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Cryotherapy

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ABSTRACT: Cryotherapy is optimal immediately following tissue damage and throughout healing to ease the effects of tissue injury. Cryotherapy results in vasoconstriction, decreased bleeding and edema, and alleviation of pain. Cryotherapy should be applied to the injured tissue as soon as possible for a beneficial reduction in metabolism. Ice is typically used, and current recommendations are to immediately apply it for 20 minutes after surgery if the patient's body temperature is not excessively low. Further treatments should be performed two to four times per day for 20 minutes per application for the first 3 to 4 days after surgery. The continuation of therapy further aids in reducing swelling, edema, and pain. Cryotherapy should be applied to injured tissue using a thin cloth barrier. No recommended target tissue temperatures have been published; therefore, soft tissue should be evaluated after 5 to 10 minutes of contact with the ice pack to assess whether the tissues are tolerating the cold. Because longer or colder applications can cause injury, the patient's behavior and level of discomfort should also be assessed during cryotherapy.

Cryotherapy, the therapeutic use of cold, is a primary method of physically controlling pain and inflammation in the period immediately following an injury.[1] Ice is the medical and physical standard on which this therapy is established. As with many remedies, the use of ice has developed empirically over time.[2] Hippocrates advocated the therapeutic use of ice and snow. Napoleon Bonaparte's surgeon, Dominique Jean Larrey, performed "painless" amputations on soldiers with hypothermia due to subzero ambient temperatures. Early research found that injured army recruits who had ice applied to their wounds returned to duty earlier.[3] In the early 1950s, "refrigeration anesthesia" was frequently used for gangrenous amputations in patients too ill to receive general or spinal anesthesia.[4]

In a review of ice therapy in medical textbooks, MacAuley[5] concluded that ice is an accepted method of treating soft tissue injury. However, standard textbooks are inconsistent and even contradictory regarding protocols for applying ice. Healthy animals have been used as models to study applications of cryotherapy to benefit humans, but we are unaware of any published small animal clinical veterinary studies on cryotherapy. This article reviews the current knowledge and selected pertinent human and animal research regarding cryotherapy.

PATHOPHYSIOLOGY

The therapeutic objective of cryotherapy is to lower tissue temperature to suppress the metabolic rate of the tissue.[6] In humans, cryotherapy

results in decreased swelling, pain, hematoma formation, wound drainage, and inflammation.[7] At the cellular level, cryotherapy slows cellular metabolism and decreases membrane permeability, thereby decreasing cell death and tissue damage caused by hypoxia.[2] At the tissue level, cryotherapy results in vasoconstriction, which reduces blood flow and capillary permeability, which in turn limits hemorrhage, edema, and the local inflammatory response.

Vasoconstriction typically occurs in the skin following application of cold; however, skin blood flow may increase immediately following local application of ice. This is known as the *hunting reflex*, which is a physiologic reflex to protect tissue from cold damage. The theoretical basis for this effect is that cold causes vasoconstriction, which helps reduce hemorrhage, but when temperature reduction is so great that it may compromise tissue viability, there is reflex vasodilation.[3]

With respect to neural tissue, the cooling effect results in a decrease in motor and sensory nerve conduction velocity, resulting in analgesia. Local cooling depresses the excitability of free nerve endings and peripheral nerves, thereby increasing the pain threshold.[7] The relationship between cooling and decreased nerve conduction is thought to be linear until 50°F (10°C), when neural transmission is blocked.[1,8] The anesthetic effect of local cooling is primarily produced by the slowing or elimination of pain signal transmission.[9]

When applied to muscle, cold therapy produces temporary relief of pain-producing spasticity of the muscle spindle, allowing better voluntary control.[10] Cold has been used to down-regulate muscle excitability by decreasing the responsiveness of muscle spindles to stretch, thereby decreasing painful spasms.[11] The majority of tension in a muscle is controlled through a feedback loop system from muscle spindles mediated via class Ia, II, and gamma nerve fibers.[11] Muscle spindles are specialized muscle fibers lying within skeletal muscle. The muscle spindle sends information via class Ia and II fibers to the motor nerve cell. The influence of the muscle spindle on the motor nerve cell is modified at the spinal cord level. This creates a delicate servomechanism to precisely and correctly control muscle function. Loss of the cortical modifier influence on muscle spindle input can lead to hyperreactivity, resulting in exaggerated responses to muscle stretch, known as *spasticity*.[11] This process is markedly attenuated by the application of cold.

Local cooling causes vasoconstriction, reduces blood flow and edema formation, and slows nerve conduction velocity, with the greatest effect on peripheral nerves.

PRACTICAL APPLICATIONS

The mnemonic *ICE* is used as a guide to acute injury management in humans: *I*ce, *C*ompression, *E*levation.[11] Because ice is commonly combined with compression and elevation in human medicine, it is difficult to determine the value of cryotherapy alone.[12] However, cryotherapy can be useful in treating the acute phase of inflammatory conditions, such as bursitis, tenosynovitis, and tendonitis, whereas the application of heat may result in additional congestion of tissues and increased pain.[11]

Cryotherapy can be applied to injured tissue in several different ways: a bag of ice wrapped in a thin cloth, a commercial cold pack, homemade cold packs of two parts water to one part isopropyl alcohol, and circulating cooling blankets. Because ice applied directly to the skin can cause burns, a barrier should be placed between the ice and the skin. This barrier should be thin to maximize the effectiveness. The current recommendation is to use a damp cloth barrier between the cold source and the affected area and to secure it with a compression wrap.[3] Cold is not conducted through padded elastic bandages.

Compression, in combination with cryotherapy, increases contact between the cold source and the skin. Compression can improve cold conductivity, reduce blood flow, and limit rewarming. In addition, long-term use of compression decreases hematoma formation and edema. Particular attention should be paid to the type of compressive dressing used because circumferential dressings decrease venous flow, possibly resulting in deep venous thrombosis.[7] Cryotherapy and compression have been combined in the Cryo/Cuff (Aircast)[7]; however, the effectiveness of this icing modality varies in human studies.

There is strong evidence that the application of cold can be useful as a therapeutic modality in certain situa-

tions. It seems ideally suited to acute injuries, in which the reduction of local factors such as hemorrhage and edema can hasten recovery.[13] The sooner cryotherapy is initiated after injury, the more beneficial the reduction in metabolism. Cryotherapy can be used after exercise or during rehabilitation to minimize secondary inflammatory responses; in veterinary medicine, however, cryotherapy is most commonly used postoperatively.

In one study,[12] cryotherapy was initiated either immediately after surgery or after wound dressing, but few significant differences were reported in the treatment outcome. The current recommendations are to apply ice for 20 minutes immediately after surgery if the patient's body temperature is not excessively low (<95°F [<35°C]). Further treatment should be administered two to four times per day for 20 minutes per application for the first 3 to 4 days after surgery. The continuation of therapy further aids in reducing swelling, edema, and pain. No recommended target tissue temperatures have been published; therefore, soft tissue should be evaluated after 5 to 10 minutes of contact with an ice pack to assess whether the tissue is tolerating the cold. Because longer or colder applications can cause injury, the patient's behavior and level of discomfort should also be assessed during cryotherapy. In studies on humans, cryotherapy has resulted in decreased narcotic consumption and length of hospitalization while also increasing patients' range of motion, compliance with rehabilitation, and tolerance of weight bearing.[7]

CONTRAINDICATIONS

Although cryotherapy has potentially useful physiologic effects, specific contraindications to its use must be recognized. If cryotherapy impairs motor function or proprioception, it could increase the probability of reinjury.[5] Frostbite and nerve palsy are reported complications of cryotherapy. If the cold modality is colder than 32°F (0°C) and is applied directly to the tissue, particularly with compression, the superficial tissue can freeze.[11] Other contraindications to cryotherapy include an anesthetized extremity, an unresponsive patient, peripheral vascular disease, diabetes mellitus, cold hemagglutination, cryoglobulinemia, and pheochromocytoma.[7] In addition, humans can experience cold allergy, resulting in giant hives and joint pain; paroxysmal cold hemoglobinuria, possibly leading to serious renal dysfunction; and systemic blood pressure elevation in response to cold immersion.[11] Patients with rheumatic conditions have noted increased signs of pain and joint stiffness with local application of cold.[11]

CONCLUSION

Cryotherapy is a readily accepted and widely practiced method of treating injury; however, there is limited steadfast proof of its effectiveness. The use of cryotherapy has developed empirically over time. The human literature shows little consistency regarding types of icing modalities or the length of time of application of cold. Studies have used healthy humans or animals as models to study cryotherapy; however, no target tissue temperatures for veterinary patients have been published. Cryotherapy has been shown to be most effective when applied via a thin cloth barrier. The recommended therapeutic regimen is two to four times daily for no more than 20 minutes each time for at least 3 to 4 days after tissue injury. Literature reviews of cryotherapy studies have concluded that further high-quality clinical studies are needed. Future studies should focus on developing protocols that standardize the mode, duration, and frequency of cryotherapy to optimize it during acute and rehabilitative care of veterinary patients.[12]

Cryotherapy should be performed two to four times per day for 20 minutes per application for the first 3 to 4 days after a tissue injury.

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1. The primary physiologic effects of cryotherapy include
a. increased blood flow.
b. vasoconstriction.
c. increased sensory and motor nerve conduction velocity.
d. increased muscle spasms.

2. Cryotherapy is thought to reduce pain and swelling by
a. decreasing the metabolic demand of cells.
b. vasodilation.
c. increasing pain-producing spasticity of the muscle spindle.
d. increasing motor and sensory nerve conduction velocities.

3. The recommended immediate postoperative duration of cryotherapy is _____ minutes.
a. 5
b. 10
c. 20
d. 25

4. Which of the following is not associated with the hunting reflex?
a. physiologic reflex to protect tissue from ice damage
b. reflex vasoconstriction
c. prevention of compromise to tissue viability
d. reflex vasodilation

5. The possible side effects of cryotherapy do not include
a. peripheral nerve damage.
b. frostbite.
c. nerve palsy.
d. peripheral edema.

6. The recommended frequency of cryotherapy is _____ times per day.
a. one to two
b. two to three
c. two to four
d. three to four

7. Which statement regarding the use of a barrier during cryotherapy is correct?
a. Ice should be applied directly to the skin.
b. A damp cloth is not recommended as a barrier.
c. Cold is conducted through padded elastic bandages.
d. The barrier should be thin to maximize effectiveness.

8. Soft tissue should be evaluated after _____ minutes of cryotherapy.
a. 5 to 10
b. 10 to 15
c. 15 to 20
d. 20 to 25

9. Which statement regarding compression and cryotherapy is true?
a. Compression can increase blood flow.
b. Compression can improve cold conductivity.
c. Compression can enhance rewarming.
d. Compression decreases the contact time between ice and skin.

10. In humans, cryotherapy does not result in
a. decreased hematoma formation.
b. increased wound drainage.
c. decreased swelling.
d. decreased inflammation.