eMedicine from WebMD emedicine.medscape.com

eMedicine Specialties > Physical Medicine and Rehabilitation > Therapeutic Modalities

Deep Heat

Milton J Klein, DO, MBA, Consulting Physiatrist, Sewickley Valley Hospital, Allegheny General Hospital, Harmarville Rehabilitation Center, Ohio Valley General Hospital and Aliquippa Community Hospital

Updated: Sep 25, 2008

Introduction

Deep heat is produced when energy is converted into heat as it passes through body tissues.[1] Energy sources include (1) high-frequency currents (shortwave diathermy), (2) electromagnetic radiation (microwaves), and (3) ultrasound (high-frequency sound).

The temperature distribution in the tissues heated by any of these modalities results from the pattern of relative heating, which is the amount of energy converted to heat at any given location. The practitioner should choose a heating modality that produces the highest temperature at the site of concern without exceeding the temperature tolerance at the affected site or in tissues above or below that site. The temperature rise depends on the properties of the tissue, including the specific heat, thermal conductivity, and the length of time that the heating modality is applied.

The temperature rise and distribution of heat that are associated with these modalities are superimposed on the physiologic temperature distribution in the tissues prior to diathermy application. Usually, the superficial temperature is low at the skin surface and higher at the core.

The physiologic effects of temperature occur at the site of the application and in distant tissue. The local effects are caused by the elevated temperature response of cellular function by direct and reflex action. Locally, there is a rise in blood flow with associated capillary dilatation and increased capillary permeability. Initial tissue metabolism increases, and there may be changes in the pain threshold. Distant changes from the heated target location include reflex vasodilatation and a reduction in muscle spasm (as a result of skeletal muscle relaxation).

Vigorous heating produces the highest temperature at the site where the therapeutic result is desired. The tissue undergoes a rapid temperature rise, with the temperature coming close to the tolerance level. Vigorous heating is used for chronic conditions that require deep structures, such as large joints, to be heated. When acute inflammatory processes are occurring, deep heating requires extreme care, because it can obscure inflammation.

Local tissue temperature is maintained during mild heating, the primary effect being the production of a higher temperature at a site distant from the heating modality's application. Reflex vasodilatation occurs when the rise in temperature is slow for short periods, such as during a subacute process. With the proper application, superficial and deep heating methods can accomplish mild heating.

The best method for large-area deep heating is shortwave diathermy. This modality is useful for various indications.

Related eMedicine topic:
Superficial Heat and Cold

Shortwave Diathermy

This deep heat modality involves the therapeutic application of high-radiofrequency electrical currents. The electromagnetic field is usually at a radio frequency of 27.12 MHz (λ = 11.06 m). Hyperemia, sedation, and analgesia are the basic physiologic effects.[2] The reduction in muscle spasm resulting from muscle relaxation is caused by an increased vascular supply to the treated area. A transverse technique is applied to treat a larger anatomic area, with the primary concentration at the midpoint between electrodes.

Proper application and tuning are required for this modality. The patient's electrical impedance becomes part of the impedance of the patient's own circuit. The patient's circuit must be set to resonance, so the patient's circuit frequency is equal to that of the machine. The patient should feel only a comfortable heat. For therapeutic benefit, the tissue temperature should be elevated to between 40° and 45° C. Continuous supervision and observation of the patient are required. The treatment time is usually 20-30 minutes. At clinically relevant energies, shortwave diathermy can increase subcutaneous fat temperature by 15° C and muscle temperature by 4-6° C at a depth of 4-5 cm. Patients should be placed on a wooden table or chair when shortwave diathermy is applied.

One means of applying shortwave diathermy is through the condenser method. In this, the treatment site is placed between 2 electrodes functioning as capacitor plates. Monitoring of patient movement is required, because movement can affect the amplitude of the heat concentration being applied. Another technique, the inductive coil method, involves coil applicators that selectively heat superficial musculature (unless these applicators are used on joints with minimal overlying soft tissue, resulting in selective heating of the joint).

Inductively coupled units use induced eddy currents to heat tissue, especially tissue, such as muscle, with high water content. Units joined to provide aggregate capacity use electrical fields to heat tissue with low water content, such as fat. Self-adjusting resonators minimize the positioning effect.

Felt or plastic spacers should be used with the condenser method. When the condenser or inductive coil method is applied, a towel should be used to absorb perspiration, thereby avoiding localized heat concentration. The patient must be instructed to remain motionless. The output of the machine should be adjusted to a desired level so that movement does not change the impedance circuit and increase current flow (which would mean a greater risk of a dose increase and resultant burns). The shortwave diathermy unit should be tuned to low power as per patient tolerance, and the meter readings should be properly documented. Heating localization depends on the coupling of radio waves to the patient.

Applications

The following problems can be treated with shortwave diathermy, depending on the individual condition of each patient and the desired treatment goals:

- Localized musculoskeletal pain
- Inflammation (joint or tissue)[3]
- Pain/spasm
- Sprains/strains
- Tendinitis
- Tenosynovitis
- Bursitis
- Rheumatoid arthritis[3]
- Periostitis
- Capsulitis

Contraindications

Shortwave diathermy has the following precautions or contraindications:

- Malignancy
- Sensory loss
- Tuberculosis
- Metallic implants or foreign bodies
- Pregnancy

- Application over moist dressings
- Ischemic areas or arteriosclerosis
- Thromboangiitis obliterans
- Phlebitis
- Cardiac pacemakers
- Contact lenses
- Metal-containing intrauterine contraceptive devices
- Metal in contact with skin (eg, watches, belt buckles, jewelry)
- Use over epiphyseal areas of developing bones
- Active menses

In addition, extreme care must be used with pediatric or geriatric patients.

The literature is not clear on the amount of heating that occurs in the case of metal surgical clips; in addition, the effect of shortwave diathermy on actual bony growth plates is not known with certainty. The most common complication of shortwave diathermy is the development of burns, which may be caused by a number of factors, including the following:

- Faulty equipment
- Improper technique
- Inadequate patient supervision
- Inappropriate positioning of the patient

Microwave Diathermy

Microwave diathermy, which employs a form of electromagnetic radiation, is another deep heat modality that selectively heats tissues with high water concentration.[4,5] Hyperemia, sedation, and analgesia are the physiologic effects, similar to the results of shortwave diathermy.[2,6] Secondary, local vascular dilatation results in increased local metabolism.

The 2 frequencies designated for microwave diathermy are 915 MHz and 2456 MHz, with the former being the most commonly used. Because the frequencies are higher than those used in shortwave diathermy and the wavelengths are the same size as the applicator, microwave diathermy can be focused more easily than can shortwave diathermy. The lower frequency is preferred because it provides selective heat deep into muscle, and less energy is converted to heat in the subcutaneous fat.[5] Direct contact applicators with full aperture skin contact are optimal for improved coupling and for reducing stray radiation.

Because microwave diathermy selectively heats muscles and deep heat improves the flexibility of collagen tissues, muscle contractures can be treated with this modality (in combination with a physical therapy stretching program). Microwave diathermy can also be used to reduce secondary muscle spasm under a trigger point. In addition, this modality can effectively treat the superficial joints of the hands, feet, and wrist because of the thin soft-tissue layer overlying these joints.

A microwave director is used to aim the microwaves at the area of treatment, allowing observation of the treatment site. Heat can be reduced by increasing the distance of the microwave director from the treatment site. As with shortwave diathermy, microwave diathermy can result in hot spots and burns; these can occur secondary to localized perspiration associated with selective heating of the treatment zone. The microwave diathermy equipment should be adjusted to provide comfortable heating, with treatment time ranging from 20-30 minutes.

The previously mentioned contraindications to shortwave diathermy also apply to microwave diathermy. Additional precautions include synovitis with joint effusion, systemic/local infection, and use over bony prominences. The aforementioned therapeutic indications for shortwave diathermy are similar to those for microwave diathermy.

Related eMedicine topic:
Transurethral Microwave Thermotherapy of the Prostate (TUMT)

Ultrasonography

Ultrasonography is a deep heating modality that uses high-frequency acoustic vibrations; the frequencies employed are above the human audible spectrum, that is, they are greater than 17,000 Hz. Therapeutic ultrasonography uses a frequency range of 0.8-1.0 MHz. Ultrasonographic energy is generated by the piezo-electric effect; electrical energy is applied to a crystal, causing the crystal to vibrate at a high frequency and thereby produce ultrasound. Ultrasound is delivered by continuous or pulsed waves (the goal being to produce nonthermal effects, such as streaming and cavitation) and provides a high heating intensity.[7,8]

Ultrasonographic energy is absorbed and transformed into heat energy as it propagates through tissue. The therapeutic dose is computed by the power output (total W) and the size of the ultrasonographic head. The usual initial dose is 1 W/cm^2 and is adjusted to patient tolerance, as well as to the treatment goals. The practitioner must select the wave form (continuous or pulsed), intensity, and duration. The patient should experience a comfortable heating or no sensation at all. The treatment time is 5-10 minutes, taking into account the patient's tolerance and comfort. After the skin is cleansed, a coupling agent, such as an ultrasonographic gel, is required to provide effective conduction between the ultrasonographic head/transducer and the skin surface. To avoid hot spots, the ultrasonographic head must be continuously moved over the treatment site.

Therapeutic ultrasonography produces the following biologic effects:

- Temporary analgesia[2,9,10]
- Increased peripheral blood flow
- Increased vascularity with associated hyperemia/inflammatory response[2]
- Increased cell membrane permeability
- Peripheral nerve conduction changes (reversible conduction block with high-intensity ultrasonographic exposure)
- Relief of muscle spasms[10]

The following factors influence the propagation of ultrasound in biologic tissue:

- Transmission
- Absorption
- Refraction
- Reflection

Therapeutic ultrasonography is ideal for providing deep heat to large joints. For example, it is effective in treating the shoulder or hip, because a standing wave is produced as a result of the curved reflection of the glenoid or the acetabulum; this effect concentrates heat energy at the articular surfaces of the joint.

In combination with a physical therapy program utilizing range of motion (ROM) and stretching activities, the localized, intra-articular heating produced by ultrasonography greatly facilitates the mobilization of joint adhesions or capsular restrictions caused by tightness or scarring. Ultrasonography is also used to treat osteoarthritis, tendinitis, and bursitis.[10] Ultrasonographic deep heating has not been found to be effective for the preventive management of posteccentric exercise, delayed-onset muscle soreness.[11]

As mentioned above, the nonthermal effects of ultrasonography include cavitation, which disrupts chemical and cellular bonds, thereby assisting with the treatment of fibrous tissue, scar tissue, and joint capsule adhesions. A form of ultrasonography known as phonophoresis is used to diffuse a topical medication, such as a steroid, analgesic, or anesthetic in a gel, into the subcutaneous tissue.[9]

Most of the indications for therapeutic ultrasonography are similar to those for other deep heating modalities. Additional indications for ultrasonography include the following:

- Joint contracture
- Joint adhesions
- Calcific bursitis
- Hematoma resolution
- Neuromas

Other conditions that may be treated by ultrasonography, although with limited therapeutic benefit, include the following:

- Fibrosis
- Phantom limb pain
- Myofascial pain
- Reflex vasodilatation
- Ulcer debridement

Precautions to be noted in the use of therapeutic ultrasonography are the same as those for most other deep heating modalities. Although the literature for physical therapy and for physical medicine has differing opinions, therapeutic ultrasonography can be used over metal implants with caution and with constant motion of the ultrasonographic head.

Additional contraindications for the use of ultrasonography include conditions in which the application of deep heat would require direct exposure of the eye, pregnant uterus, spine, laminectomy sites, brain, heart, or known ischemic areas, which can result in detrimental cavitation and heating of those tissues.

Summary

The therapeutic effects of deep heating modalities are usually produced by the conversion of applied energy into heat as the energy penetrates tissue. Because the temperature distribution varies significantly across different modalities, the clinician should use the appropriate modality for the condition at hand. To provide the greatest therapeutic effect, the temperature rise generated by the modality should be the maximum increase that the patient can tolerate. For a specific localized pathology, the deep heating modality that is selected must produce a maximum temperature elevation at the site of the pathology.

The following areas are treated selectively by the listed modalities:

- The application of microwave radiation or of shortwave diathermy with capacitor plates, at a frequency of 2456 MHz, can provide selective heat to deep subcutaneous tissue and superficial muscle.
- Shortwave diathermy with an induction coil applicator, administered at 27 MHz, can heat superficial muscle.
- Microwave diathermy administered at 915 MHz can selectively, but thoroughly, heat muscle.
- Ultrasonography administered at a frequency of 0.8-1 MHz preferentially heats joints, ligaments, tendons, tendon sheaths, fibrous scars, nerve trunks, and myofascial interfaces. Ultrasonography is especially useful for heating joints that have a thick layer of overlying soft tissues that shortwave diathermy or microwave diathermy cannot penetrate.
- Shortwave diathermy with internal electrodes, administered at 27 MHz, can provide selective heat for pelvic organs in cases of chronic pelvic inflammatory disease and can be employed for the management of coccygeal muscle

spasms (such as those of the urogenital diaphragm).

References

1. Lehman JF, De Lateur BJ. Therapeutic heat. In: Lehmann JF, ed. *Therapeutic Heat and Cold*. 4th ed. Baltimore, Md: Williams & Wilkins; 1990:417-581.
2. Helfand AE, Bruno J. Therapeutic modalities and procedures. Part I: cold and heat. *Clin Podiatry*. Aug 1984;1(2):301-13. [Medline].
3. Weinberger A, Fadilah R, Lev A, et al. Deep heat in the treatment of inflammatory joint disease. *Med Hypotheses*. Apr 1988;25(4):231-3. [Medline].
4. Biundo JJ Jr, Torres-Ramos FM. Rehabilitation and biomechanics. *Curr Opin Rheumatol*. Apr 1991;3(2):291-9. [Medline].
5. Giombini A, Giovannini V, Di Cesare A, et al. Hyperthermia induced by microwave diathermy in the management of muscle and tendon injuries. *Br Med Bull*. 2007;83:379-96. [Medline].
6. [Best Evidence] Lewis M, James M, Stokes E, et al. An economic evaluation of three physiotherapy treatments for non-specific neck disorders alongside a randomized trial. *Rheumatology (Oxford)*. Nov 2007;46(11):1701-8. [Medline].
7. Straub SJ, Johns LD, Howard SM. Variability in effective radiating area at 1 MHz affects ultrasound treatment intensity. *Phys Ther*. Jan 2008;88(1):50-7; discussion 58-62. [Medline].
8. Demchak TJ, Straub SJ, Johns LD. Ultrasound heating is curvilinear in nature and varies between transducers from the same manufacturer. *J Sport Rehabil*. May 2007;16(2):122-30. [Medline].
9. Fedorczyk J. The role of physical agents in modulating pain. *J Hand Ther*. Apr-Jun 1997;10(2):110-21. [Medline].
10. Rand SE, Goerlich C, Marchand K, et al. The physical therapy prescription. *Am Fam Physician*. Dec 1 2007;76(11):1661-6. [Medline]. [Full Text].
11. Symons TB, Clasey JL, Gater, DR, et al. Effects of deep heat as a preventative mechanism on delayed onset muscle soreness. *J Strength Cond Res*. Feb 2004;18(1):155-61.

Keywords

deep heat, heat therapy, diathermy, wave diathermy, ultrasonic heat therapy, ultrasound heat therapy, ultrasonographic heat therapy, ultrasonography, ultrasound, shortwave diathermy, electromagnetic radiation therapy, short-wave diathermy, microwave diathermy

Contributor Information and Disclosures

Author

Milton J Klein, DO, MBA, Consulting Physiatrist, Sewickley Valley Hospital, Allegheny General Hospital, Harmarville Rehabilitation Center, Ohio Valley General Hospital and Aliquippa Community Hospital
Milton J Klein, DO, MBA is a member of the following medical societies: American Academy of Disability Evaluating Physicians, American Academy of Medical Acupuncture, American Academy of Osteopathy, American Academy of Physical Medicine and Rehabilitation, American Medical Association, American Osteopathic Association, American Pain Society, and Pennsylvania Medical Society
Disclosure: Nothing to disclose.

Medical Editor

J Michael Wieting, DO, MEd, Professor of Physical Medicine and Rehabilitation, Professor of Osteopathic Principles and Practices, Director of Sports Medicine, Associate Director of Physician Assistant Training Program, Department of Osteopathic Principles and Practice, Lincoln Memorial University-DeBusk College of Osteopathic Medicine

J Michael Wieting, DO, MEd is a member of the following medical societies: American Academy of Osteopathy, American Academy of Physical Medicine and Rehabilitation, American Academy of Physical Medicine and Rehabilitation, American Association of Neuromuscular and Electrodiagnostic Medicine, American College of Forensic Examiners, American College of Sports Medicine, American College of Sports Medicine, American Osteopathic Association, American Osteopathic Association, American Osteopathic College of Physical Medicine and Rehabilitation, American Osteopathic College of Physical Medicine and Rehabilitation, Association of Academic Physiatrists, Association of Academic Physiatrists, and International Society of Physical and Rehabilitation Medicine
Disclosure: Nothing to disclose.

Pharmacy Editor

Francisco Talavera, PharmD, PhD, Senior Pharmacy Editor, eMedicine
Disclosure: Nothing to disclose.

Managing Editor

Michael T Andary, MD, MS, Residency Program Director, Professor, Department of Physical Medicine and Rehabilitation, Michigan State University College of Osteopathic Medicine
Michael T Andary, MD, MS is a member of the following medical societies: American Academy of Physical Medicine and Rehabilitation, American Association of Neuromuscular and Electrodiagnostic Medicine, American Medical Association, and Association of Academic Physiatrists
Disclosure: allergan Honoraria Speaking and teaching

CME Editor

Kelly L Allen, MD, Regional Medical Director, IMX-Medical Management Services
Disclosure: Nothing to disclose.

Chief Editor

Consuelo T Lorenzo, MD, Consulting Staff, Department of Physical Medicine and Rehabilitation, Alegent Health Care, Immanuel Rehabilitation Center
Consuelo T Lorenzo, MD is a member of the following medical societies: American Academy of Physical Medicine and Rehabilitation
Disclosure: Nothing to disclose.

Further Reading