boots as manufactured, using cubed ice (Fig. 1). Due to these differences, hospital location was included in the statistical regression model.

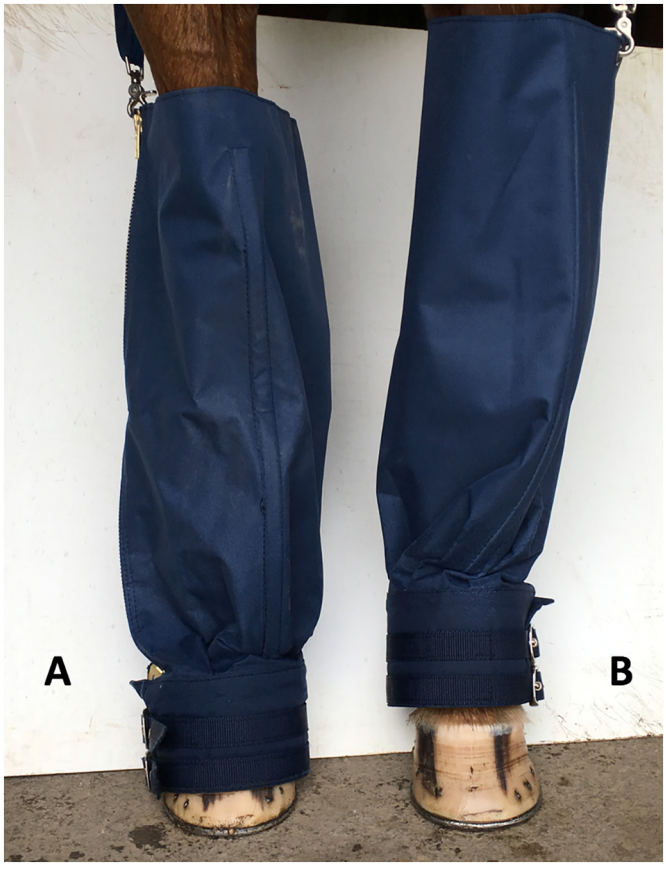


**Fig. 1.** Application of sleeve style ice boots. At University A, the boots were modified by reducing the width of the distal foam cuff and applying the cuff around the hoof wall to allow ice to be in contact with the coronary band (A). At University B, the boots were applied as manufactured, with the foam cuff surrounding the pastern (B). The boots were filled with crushed ice at University A and cubed ice at University B.