Effects of External Thermal Manipulation on Laminar Temperature and Perfusion of the Equine Digit

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This study evaluates the responses of the normal equine digit to the external application of heat and cold. Cooling the foot in ice water significantly reduces laminar temperature and perfusion and may decrease enzymatic activity associated with laminitis. Immersing the digit in 47°C water increases local perfusion. Author’s address: Department of Clinical Science, College of Veterinary Medicine, 1800 Denison Avenue, Manhattan, KS 66506. © 2001 AAEP.

1. Introduction

The application of heat and cold has been used for decades to treat injured tissue. Although both heat and cold therapies have been applied extensively to the legs, feet, and other sites in horses, only a few reports are available of the effects of these therapies on the underlying tissues.1,2 These reports suggest that the effect is dependent on the specific tissue treated as well as the treatment modality.1–4

Typically, application of cold has been advocated for acute injuries.4 Metabolic activities of neutrophils, synovial leukocytes, and collagenases are decreased with reduced tissue temperature, which reduces the release of other inflammatory mediators.4 The benefits of local cold therapy have been shown in an experimental model that demonstrated histologically a reduction in inflammation in injured ligaments treated with ice for 20 minutes in two cycles.5 Recently, cold has been advocated as a treatment of acute laminitis.3,6 Beneficial response to topical application of heat has been identified in some chronic disease processes.2 The application of heat can enhance the plasticity of connective tissue and aid in the prevention of injury. Both modalities are believed to alter local tissue perfusion, however, to date, relatively little data is available on these about these effects in various tissues.

The objective of this study was to assess the effects of external thermal manipulation on laminar temperature and soft-tissue vascular perfusion of the equine digit using nuclear scintigraphy. This study was conducted to test the hypothesis that external application of heat or cold to the equine digit could alter digital perfusion and core temperature.

2. Material and Methods

Six horses were used in a randomized crossover design. Each horse was treated with external heat...

LAMENESS IN THE ATHLETIC HORSE

Soft Tissue Perfusion (Heat vs. Cold) before, during, and after therapy

![Graph showing ratio of digital scintillation counts (treated:untreated) for soft tissue perfusion.]

- **Heat therapy**
- **Cold therapy**
- **Baseline (no difference)**

* P ≤ 0.01

Tc⁹⁹ Radioisotope injection

Vascular Perfusion (Heat vs. Cold) before, during, and after therapy

![Graph showing ratio of digital scintillation counts (treated:untreated) for vascular perfusion.]

- **Heat therapy**
- **Cold therapy**
- **Baseline (no difference)**

Hot vs. Cold p = 0.02

Tc⁹⁹ Radioisotope injection

**Fig. 1.** (a) Radioactive counts representing digital soft-tissue perfusion over time before, during, and after treatment. (b) Radioactive counts representing digital vascular perfusion over time before, during, and after treatment. Time zero is the start of hot or cold therapy. Results are expressed as a ratio of counts measured in the treated digit compared to the untreated digit. Arrows indicate technetium⁹⁹ MDP injections, the start of treatments, and the end of treatment intervals. Data represent mean ± SEM. Asterisks indicate significant differences (p < 0.05) due to treatment effects compared to baseline (a), or between treatments (b).
(heated water bath; 47°C) or external cold (ice water bath; 4°C) applied to a digit for 30 minutes. The opposite front foot was untreated and used for control measurements. Nuclear scintigraphy was performed before, during, and after therapy to assess vascular and soft-tissue perfusion of the digit in response to therapy.

Dorsal hoof wall laminar tissue temperatures were recorded before, during, and after therapy using a thermistor.

Soft tissue and vascular phases were analyzed separately using analysis of variance for repeated measures. A paired t-test was used to evaluate maximal changes in laminar temperature with therapy. Statistical significance was determined using $p < 0.05$.

3. Results

All horses tolerated the application of cold and heat to the foot with minimal restraint. At the conclusion of the study, complete physical and lameness examinations were conducted on each horse and results were within normal limits. There was no evidence of thermal injury in either group.

Topical cold treatment significantly ($p = 0.01$) decreased soft-tissue perfusion of the digit to 80.5% of the pre-cooled values (Fig. 1a). Soft-tissue perfusion increased during the 30 minutes after discontinuation of cold therapy, to 86.8% of pre-treatment values, but did not recover to pre-treatment levels within this period. Application of external heat significantly ($p = 0.003$) increased soft-tissue perfusion of the digit. Mean values during heat application were 25.1% above the pre-heated values. Soft-tissue perfusion in the 30 minutes after discontinuation of heat therapy remained significantly elevated above pre-treatment values. Vascular perfusion showed similar, but not statistically significant trends (Fig. 1b).

External cold therapy caused a mean decrease in laminar-tissue temperature of 11.6°C below pre-treatment levels ($p = 0.001$; Fig. 2). In contrast, external heat therapy caused an increase in laminar-tissue temperatures of 3.9°C above pre-treatment levels ($p = 0.012$; Fig. 2). Mean laminar temperatures decreased continually during the period of external cold application, reaching a minimum at 30 minutes. After initiation of heat therapy, mean laminar temperature peaked at 15 minutes and then declined by 0.3°C between 15 and 30 minutes (Fig. 3). The laminar temperatures did not return to pre-treatment levels within the 30-minute recording period following either treatment regimen. Although there were no detrimental effects observed with either hot or cold therapy, one horse had an extremely low laminar temperature (13°C) after 26 minutes of treatment in ice water.
4. Discussion

The application of hot water and ice water to the digit was a safe, well tolerated, and economical therapy. These results demonstrate significant changes in laminar temperatures and digital perfusion following external application of cold and heat. These responses were evident within 30 minutes of treatment and persisted for at least 30 minutes after the treatments were stopped.

The therapeutic selection of either external heat or cold should be based on an understanding of the underlying disease processes to be treated and the current phase of the disease. In the presence of acute inflammation, external cold therapy may be more appropriate to decrease local edema and the activity of inflammatory mediators. Recently, Pollitt has suggested that cold therapy may prevent some of the detrimental aspects observed during the acute-phase laminitis. Lower laminar-tissue temperatures may reduce the activity of the proposed enzymatic mediators of laminitis (MMP-2 and MMP-9) that disintegrate the lamellar basement membrane. This study establishes a baseline of soft-tissue perfusion and temperature responses to external application of hot and cold within the normal equine digit.

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References and Footnotes


"Technetium" MDP; Mallinckrodt, Kansas City, KS 66102.

bLudlum model 2600 spectrometer, serial # 5486; Ludlum 44-3 gamma scintillation probe p782. Plano, TX 75075.

cYSI 552 22-gauge hypodermic thermoprobe; YSI Inc. Yellow Springs, OH 45387.

dThermometer #15-043 (value standardized by the National Bureau’s Standard); Fisher Science, Houston, TX 77034.