Cryotherapy

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Abstract

Cryotherapy is the application of cold for the treatment of soft tissues injuries or diseases. Its use in sports medicine is widespread. Cryotherapy is a proven method for the treatment of acute soft tissue injuries or traumas but there is in consistency between the scientific basis for cryotherapy and clinical studies. Several methods of cold therapy are available such as ice packs, ice towels, gel packs, ice massage refrigerant gases and inflatable splints. Cryotherapy is also used to decrease the recovery time as part of the rehabilitation programme both after recent injuries and in the treatment of old or chronic injuries. Use of cryotherapy has also been shown to reduce pain effectively in the post-operative condition

after reconstructive surgery of the joints. Both superficial and deep temperature changes by the use cryotherapy depend on the method of application, initial temperature and used time. The physiological and biological changes occur due to the decrease in temperature in the various tissues, together with the neuromuscular effects and relaxation of the muscles produced by the application of cold therapy. Cold therapy increases the threshold of pain, the viscosity of blood, lymph and the plastic distortion of the tissues but reduces the motor performance. The application of cold has also been found to reduce the inflammatory process in an experimental situation. Cold application appears to be effective and beneficial and only few complications or side-effects after the application of cryotherapy are reported. However prolonged application at very low temperatures should be avoided as this may lead to serious side-effects, such as cold injury, frost-bite and nerve injuries etc.

Introduction

It is the application of cold that have temperature range between 0-18*C. During cryotherapy heat is removed from the body and absorbed by the cold modality until the temperatures are equal. The application of cold after injury is a practice as old as medicine. Cooling can be achieved by several ways such as evaporating liquids, blowing cold air over skin but vast majority of cold treatment are given with crushed ice. Ice is believed to decrease the pain by activating local anaesthesia. Application of ice leads to decrease oedema, nerve conduction velocities, cellular metabolism and local

blood flow.

Temperature changes in the tissues depend on both the rate and removal of heat energy. So, the temperaturedrop in the tissues depend on;

1. The difference between the coolant and the tissues.Colder the application greater the heat loss from the tissues.
2. Thermal conductivity of the tissues. Water filled tissue such as muscles have high thermal conductivity compared to fat tissues.
3. The length of time for which the cold is applied over the part to be treated.
4. Size of the area to be treated,

Physical Principle

When ice is applied to the skin heat is conducted from the skin to the ice in order to melt it. To change its state the ice requires considerable amount of energy (latent heat of fusion); to raise the temperature of 1gm of ice at 0* C to 1gm of water at 37*C requires 491 joule, whereas to raise 1gm of water at 0*C to 37*C requires only 115 joule. So, when trying to cool the tissues it is important to use ice during the treatment and not just the cold water.

Lewis Hunting Reaction

The Lewis hunting reactionrefers to a process of alternating vasoconstriction and vasodilation in the extremities which exposed to cold. The term Lewis reaction is named after the scientist Thomas Lewis, who first described the effect of cold application in 1930. Vasoconstriction happens to reduce heat loss, but also results in greater cooling of the extremities

where applied. After about five to ten minutes the start of cold exposure, the blood vessels in the extremities will suddenly go for vasodilation. This is possiblytriggered by a sudden decrease in the release of neurotransmitters from the sympathetic nerves to the muscular coat of the arteriovenous anastomoses due to local application of cold. Vasodilation due to cold application increases blood flow to the area and subsequently the temperature of the part. A new cycle of vasoconstriction followed by the vasodilation, after which the process repeats itself.

Methods of Application

Cold may be applied by the following ways:

Local Immersion

It involves placing the part in a container of iced water - a mixture of water from cold tap and flaked ice. At temperature around 16-18*C continuous immersion can usually be tolerated for 15-20 minutes. At lower temperature around 10*C continuous immersion is uncomfortable so, intermittent application is given. Such treatment can only be applied to the extremities.

Cold Packs

Ice Pack

Flaked ice is folded into damp terry-towel or put into bags made of same material and applied directly to the skin or flaked ice may put into a suitably sized polythene bag. The top of the bag is tied to prevent water leaking out. This water filledbag can be molded to fit the part to which it is applied and a damp towel is used to support bag from the skin. As the

water from melting ice is confined within the bag, this is clean and convenient method of application.

Commercial Pack

These are basically plastic often vinyl bags filled with mixture of water and some substances that prevents the water from freezing solid thus the pack will remain flexible and can be molded to the part. Silica gels are most commonly used. Commercial packs are of various sizes but normally small enough to store in the freezer compartment of domestic refrigerator. This pack can be stored at a temperature below 0*C often -5*C or even -12*C depending on their size such pack may provide adequate cooling for about 20 minutes.

Ice Towel

If a terry towel is put into a mixture of flaked ice and water and then wrung out much of the chipped ice will be

found adhere to the cloth. This can be placed over quite large area. This ice towels need to be replaced by another after 2-3 minutes. It allows movements or exercises to be performed while cold therapy is being applied.

Ice Massage

This is given with a solid piece of ice either as cube wrapped in a paper or cloth or as an ice lollipop on a wooden stick. This can be made by putting a wooden spatula upright in a small plastic cup of water in the freezer. Being larger the lollipop lasts longer and is easier to handle than usual size of the cube.

Two distinct purposes for ice massage: Slow and prolonged (15-20 min) for pain relief and brief (few seconds) strokes for muscle facilitation. The application should be over the dermatome supplied by the same nerve roots as those of the muscle to be stimulated.

Evaporating Sprays

Spraying a rapidly evaporating liquid on the skin has effects of using heat energy and hence cooling the surface. Ethyl chloride is mostly used but it is highly inflammable and thus posed some risk, other sprays like fluorimethane is non inflammable. Cooling from such sprays can be very rapid but does not last very long.

Excitatory Cold

The marked sensory stimulus of ice on the skin may be used to facilitate contraction of inhibited muscles. This sensory stimulus can be generated by the application of quick ice strokes over the dermatome of the inhibited muscles. In the later stages of recovery following a nerve lesion, the technique of quick ice is often useful stimulus in aiding voluntary contraction of muscles.

Physiological Effects of Cryotherapy

Local Effects

On Cutaneous Blood Fow

There is immediate constriction of cutaneous blood vessels which restricts the blood flow in the skin so, that heat loss is minimized. The immediate vasoconstriction indicates that there is a reflex in the autonomic nervous system which is activated by stimulation of thermal receptors in the skin by the application of cold.

The increased viscosity due to cooling also reduces the blood flow. After some minutes the vasoconstriction is followed by vasodilation which lasts for 5 to 10 min. before replaced by another episode of vasoconstriction, This alternation of constriction and dilation is called ‘ Lewis hunting reaction’ in the sense that vessels hunts or oscillates about its mean position.

On Muscle Blood Flow

The response of muscle blood flow to cooling is same. The cooling provokes vasoconstriction in all smooth muscles and the increased viscosity certainly reduces the blood flow but it takes more time for cooling the smooth muscles at deeper level than cooling the skin.

On Metabolic Rate

While treating the acute injury the primary physiological effect of cold is the reduction cell’s metabolism. On cooling living tissues metabolic rate decreases in accordance with VantHoff’s law. Lowered metabolic rate causes reduced oxygen uptake, reduced production of metabolite, reduced cellular activity and slower healing. Thus cooling does not benefit the healing process.

On Perpheral Nervous System

Cold applied to the skin provides strong sensory stimulus by stimulating the cold receptors. This may be used remediallyin the suppressionof pain and treatment of hypertonicity. All nerve fibers are not equally affected by cooling. The small diameter non myelinated slow conducting group C fibers, B fibers also small but myelinated preganglionic autonomic fibers are least affected by the cold. The A-delta fibers which are fast conducting fibers and A-beta and A-gamma fibers are most affected by the cold application.

On Nerve Conduction Velocity

If the cold is intense it reduces the conduction velocity of peripheral nerve. Conduction velocity of the nerves decreased by reducing the rate ofsynaptic transmission and increasing the time required for depolarization and repolarization. The time required for the nerve to depolarize andrepolarize is lengthened, decreasing overall frequency of nerve transmission.

General Neffects of Cooling

Cooling stimulates cold receptors which are more numerous than heat receptors in any given area of the skin. These impulses are carried by lateral spinothalamic tract to the brain synapses in the thalamus giving awareness of cold. Normal cooling causes vasoconstriction if temperature drop is great enough shivering will occur. This increases metabolism and hence heat production by irregular contraction of muscles.

Therapeutic Effects of Cold Therapy

Recent Injury

The function of ice application during immediate

treatment is to decrease the cell's metabolism therefore decreased need for oxygen in the injured area. This effect reduces the amount of secondary hypoxic injury and secondary enzymatic injury by enabling the tissues in the injured area to survive on limited amount of oxygen they are receiving. When bleeding occurs on the skin surface the application of cold causes immediate vasoconstriction and makes the blood more viscid both diminishes the blood loss.If cold application combined with pressure over the wound leads to hemostasis. However the cooling must not be so intense or so prolonged because it delays the blood coagulation by lengthening the clotting time.When bleeding is deep in the tissues forming an intramuscular hematoma much longer periods of cold application is needed to achieve the depth.

In case of heat burn cooling the areas lowers the tissue temperature and thus limits the tissue damage.

Pain

Pain can be decreased by several ways:

1. By reducing the muscle spasm.
2. By reducing the release of pain inducing irritants.
3. By reducing the conduction velocity and numbers of impulses.
4. By pain gate mechanism- stimulation of cold receptors send back impulses which have to pass into spinal cord via posterior root. These impulses which arrive through relatively large diameter nerve fiber effectively block out any other pain impulses attempting to enter the cord that is the 'the pain gate' is closed. This gives the temporary pain

relief.

Muscle Spasm

Cold reduces spasm by suppressing the stretch reflex by two mechanisms, firstly it decreases pain by reducing the rate of afferent nerve impulses and secondly it decreases the sensitivity of muscle spindle.

Inflammation

Cold application decreases the inflammatory response by,

1. reducing the release of inflammatory mediators.
2. decreasing the prostaglandin synthesis.
3. decreasing capillary permeability.
4. decreasing leucocyte-endothelial interaction.
5. decreasing creatinine kinase activity.

Spasticity

Pathological state of increased muscle tone resulting

fromUMN lesion. This occurs due to imbalance between the excitatory and inhibitory control of muscle contraction in the region of anterior horn cells in the spinal cord.

Many authorities suggest that skin stimulus produced by cold have an effect on the level of excitation and inhibition in the region of anterior horn cells of spinal cord. In fact it probablychanges the bias around the anterior horn cells from excitation to inhibition that causes reduction in the muscle tone.

Oedema

It is the buildup of excessive fluid and protein in the interstitial space resulting from imbalance between pressure inside and outside the cell membrane or an obstruction to lymphatic return and venous return mechanism. Cryotherapy limits the formation of oedema by reducing the cell's metabolism. The subsequent vasoconstriction decreases the permeability of post capillary venules and the reduced blood flow decreases the intravascular pressure both events prevents the fluid from escaping into the tissues. The mechanism of compression, elevation and muscle contraction must be incorporated into the treatment plan to reduce the oedema.

Indications of Cryotherapy

1. Acute soft tissue injuries e.g. ankle sprain, muscular sprain, ligament sprain
2. Myofascial trigger points
3. Tendinitis
4. Acute swelling

5. Bursitis
6. Post orthopaedic surgery e.g. TKR, ACL reconstruction, arthroscopic shoulder surgery.
7. Acute sports injuries
8. DOMS (Delayed onset muscle soreness)
9. Arthritic pain.

Pros

1. Pain relief
2. Swelling/oedema reduction
3. Decreased surface temperature
4. Effective in the treatment of wide range of soft tissue injuries

Cons

1. Diminutive evidence regarding duration and frequency of treatment to be effective.
2. Compression has been revealed to be more effective post operatively,
3. In rare cases bradycardia and frostbite symptoms have been observed.
4. Some more advanced cold therapy machines can reduce range of movement (ROM) following TKR due toimmobilisation of the joint.

Dangers of Cryotherapy

Ice Burn

The mildest form consists of the appearance of erythema and tenderness of the skin a few hours after application of ice, subsiding in one or two days, this is called an ice burn.

Amore severe form of ice burn with fatty necrosis shows bruising as well as more tenderness and can last up to three weeks. This occurs in areas where there is thick subcutaneous fat and becomes cool rapidly.

Frostbite or Cold Injury

Slower cooling tends to cause freezing of extracellular fluid withdrawal of water from the cells. This is known as frostbite. Rapid cooling causes ice crystal formation inside the cells which may lead to cell death. After five minutes of cold application the skin is marked by erythema, indicating that the circulatory system delivering the warm blood, if the area becomes pallor means the circulatory system is now unable maintain the tissue temperature within the normal physiological limitincreases the risk of frostbite and if tissues become cyanotic the treatment should be discontinued.

Cryoglobinemia

It is an abnormal protein present in the blood and it can form a precipitate at low temperature blocking the blood vessels and thus causing local ischaemia.

Cold Urticaria

Application of cold causes the release of histamine from the mast cells leading to formation of cold wheal erythema and sometimes general symptoms such as lowered blood pressure and raised pulse rate.

Contraindications of Cold Therapy

Cardiac Disease

Coronary thrombosis and anginal painhave sometimes been provoked by locally applied ice, may cause reflex

vasoconstriction of coronary arteries and should therefore not be given to the patient who have coronary artery disease.

Sympathetic nerve supplyof the left shoulder and heart are same and it has been shown that ice applied to the shoulder can cause overflow of excitatory impulses to the heart via sympathetic nerve. Therefore ice application to left shoulder should be avoidedin any patient with any sort of cardiac disease.

Sensory Deficincy

Ice should not be applied to the areas with some sensory deficiency because, firstly the neurological effects of cooling such as facilitation of muscle contraction require intact sensory nerve supply and secondly the normal circulatory response is altered if autonomic nerves are affected so, that tissue cooling occur more rapidly and more deeply than normally therefore caution is required if the skin with defective innervation is to be treated.

Vsospastic Disease

The vasospasm in diseases like Raynaud's phenomenon is made worse by the application ice. Exposure of cold causes vasoconstriction which further aggravates the condition causes spasm of the digital arteries of the hand.

Peripheral Vascular Disease

Cold application over peripheral vascular disease like Thromboangitisobliterance (Buerger's disease) should be avoided.

Psychological Problem

The thought of ice onlyfrightens many patients particularly the elderly. In fact many claim that their condition is made worse by the application of cold.

Cold application is also not suitable,

1. If there is a risk of cramping, as cold can make this worse
2. If the person is already cold or the area is already numb
3. If there is an open wound or blistered skin
4. If nerve disorder affects blood flow
5. If the person is hypersensitive to cold and immediately before activity.

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