Local Application of Therapeutic Heat and Cold

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The application of heat and cold is usually a nursing responsibility. These applications can be quite effective when used properly but can cause injury and discomfort when principles for their use are not followed. The nurse must have knowledge of the physiologic principles of the effective use of heat and cold in order to implement safe therapies. In addition, the nurse must be able to teach and supervise other health workers, patients and families in the use of therapeutic heat and cold application.

Physiology

The skin contains sensory end organs which have warm, cold and pain receptors. The cold receptors, which are more concentrated in the upper trunk and extremities, are also more superficial and three to ten times more numerous than the warm receptors.[1, 2, 3] Pain receptors are stimulated when the warm or cold receptors are stimulated strongly enough.[4]

When heat or cold is applied to the skin, the sensation is transmitted to the body's thermostat which is the anterior hypothalamus of the brain. The interpretation of the impulses then occurs in the cerebral cortex where they are recognized as being warm or cold and whether or not they are painful.[1, 5]

The brain interprets the sensation of warmth or coldness when there is minimal stimulation of warm or cold receptors. The sensory receptors respond very vigorously at first but progressively less and less. This loss of sensation is called adaptation of the sensory receptors.[6] When a stimulus is severe, the impulse does not travel to the brain but to the spinal cord and a reflex action is produced.[1]

Local and systemic conditions cause blood vessels in the body to dilate or constrict. Vasodilatation occurs with application of heat and vasoconstriction with cold. Continuous application of local heat or cold can result in the opposite effect and is called the rebound phenomenon.[3] This phenomenon occurs when the maximum therapeutic effect from the heat or cold is achieved. Intense heat or cold paralyzes the discriminatory power of the skin and interferes with circulation when applied for a prolonged period.[7]

Temperature tolerances of the cutaneous tissue are considerably higher than those of the vital organs.[8] The body's ability to transfer heat from the area to which it is applied affects the temperature changes produced within the tissues.[8, 9]

Consensual response occurs when other parts of the body are affected by the application of heat and cold. Downey states this is a result of a nervous reflex through the sympathetic system.[10] Afferent nerve impulses from skin receptors pass to the central nervous system through the peripheral and sympathetic nerves and return by the efferent pathway to another part of the body.[10]

According to Bierman, temperatures which can be tolerated by the human body for long periods without irreversible damage are:[11]

Local	— upper limit —	43.3°C (110°F)
	— lower limit —	4.4°C (40°F)
Systemic	— upper limit —	41.7°C (107°F)
	— lower limit —	23.9°C (75°F)

It is important to note that in many cases the application of heat or cold may cause similar effects and in other cases the opposite response is produced.[12]

Cold

When the skin is exposed to a temperature below 12°C (53.6°F), the cold receptors are not stimulated and a sensation of pain is felt.[1]

Vasodilatation occurs after 30 minutes to one hour of continuous cold. This syndrome is known as the "secondary effect" or "Hunting reaction."[2] It lasts about 10 to 15 minutes and is thought to be the body's defense to prevent damage to the tissue from prolonged ischemia. The skin temperature increases temporarily with reddening and warming of the area.

Cold applications in most instances should be removed after 30 minutes with an hour given for recovery. After removal of cold, the skin temperature soon reaches 25°C (77°F) and tends to remain at that level for an hour.[13] If too prolonged, cold threatens destruction of tissue by slowing the circulation and decreasing cell activity so that their function may be destroyed.[7] Kaye *et al*

maintain that most doctors suggest using application of cold intermittently for 10 to 20 minutes, four to five times a day.[14] Underlying subcutaneous fat tissues have low thermal conductivity; therefore, application of cold for periods less than 20 minutes will not be effective in cooling deeper tissues.[15]

Heat

The approximate therapeutic range when applying heat is 40-45°C (104-113.9°F) with tissue damage being associated with the upper part of the curve.[16, 17] Most authorities state that between 43-44°C (109-111°F) is the upper limit for skin temperature with local application of heat.[1, 7, 8, 18, 19] Higher temperatures are thought to cause irreversible damage. Transient erythema and irreversible tissue damage are not far apart. Pain can be experienced when skin temperature is raised above 43-44°C.[8, 20] Stillwell notes that a skin temperature of 45°C (113°F) is critical for evoking pain and producing cutaneous burns.[18] During heat treatments the patient should feel comfortable, warm and relaxed and the skin should be warm, pink and moist.

The maximal increases in circulation and tissue temperature result after 20 to 45 minutes of exposure.[1] Vasoconstriction occurs after approximately one hour of continuous application of heat; this phenomenon is called "secondary effect."[1] In order to prevent this "secondary effect," the heat should be discontinued after approximately 45 to 60 minutes and at least one hour of recovery time allowed.

Henderson and Nite say that investigators have observed that the temperature of skin in direct contact with a heating source rises rapidly.[7] The subcutaneous temperature rises slower to a lesser degree. Muscle and joint temperatures do not rise until the period of time when the body temperature may become elevated.[7] According to Gucker, the penetration of heat and the rise in deep tissue temperature depends on the amount and duration of heat applied and the relationship to local circulation.[9] Lehmann *et al* suggest that the rate of temperature elevation may also play a role in determining the extent of biologic responses.[16] Temperatures may stay below those which produce any significant physiologic responses, and no more than a placebo effect is obtained if inadequate techniques of application are used.[16] The treatment modality that should be used is one which produces the highest temperature at the treatment site without exceeding tolerance levels.[16]

Factors Influencing the Effects of Heat and Cold

There are many factors that influence the effects of local heat and cold application on the body's physiological response.

The following factors must be taken into consideration prior to initiating the treatment:[1]

1. Prior skin temperature.
2. Condition of the skin.
3. Condition of the circulatory system.
4. Coloring of the skin.
5. Age of the patient.
6. General physical condition.
7. Location of the application.
8. Length of the application.
9. Size of the area being treated.
10. Intensity of the temperature of application.
11. Environmental temperature.

Indications

Cold

Local cold application has many therapeutic uses. Cold results in vasoconstriction which decreases blood flow and increases viscosity of the blood in the area.[1]

Indications for local cold applications are to:

1. **Prevent edema** by reducing the accumulation of fluid in body tissue.
2. **Reduce inflammation.**
3. **Slow metabolism.**
4. **Control hemorrhage.**
5. **Relieve pain** caused by pressure by decreasing the circulating fluid. Cold also depresses the excitability of free nerve endings and peripheral nerve fibers which increases the pain threshold.[15] The decision as to whether to use heat or cold for relief of pain depends on the cause of the pain.
6. **Decrease muscle tonus** by decreasing the responsiveness of muscle spindles to stretch.[15]
7. **Prevent suppuration.**
8. **Retard bacterial growth.**[1]
9. **Achieve motion in joints** that have begun to stiffen after acute inflammation subsides.
10. **Prevent spread of malignancy** when it is suspected in the area of injury or pain.[14, 21] This indication is very debatable.
11. **Prevent alopecia** when chemotherapy or irradiation is being used.[22] Research in this area has had inconsistent results.[23]
12. **Reduce effect of burns** if applied shortly after the occurrence.[12]

Heat

Application of local heat causes dilatation of the blood vessels which increases the blood flow to and from the area. The resultant increased blood flow permits heat to be therapeutic when used appropriately.

Usual treatment is to switch from cold to heat 24 to 72 hours after an injury, when cold does not relieve the pain or discomfort, or if the joint being treated with cold becomes red or hot.[14] When unsure of whether to use heat or not and there are no contraindications, most physicians suggest local application of heat when the affected area feels hot and is erythematous.[14]

Indications for using heat are to:

1. **Hasten healing** by increasing oxygen, supply of leukocytes, antibodies and nutrients to the injury and removing waste products.
2. **Promote suppuration.**
3. **Increase phagocytosis.**[1, 3, 18]
4. **Warm a chilled part.**
5. **Reduce edema.**
6. **Reduce deep congestion** because less blood is available in the deeper viscera.[1]
7. **Relieve pain** from ischemic tissues, muscle spasm and local congestion. Heat decreases pain in subacute or chronic states.[8] The exact mechanisms are unknown. One theory is that heat receptors compete with the pain receptors to be recognized by the cerebral cortex.[24]
8. **Relax muscles** for massage and/or activity.
9. **Reduce inflammation.**
10. **Increase extensibility of collagen tissue.**[12]
11. **Decrease joint stiffness.**[12]

Contraindications

In order to use local heat or cold effectively and prevent complications, one must be cognizant of any contraindications for their use. Both heat and cold must be ***carefully*** used when the patient is very old or very young, anesthetized, unconscious or unable respond to painful stimuli for whatever reason. Heat and cold are contraindicated when the patient has impaired circulation.

Cold

According to Dodd, the use of cold is not indicated if edema is already present and after 24 to 36 hours of use it retards healing because it slows the reabsorption process.[1] However, there are others who state that the use of cold application has no time limit and should be used until the signs and symptoms subside and full range of motion is restored.[25] When there are conditions that suggest poor circulation of an area, cold should be avoided.[7]

Some patients are allergic to cold and will develop giant hives. Fair skinned individuals may be hypersensitive to cold. Cold sensitivity can be tested by a limited local application of ice.

Although cold is used to decrease pain with its anesthetic effect, patients with rheumatic conditions may note an increase in symptoms of pain and joint stiffness.[15] In others it may mask pain which is an important protective mechanism.[15] McMasters emphasizes that application of cold during intense physical activities may alter extensibility of collagen tissue and interfere with normal function which could predispose to additional injury.[15] Therefore cold application during athletic events should be used with caution.[15]

Heat

Acute inflammation may be aggravated by local heat, because the increased blood flow causes additional tissue tension.[18] Local heat also intensifies the process of suppuration, which may result in tissue necrosis.[7] Nerve excitation and contraction of skeletal muscles have been shown to be caused from very rapid temperature elevations.[11]

When there is a malignancy in the treatment area, heat should not be used. The increased blood flow may hasten metastasis[17, 26] by increasing the metabolism of abnormal as well as normal cells.[1] It has been shown that the rate of growth may be increased at moderate temperature elevations.[16]

Heat is contraindicated in diseases or disorders that inhibit the exit of metabolic wastes. This includes any condition where arteriosclerosis and atherosclerosis are present.[1]

Rarely is heat applied to the head due to the vasodilatation of the cerebral vessels which causes pain and discomfort.[7] Reduced heat is used on open wounds because of their limited sensory capabilities.[27]

Women who are pregnant should not use heat on their abdomen because it can affect the developing fetus.[3, 12] Heat is not recommended for application to the testes as it can inhibit the development of sperm as well as destroy sperm.[3]

Methods for Local Heat and Cold Applications

The treatment modality depends on the area of the body to be treated and the purpose of the treatment. The availability, convenience, cost, simplicity of use, comfort, preciseness and safety of the method being used are all important factors to be taken into consideration. Near the top of the list of negligent acts frequently charged to nurses are burns of one kind or another including hot water bottles and heating pads.[26] Statistics also indicate that heating pads are among the top five most frequent pieces of electro-medical equipment involved in medical malpractice claims.

Local heat is most often applied with aquamatic heating pads, hot water bags, hot soaks and chemical heat packs. The most frequently used cold methods are ice bags, ice collars, plastic gloves, aquamatic pads, cold soaks and chemical cold packs.

Chemical heat and cold packs are of the reusable or single use type. The packs are prefilled with precisely measured active ingredients that can produce a controlled and predictable temperature.[7] For this safety reason alone, the use of this treatment modality should be considered. As with all other methods, the correct procedure must be followed, but the likelihood of error is less than with other methods of treatment.

Allegiance Healthcare Corporation has developed a heat and cold system called T-Pak® which consists of an inner bubble of liquid surrounded by dry chemicals and sealed in a textured, nonslip outer bag. The non-caustic liquid chemical is sealed into a tough Mylar® pouch containing a predetermined rupture line for ease of activation. The pouch of liquid chemical and the non-caustic dry chemical is sealed into a tough, fabric-textured outer bag. To activate, the pack is squeezed to rupture the inner bubble and shaken to mix the contents. The warm or cold reaction begins immediately. The pack remains firm but pliable throughout the full period of treatment.[30] Advantages of the controlled heat and cold system are:

Safe and Precise: The temperatures are controlled to prevent frostbite or burn, and the packs maintain a fairly constant temperature. Cold packs, when activated, begin at 0.6°C (33°F). At the end of one hour's application, the skin temperature will still be about 21.7°C (71°F). Heat packs raise the skin temperature to a therapeutic level of about 43.2°C (110°F) and the temperature drops gradually to about 38.9°C (102°F). The controlled temperature of Allegiance's heat pack is an exclusive in the heat and cold therapy industry.

Convenient: Packs can be stored at room temperature and be activated immediately by the nurse or the patient.

Comfortable: Allegiance's wrap has a dry, fabric-textured exterior. Thorough activation of contents produces a pliable compress that conforms to body contours and will allow patients to be ambulatory while receiving therapy.

Simplicity: There is immediate availability of a therapeutic temperature level. Requires no nursing time to activate or apply.

Single Use: No biohazards. Diminishes the incidence of cross infection.

Economical: Can be stored in utility or storage room cabinets, at nursing stations and at patients' bedsides. Reduces nursing time in ice glove assembly. Cleaning and sterilizing for re-use is eliminated. Equipment setup and maintenance is alleviated.

Application of Heat and Cold Packs

Prior to the administration of any local heat and cold treatment, the patient should be assessed for skin sensitivity and normal vascular response. The patient should be told what to expect to feel and to notify a health team member if he or she experiences a different sensation or discomfort. The skin should be checked frequently during treatment and any mention of discomfort should be investigated immediately. The area should be assessed for the integrity of the skin and the quality of circulation.[1] The treatment should be discontinued with any sign of complications.

Redness which does not blanch with pressure, pallor, mottled redness, pain or blisters indicates complications from heat therapy.[1, 7, 27] Cold complications include pain, numbness, bluish-purple or gray mottled skin, redness and blisters.[1, 7, 27] Areas vulnerable to cold burns are the inside of the elbow and knee, front of the shoulder and any area with heavy deposits of subcutaneous fatty tissue.[31]

In order to provide safe therapeutic care to the patient receiving local heat and cold treatments certain basic physiological principles must be adhered to.

Guide to Insuring Safe and Effective Applications of Heat and Cold[32]

Physiological Principles	Implications
1. Nerve receptors for heat and cold adapt readily if the stimulus is not extreme.	1. Once receptors adapt, patient may be unaware of temperature extremes until tissue damage occurs. Explain to patient and caution not to increase heat or cold.
2. Tolerance of temperature varies with the individual. Certain areas of the body are more tolerant to temperature than others.	2. Apply heat and cold well within safety range of temperature. Observe skin for sensitivity regardless of temperature used.
3. Water conducts heat better than air.	3. Moist heat such as a warm, wet dressing must be applied at a lower temperature than dry heat.
4. The condition of the patient can alter his tolerance to heat and cold.	4. The very old and very young do not tolerate heat well. Special care is required for debilitated or unconscious patients. Patients with disturbances in circulation are more sensitive to heat and cold. It may be contraindicated or temperatures must be less extreme than normally used.
5. Cold immediately constricts blood vessels. Prolonged use causes dilation of vessels. Heat immediately dilates blood vessels, but vessels constrict with prolonged application.	5. Various applications differ in recommended length of application. However, 15 to 30 minutes is the usual length of time for application but can be up to one hour followed by at least one hour before reapplying.
6. The skin is the body's first line of defense against infection.	6. Heat or cold applied to open wounds or lesions that may rupture demands the use of sterile technique.

Location application of heat and cold has been used for centuries. This practice continues to be a readily available and inexpensive means of treatment when used appropriately and has excellent therapeutic value.

Bibliography

1. Dodd, MJ: Caring for persons requiring applications of heat and cold. In Sorensen, K and Luckmann, J: **Basic Nursing – A Psychophysiologic Approach**, Philadelphia, W.B. Saunders Co., 1979.
2. Fischer, E and Solomon, S: Physiological responses to heat and cold. In Licht, S (ed): **Therapeutic Heat and Cold** (Physical Medicine Library, Volume 2), 2nd ed. Baltimore, Waverly Press, Inc., 1965.
3. Kozier, B and Erb, G: **Fundamentals of Nursing Concepts and Procedure**, 3rd ed. Menlo Park, California, Addison-Wesley, 1987.
4. Scott, B: Short wave diatherm. In Licht, S (ed): **Therapeutic Heat and Cold** (Physical Medicine Library, Volume 2), 2nd ed. Baltimore, Waverly Press, Inc., 1965.
5. Guyton, A: **Textbook of Medical Physiology**, 4th ed. Philadelphia, W.B. Saunders Co., 1971.
6. **Function of the Human Body**, 4th ed. Philadelphia, W.B. Saunders Co., 1974.
7. Henderson, V and Nite, G: **Principles and Practice of Nursing**, 6th ed. New York, MacMillan Publishing Co., Inc., 1978.
8. Bierman, W: Physiologic changes produced by heat. In Licht, S (ed): **Medical Hydrology** (Physical Medicine Library, Volume 7), Baltimore, Waverly Press, Inc., 1963.
9. Gucker, T: The use of heat and cold in orthopedics. In Licht, S (ed): **Therapeutic Heat and Cold** (Physical Medicine Library, Volume 2), 2nd ed. Baltimore, Waverly Press, Inc., 1965.
10. Downey, JA: Control of the circulation in the limbs. In Downey, JA and Darling, RC (eds): **Physiological Basis of Rehabilitation Medicine**, Philadelphia, W.B. Saunders Co., 1971.
11. Bierman, WA: **Physical Medicine in General Practice**, New York, Harper and Row, 1944.
12. Lehmann, JF and DeLateur, BJ: Therapeutic heat. In Lehmann, JF (ed): **Therapeutic Heat and Cold**, 3rd ed. Baltimore, Williams and Wilkins, 1982.
13. Licht, S: Local cryotherapy. In Licht, S (ed): **Therapeutic Heat and Cold** (Physical Medicine Library, Volume 2), 2nd ed. Baltimore, Waverly Press, Inc., 1965.
14. Kaye, R *et al*: When in doubt, use ice (or is it heat?). **Patient Care**, 4:99-113, May 15, 1970.
15. McMasters, WC: A literary review on ice therapy in injuries. **American Journal of Sports Medicine**, 5:124-126, May-June, 1977.
16. Lehmann, JF *et al*: Therapeutic heat and cold. **Clinical Orthopaedics and Related Research**, 99:207-245, March-April, 1974.
17. Lehmann, JF and DeLateur, BJ: Diathermy and superficial heat and cold therapy. In Kottke, F *et al*: **Krusen's Handbook of Physical Medicine and Rehabilitation**, 3rd ed. Philadelphia, W.B. Saunders Co., 1982.
18. Stillwell, GK: General Principles of thermotherapy. In Licht, S (ed): **Therapeutic Heat and Cold** (Physical Medicine Library, Volume 2), 2nd ed. Baltimore, Waverly Press, Inc., 1965.
19. Millard, JB: Conductive heating. In Licht, S (ed): **Therapeutic Heat and Cold** (Physical Medicine Library, Volume 2), 2nd ed. Baltimore, Waverly Press, Inc., 1965.
20. Hardy, JD: Temperature regulation, exposure to heat and cold and effects of hypothermia. In Lehmann, JF (ed): **Therapeutic Heat and Cold**, 3rd ed. Baltimore, Williams and Wilkins, 1982.
21. Waterson, Marion: Hot and cold therapy. **Nursing '78**, 8:44-49, October 1978.
22. Dean, J *et al*: Prevention of Doxorubicin-induced hair loss with scalp hypothermia. **New England Journal of Medicine**, 301:1427-1429, December 17, 1979.
23. Tierney, AJ: Preventing chemotherapy-induced alopecia in cancer patients: Is scalp cooling worthwhile? **Journal of Advanced Nursing**, 12:303-310, 1987.
24. Halswell, M: Moist heat for relief of postoperative pain. **American Journal of Nursing**, 67:767-770, April 1967.
25. Kalenak, A *et al*: Athletic injuries: Heat vs. cold. **American Family Physician**, 12:131-134, 1975.
26. Lehmann, J and DeLateur, B: Heat and Cold in the treatment of arthritis. In Licht, S (ed): **Arthritis and Physical Medicine**, New Haven, Conn., Elizabeth Licht Publisher, 1969.
27. Dison, N: **Clinical Nursing Techniques**, 4th ed. St. Louis, C.V. Mosby Co., 1979.
28. Creighton, H: **Law Every Nurse Should Know**, 4th ed. Philadelphia, W.B. Saunders Co., 1981.
29. Stankevich, B: 4% of professional liability claims involved electro medical equipment. **Modern Healthcare**, 74-76, December, 1980.
30. Caillouette, J: Patient-applied heat/cold therapy system proves effective in postpartum. Monograph, Kay Laboratories, Inc., 1981.
31. Hayne, C: Physiotherapy for occupational health nurses – therapeutic heat and cold. **Nursing Mirror**, 147:I-IV (Part 2 – supplement), August 24, 1978.
32. Heat and Cold Application, Independent Study. **Foundations for Nursing Practice Skills Laboratory Handbook**, Richmond, MCV/VCU School of Nursing, 1980.

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