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# Cold Intermittent Pneumatic Compression: Application in the Rehabilitation of Multiple Trauma Dogs and Cats or After Surgery

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## Abstract

Cold Intermittent Pneumatic Compression Technique (TCFPI) resulted from the evolution and combination of several rehabilitation techniques such as cryotherapy and cold compression. In this study was carried out a comparison between TCFPI and cryotherapy in dogs and cats submitted to surgical procedures or multiple trauma patients. 61 animals with orthopedic, surgical and emergency conditions were selected for the study: 33 were treated using TCFPI and 28 treated using cryotherapy. Animals treated using TCFPI achieve a faster recovery by decreasing pain effectively, reducing swelling, enhancing blood circulation, lymphatic drainage and tissue stimulation. This technique allows combining a set of different rehabilitation techniques since operation parameters as temperature, pressure and therapy duration are customizable, making the whole treatment process shorter and easier to achieve the required physical conditions to initiate the rehabilitation process, and thus decreasing the morbidity rate. Since the human biped and the quadruped animal are neuroanatomically and neurophysiologically identical, as well as at muscular co-contraction level, it is intended to highlight the importance of TCFPI facing cryotherapy on human, on Orthopedics and internal medicine, in decreasing days of hospitalization and pain.

**Keywords:** Cold intermittent pneumatic compression technique; Rehabilitation; Cryotherapy; Postoperative; Multiple trauma; Dog; Cat; Pain management; Swelling

## Introduction

Cryotherapy is one of the cheapest therapies and most used on post-operative inflammations, musculoskeletal trauma and muscle spasms, endorsing as well, structural and functional reconstruction, enhancing the rehabilitation process. However, this technique has some limitations in efficacy and TCFPI, being the combination of cryotherapy and compression, can fill those gaps and enables patients to gather the necessary physical conditions to achieve the best results within a shorter period of time.

TCFPI is applied with GameRead Accelerated Recovery System (CoolSystems, Inc., Concord, California, USA) which is an exclusive control unit that delivers an Active Compression and Cold Exchange Loop (ACCEL) by pumping water and air at each time to a hose which is connected to a wrap that is applied to the injured area. To control the system temperature, the unit container must be filled completely with ice and at least half full with clean water which will be pumped through the hose. The temperature, time and pressure applied will be regulated by knobs that can be adjusted by the operator of the control unit. Therefore, the temperature of the wrap will never be colder than the water in the ice box.

The therapeutic wraps allows a better displacement of the interstitial fluids removing them from the injured area, reducing swelling and muscle spasm and achieving a faster healing process. The appliance of those wraps also extends the application area for a better cold distribution and comfort for the patient during the treatment.

Hence, TCFPI, enables the temperature management during treatment, which can control the patients better at pain management, unlike any other techniques, also allowing a deeper cold penetration in a shorter time, letting cellular metabolism to lower secondary injuries

## Cold appliance effects in Rehabilitation

Cold is used on acute injury treatment since it minimizes the inflammatory process, stimulating analgesia [1-3].

The center responsible for controlling body temperature is located in the pre-optic region of the anterior hypothalamus which has cold sensitive neurons in quadruped animals. When the blood temperature is below than the regular levels, the cells located in the pre-optic region of the anterior hypothalamus will be inhibited, activating the hypothalamus producing heat which leads to trigger mechanisms that increase body temperature. In response , vasoconstriction occurs dropping skin temperature to room temperature and allowing a reduced heat loss which will result in temperature rising [4-6].

Tissues with high concentration of water, such as muscles, are excellent cold conductors unlike fat that has low conductivity. Ice has better penetration capacity (2 to 4 centimeters) and longer action when applying heat [7-10]. The reason lies in the thermodynamic properties and the impact of these when there is a physical change of state, in this case from solid to liquid. The heat transferred by contact with ice will be the amount of heat which is directly transferred to it and the heat exchange from the transition of physical state when ice melts into water. This leads to a decreased intramuscular temperature due to a greater heat transfer by ice that changes its state to liquid [11].

### Cold appliance effects in inflammation control

Cold reduces the acute inflammatory process mostly in acute trauma, preventing blood leakage from capillaries and resulting in reduced synthesis of collagen and scar tissue [5,12].

### Cold appliance effects in the musculoskeletal system

In musculoskeletal injury during the acute inflammatory response due to vessel injury and swelling, occurs a drop of oxygen supply to healthy cells near the affected tissues. Thus, the cold's role is to reduce the metabolic rate of hypoxic tissues, allowing better survival odds in this period and minimizing secondary injury [5,12].

Multiple trauma patients are those with multiple injuries from the same incident. Young animals, both dogs and cats, are much more likely to be affected by traumatic processes because those individuals are more active, therefore, more liable to accidents. The application of cold in musculoskeletal injuries and multiple trauma patients aim to reduce pain, inflammation and the release of inflammatory mediators, helping tissue recovery after trauma and reducing the need for medicine consumption [1,13].

### Cold appliance effects in pain control

Pain during ice massage is not as intense because the cold is applied in the form of scanning. Due to the temperature decrease, there is a reduced muscle activity and muscle relaxation, improving spasticity reduction and easing the kinesiotherapy exercises execution, neuroanatomically speaking, active cold inhibits Alpha motor neurons (α-MNs) contraction of the intrafusal fibers, allowing relaxation, avoiding pathological muscle co-contraction which may lead to hypertonicity and spasticity [1,11,14].

### Cold appliance effects in the circulatory system

When cold is applied to the affected area, heat transfers, induces vasoconstriction, reducing the amount of blood carried [12,13,15]. When vasoconstriction occurs the body responds with a dilatation of these vessels to maintain blood circulation. This phenomenon is called cold-induced vasodilation, improving metabolites removal and increasing gas exchange [12].

### Cold appliance effects in swelling control

Cold application reduces vascular permeability, restraining leukocyte migration which means that there is contention on the liberation of free proteins process, avoiding edema formation [1].

### Cold appliance effects in the neuromuscular system

To reduce spasticity it is recommended cold application for 25 to 30 minutes, which is the time required to decrease excitatory impulses, promote muscle relaxation and reach deeper tissues. The relaxation effect lasts between 30 minutes to 2 hours and during this time, some kinesotherapy exercises workout can be performed, for example, cycling motion exercises, gait stimulation and hydrotherapy, to provide the patient a greater range to move out of the spastic pattern [16]. However, as cold acts directly on the muscle spindle and the Golgi tendon organ, it reduces the response of voluntary muscle contraction so, we must be especially careful with exercises and gait to avoid a new muscle injury due to the rupture of fibers [5,16,17].

## Procedures

### Study population

The study population comprised 61 animals, including cats and dogs. On 33 was applied TCFPI and 28 were subject of cryotherapy used as control of TCFPI.

Animals included in the study were those who (i) were presented in a critical situation, multiple trauma (pubic fractures and sacroiliac dislocation) and musculoskeletal disorders (edema), (ii) had undergone orthopedic surgery and had motor limitations (dislocation of the femoral head, dislocation of the humeral radio-ulnar joint and ruptured cruciate ligament), (iii) were submitted to soft tissue surgery at risk of hypovolemic shock due to hemorrhage (eg. splenectomy, mastectomy), and (iv) were submitted to neurological surgery to remove thoracolumbar hernias.

### Protocol of TCFPI application

TCFPI was held in an isolated room in order to calm down the patient for treatment and during execution the patient could never be unattended.

In post-surgical patients, TCFPI started only when the body temperature returned to stable values (minimum temperature of 37.4ºC) then evaluate the degree of pain to determine the machine's application temperature. In multiple trauma patients, the TCFPI began immediately.

After surgery on the same day or the day of admission of multiple trauma patients, treatment was performed four times within a 6 hours interval. After this treatment period in the following week, this technique was carried out 3 times per day over a 6 hour interval. After the first week a reassessment of the patient's condition and a protocol adjustment if necessary, were made.

Orthopedic patients underwent longer treatments due to the fact that the surgeries are more invasive than the rest of the cases. With this it was possible to control the pain and reduce swelling in a gradual manner.

## Pain Assessment

Pain assessment was performed using the Glasgow Composite Measure Pain (GCMP) scale. After withdrawing the degree of pain, this value was crossed with the Glasgow abbreviated scale to know qualitatively the real pain. This procedure was performed before, immediately after and last 2/7 days of surgery (some patients did last measurement 7 days after having been submitted to more invasive surgeries) or the application of TCFPI/cryotherapy. The purpose of collecting these data is the validation of TCFPI in reducing the degree of pain and comparison of improvements over the cryotherapy. This review was also important to adjust the temperature, pressure and duration of application of TCFPI for maximum patient comfort.

## Results

### Pain assessment

The assessment of degree of pain was performed for all patients who underwent TCFPI and cryotherapy.

Orthopedic patients undergoing TCFPI, decreased approximately 4 degrees on the scale of pain and those who underwent cryotherapy decreased approximately 2 degrees.

Surgical patients undergoing TCFPI, decreased approximately 4 degrees on the scale of pain and those who underwent cryotherapy decreased approximately 2 degrees.

Emergency patients undergoing TCFPI decreased approximately 3 degrees on the scale of pain and those who underwent cryotherapy decreased approximately 3 degrees.

### Pain evolution within the fields of veterinary medicine

For a better understanding on how the pain decreases, two samples, TCFPI and cryotherapy, were considered and the sample values were gathered for defined days (day 1 being the first measurement made during triage) and for each field of Veterinary Medicine. It was calculated two trend lines for each one of the techniques, which correspond to an estimation of the degree of pain to a certain day of measurement.

In Orthopedics, the average value for the degree of pain in TCFPI was 8.14 ± 1.07 and in the cryotherapy technique was 8.50 ± 0.93. There are no significant differences (p-value=0.500 t=0694).

### Pain evolution according hospitalization days

As for the evolution of the degree of pain according to the number of hospitalization days for Orthopedic patients, the TCFPI trend line has a bigger slope when compared to the cryotherapy trend line, implying a greater decrease in pain level using TCFPI in the same period of time (Figure 1). After 10 hospitalization days, the pain level declined two values more compared to those treated with cryotherapy.

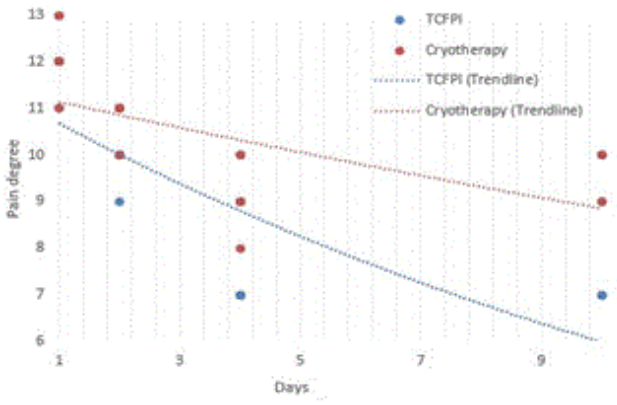


**Figure 1:** Evolution of pain degree in emergency patients to the cold intermittent pneumatic compression technique and cryotherapy.

In Surgical patients, the average value of the degree of pain with TCFPI was 7.90 ± 1.52, while for cryotherapy it was 7.50 ± 0.55. There are no significant differences (p-value=0.550 and t=-0612). It was not possible to obtain meaningful results for Surgery patients in the evolution of pain degree according to the hospitalization days.

In Emergency, the average value of pain for TCFPI was 9.92 ± 0.29, while for cryotherapy was 10.50 ± 0.52. There are significant differences (p-value=0.002 t=3,457). As for the evolution of pain degree according to the hospitalization days in Emergency patients, the trend line for TCFPI has a greater slope than the line of cryotherapy, implying a greater decrease in pain in the same period of time when compared with cryotherapy, after 10 days, patients decreased 2 more levels compared to cryotherapy. In terms of time, the same results were achieved in approximately 2 days of treatment with TCFPI and in 10 days with cryotherapy.

## Discussion

This study allowed to visualize the positive effects of TCFPI in terms of reducing the amount of pain and therefore in hospitalization days in post-surgical and multiple trauma patients who used GameReady for their rehabilitation.

Regarding the age of patients treated using TCFPI and cryotherapy, there was a predominance of adults and geriatric, being the young animals the smallest age group in this study. This result is interesting due to the fact that, one of the factors for the owners not to invest in the rehabilitation of their animals, lies in the prejudice that age is a prediction and a drawback in their recovery, which was not observed in this study. The average age of TCFPI samples and cryotherapy were very similar although there is a wide dispersion of ages, from young patients to geriatric ones, justifying the high standard deviation value. Regardless the patient's age, there were improvements, which overcome the study by Drygas, which only observed the positive effect of TCFPI in significantly different animal samples, those patients who underwent TCFPI were significantly younger than animals that have not undergone any therapy [18].

Regarding the evolution of pain within the considered Veterinary Medicine fields, it was observed that in Orthopedic and Emergency patients that used TCFPI, it decreased significantly more than with cryotherapy. This data opposes to a human study in which orthopedic patients that applied TCFPI had empirical improvements, but not significant ones when compared to other techniques, such as cryotherapy [19]. The mentioned study shows no positive results for the appliance of TCFPI due to the small sample of patients used for this study and the assessment of the degree of pain being self-made, is not the most assertive method. Thus, it is recommended that a new comparative study is made in humans, specifically in Orthopedic patients, with a higher number of subjects and the assessment of pain must be performed by qualified professionals using scales for this purpose.

In dogs and cats, orthopedic patients, that used TCFPI, it was observed that the degree of pain decreased the most, verifying that it requires substantially less time for recovery than the cases that used cryotherapy. In Emergency patients, improvements from the use of TCFPI become more evident. In terms of time, TCFPI achieves the same results in approximately 2 days of treatment while cryotherapy takes 10 days. These results were positive, however, only the sample of Emergency patients contains significant results, which corroborates the results obtained when compared with the hospitalization days. This corroborates a study in humans by Nick C. Leegwater in which there was improvements in reducing the degree of pain and days of hospitalization in Orthopedic patients [20].

The Emergency patients sample was composed by cats who jumped from buildings or trees and fractured the basin and, although they have not undergone any surgery, they recovered using TCFPI only. It can be assumed that TCFPI may be a supplement or a valuable

alternative to more invasive procedures such as surgery, as suggested by Kim in a study of a treatment in dog patients with ruptured cruciate ligaments in which it was used conservative management instead of surgery [21]. Most Emergency dogs that were hit by a car or unknown causes showed swelling in the limbs. In these animals, it was found that TCFPI was able to reduce edema more effectively, corroborating the competition study in dogs [15]. In this study, multiple trauma or undergoing surgery dogs and cats, greatly reduced the degree of pain using TCFPI when compared to cryotherapy, for each one of the fields of Veterinary Medicine, with particular emphasis on Emergency animals. Regarding the recovery time, animals using TCFPI required fewer days of hospitalization.

## Conclusion

TCFPI is an asset for Animal Rehabilitation because it accelerates the recovery of patients who have undergone surgery or have multiple trauma, so that these achieve the necessary physical conditions to perform rehabilitation exercises and consequently decrease a morbidity rate.

Due to the obtained results in this study and due to neuroanatomical and neurophysiological similarities between the human biped and the quadruped animal, grows the importance and potential of TCFPI applied to humans to accelerate the recovery process to begin rehabilitation exercises and decrease hospitalization days. Besides being a functional rehabilitation modality that controls muscle spasticity, which is a clinical symptom that stimulates the movement disorder in all Lower Motor Neuron Syndrome patients, it may still be interesting to relate this modality with the diseases in their pathophysiology that have a deficit of co-contraction and throughout the Neuro Motor plate and neuropathic pain, which is a complex in decreasing the quality of human life.

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