CHAPTER 48

Principles of physical medicine

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The therapeutic and diagnostic application of physical energies is described in this chapter. The modalities include thermotherapy (heat and cold), ultraviolet irradiation, electrotherapy, massage, manipulation, stretching, and traction. The chapter concludes with discussions of diagnostic tests and prescription writing.

THERMOTHERAPY

Heat

Biologic processes generate and are affected by physical energies, one of which is heat.

Heat is the most commonly used modality in rehabilitation medicine and is applied before exercises, stretching, or electrotherapy. It is employed for both acute and chronic disorders, and the physiologic effects are the same whatever the source, varying only in the depth of penetration.

Physics

Heat is a part of the electromagnetic spectrum and is a state of particle excitation (entropy). Every atom or molecule above zero degrees Kelvin has excitation and is capable of transmitting energy to another particle either by direct collision or radiation. Energy transfer by collision in solids is *conduction* and in liquids or gases *convection*. It occurs only when the absorbing particle has lower entropy (temperature). Heat can therefore be transmitted only from higher temperature to lower temperature. *Radiation* is the emission of photons (quanta or packets of energy), which cross space and when absorbed increase the particle's excitation state, alter its chemistry, or are reemitted as heat or light (fluorescence, phosphorescence).

The skin is a good reflector, fair radiator, and poor conductor of heat. The heat absorbed by the skin immediately encounters the high concentration of water molecules in the subcutaneous capillary and fat beds, which are subject initially to physical and then to physiologic reactions. The *specific heat, the calorie gain or loss needed to change the* temperature of 1 g of a substance, is approximately three times greater for water than it is for tissue molecules. The subcutaneous water thus becomes an excellent heat storage reservoir or insulator and significantly contributes to maintenance of relatively constant body temperature.

Heat can also be produced in tissue by conversion of high-frequency electromagnetic waves into microcurrents (short wave or microwave) or into shearing, vibrational, frictional, or compressive mechanical waves. These modalities are described as diathermy and ultrasound, or deep heat. Conductive, convective, or radiant heat penetrates 0.5 to 1 mm beneath the skin and is called superficial heat. Diathermy can reach superficial muscle fascia, and ultrasound reaches deeper.

In summary, heat is electromagnetic energy that is absorbed by a particle having a lower temperature than the source. The absorbed energy raises temperature, produces chemical reactions, is transmitted to another particle, or is reemitted as light or heat.

The skin may reflect or absorb the energy. Absorption is achieved to the greatest extent by water in the subcutaneous fat and capillary beds.

Physiologic effects of heat[22]

Physiologic functions are governed by the energy manipulations of specialized molecules, usually protein within the cell, its membranes, and extracellular compartments. These molecules have inherent mechanical, electrical, and chemical energy that they generate and transfer. Adding thermal energy to this system increases these transduction processes. Thermal energy in the water molecules acts as a driving force for the reactions and may increase oscillating motion and charges or dipole separation or may produce electrical changes. In addition, heat causes hydrogen bonds to be made

or broken and causes chemical changes from alterations in molecular configurations. These effects are anabolic or catalytic and function in life as substrate molecules are available.

We may postulate the following sequence resulting from the application of heat to cells: (1) increase cellular catalysis-metabolism requiring (2) energy source molecules (O_2, proteins, fats, carbohydrates) producing (3) vasodilation and increased capillary pressures with (4) transudation and, from alteration of membrane configuration or dynamics, (5) ionic "pumping" of electrolytes, fluids, metabolites, and enzymes.

Continuing application of heat or reduction of temperature may result in protein degradation, creating histamine-like substances or cryoglobulin; leukocytosis and associated immunologic reactions; and concomitant inflammatory or antiinflammatory reactions.

The molecular and structural characteristics of proteins such as collagen are temperature dependent. Such proteins elongate with temperature elevation (viscoelastic effect).[7,17] The chemical energy of dephosphorylation of adenosine triphosphate (ATP) to adenosine diphosphate (ADP), with accompanying mechanical work of shortening muscle fibers, generates heat that may produce changes in the configuration of fiber proteins and in the mechanical characteristics of the sliding filaments. Protein fractions such as histamines or antigens (cryoglobulins) may be released with temperature alterations.

Dynamics of fluids and electrolytes in the membrane, particularly in excitable tissues such as nerve, are temperature dependent. The mechanisms of impulse transmission, including ionic, electrical, thermal, and light energies, are interrelated. Infrared emissions from live crab nerves have been described.[50] The configurations of protein lipoid molecules in end organs and membranes are modified by temperature changes, and secretions of synovial fluids increase with temperature elevation.[35]

Thermal energy therefore affects the structural, chemical, immunologic, and electrical characteristics of molecules; enzyme activity; degradation products; and membrane functions of cells.

Clinical effects of heat

Local skin reactions to heat include the sense of warmth, vasodilation (erythema), sweating, reduction in skin resistance, and increase in local tissue metabolism. If heating is continued beyond 60 minutes, core temperature may be elevated and homeostatic responses of distal vasodilation occur.

Usually temperature, pulse, and blood pressure are unaffected by heat, as are the renal and gastrointestinal systems. Nerve conduction velocities and action potentials may increase. Muscle tone or tension may soften, or the elasticity increase. Ligament and capsular fibers similarly gain elasticity, and the motion of joints increases.

Pain may be relieved by heat. One explanation is that pain relief with heat may be related to spindle gamma afferent release, but there is as yet insufficient evidence to support this.

The anti-inflammatory action of heat includes leukocytosis, increased capillary pressure, and hormonal enzyme effects that act toward suppression of the tissue reaction. Thermolabile reactions of reactive proteins and of other cellular (lymphocyte) components of tissue injury such as bradykinin, prostaglandins, and leukotrienes may be postulated.

The amount, rate, and direction of tissue heat gain or loss depend on the following:

1. The source of heat, its temperature, and duration of application
2. The optical properties of the skin: reflective or absorptive
3. The core/skin temperature gradient, which varies from 5° to 10° C depending on the sites tested; core temperature averages 37° to 40° C, and skin temperature 29° to 35° C.
4. The amount of water and fat in the subcutaneous capillary and fat beds
5. Hypothalamic and skin neural controls that maintain constant temperature, such as reflex vasomotor reactions distal to treated areas
6. Respiratory and excretory mechanisms
7. Ambient temperature and humidity
8. Age (elderly and infants tolerate heat poorly), sex, nutrition, exercise, hydration, sensitivity, and disease

Indications

Heat is indicated primarily for its analgesic effect. The usual applications are for musculoskeletal and neuromuscular disorders such as neuralgias, sprains, strains, articular problems, muscle spasm, trigger points, and problems labeled by a host of terms that attempt to describe the vague problem of muscle pain. In an exhaustive review of muscle pain syndromes, Simons[44] attempted to define the many terms used to describe the problem and reported the pathologic conditions found by many investigators. Although there does not appear to be a clear understanding of the etiology, pathology, or indications for treatment of pain, heat and cold are recommended among many other modalities.

Muscle spasm is an indication for heat treatment. The nature of this condition is included in Simons' discussion[44] but has not been clearly defined. That it is benefited by heat is often noted subjectively and objectively. If possible a diagnosis should be made and aspirin or other anti-inflammatory analgesics prescribed, with rest or splinting, before a program of thermotherapy begins.

Heat before exercise, stretching, traction, or manipulation often enhances their effect and benefits.

Heat as therapy in obliterative arterial or in arteriolar

disease may be helpful but should be employed with great caution.

Wounds and ulcers may benefit from topical heat. Cellulitis and abscesses may be ripened to the point of drainage with hot, wet compresses. Since heat has an evaporative drying and vasodilating effect, it may be beneficial in the treatment of open wounds.

The use of heat in addition to surgery, chemotherapy, and radiation therapy is being favorably reported in the management of cancer. Diathermy or microthermy is applied to the tumor site. Raymond and co-workers[38] reported beneficial effects using microwave diathermy on patients with refractory tumors of the head and neck.

The soporific effect of heat is frequently noted.

Contraindications

Heat, whatever its source, should not be used in acute inflammation or trauma until the initial reaction has subsided, nor in venous obstruction, severe arterial insufficiency, hemorrhagic diathesis, or coagulation defects. In the absence of sensation special care must be exercised.

In the presence of cardiovascular, respiratory, or renal failure, heat should be used sparingly, if at all. Active inflammatory arthritis, particularly with joint swelling, may be worsened by the application of heat because collagenase activity is increased with heating.

Saunas are not advised for pregnant women or for patients with cardiac disease, epilepsy, hypotension, or hypertension. Patients taking tranquilizers, narcotics, or antihypertensive medication should be cautioned about using a sauna.

Sources

Superficial (conductive) heat.[35] Conductive heating is achieved by direct contact with the skin. The sources include solids (electric pad, hot water bottle, sand, peloids [muds], poultices), liquids (water, paraffin wax or packs, whirlpool), and gases (dry or moist air, saunas, fluidotherapy).

The choice is one of convenience and should be based on accessibility of the part, need for movement, availability of the agent, and the patient's and physician's preference. The conductive heat agents most commonly used in rehabilitation are water, hot packs, and paraffin. Hot water bottle, heating pad, moist packs, and tub baths are all readily available at home, making these preferred heat sources.

LIQUIDS.[51] The accessibility, bouyancy, cleansing effect, and ease of temperature control of water makes hydrotherapy one of the most frequently employed heat sources. Although normal heat loss is reduced with immersion, undesirable temperature elevation may occur. Movement of painful joints under water is frequently possible when motion is otherwise inhibited.

The *bathtub, pool, tank,* or *whirlpool* is used for palliation, exercises, or debridement of wounds or ulcers. Soaps, antiseptics, and detergents can be added to the water as appropriate but often are unnecessary. Full body immersion in tubs or tanks for recent widespread surface burns is used in many centers. Maintenance of neutral temperature is recommended (38 to 41° C). The addition of common salt at the ratio of 0.7 pounds per 10 gallons of water brings the bath to isotonic concentration.

Pool temperature for exercise therapy should be approximately that of the body, 32° C. Therapy may be daily, starting at 10 to 15 minutes and increasing to 20 to 30 minutes. Alternate days for elderly or debilitated patients may be considered.

Tubs, saunas, and steam rooms have been subject to bacterial contamination with *Pseudomonas aeruginosa*. Herpes simplex may also be transmitted in hot tubs without body contact.

The fluidotherapy apparatus used in hand therapy applies heat, massage, and sensory stimulation by using heated organic cellulose particles or polypropylene propelled by a compressor at a hand inserted into the unit. This is equivalent to a dry whirlpool device and is very effective in hand rehabilitation therapy. The pressure and temperature can be adjusted to the desired levels. Exposures of 20 to 30 minutes are usually adequate.

Paraffin wax remains liquid after melting at 49° C. Adding mineral oil lowers the melting temperature. Paraffin, which can be applied directly to the skin, is often prescribed for arthritis of the hand or foot. Its effectiveness for an acute swollen joint is questionable. The oil that remains after removal of the wax makes subsequent massage and stretching easier. Electric heaters or double boilers for melting paraffin are available for home use. Patients applying paraffin at home should use a thermometer to ensure proper temperature.

GASES. Saunas and steam rooms are usually available in recreational facilities and are even found in homes. The steam source is usually water on dry hot stones or on an electric heating element. The specific therapeutic benefits from these units have not been established, but the relaxing effects may be related to the hypotension that follows vasodilation of the skin and subcutaneous capillary bed.

Compresses may be made from turkish towels, strips of felt or wool blankets, or silica gel packs (Hydrocollator). The last retains heat longer when heated to 60° to 71° C. The heat is retained for approximately 30 minutes after application at above 65° C. Patients and families can easily be taught to use packs at home. To prevent burns, placing several layers of terry-cloth towels between the pack and skin is recommended.

Radiant heat. Radiant heat (noncontact, dry heat)[47] is infrared radiation, which has a wavelength of 7700 to 120,000 Å and is above the visible spectrum (3900 to 7700 Å). Its depth of penetration is approximately 1 to 10 mm for near (7700 to 15,000 Å), and 0.05 to 1 mm for far (15,000 to 120,000 Å). Photons at longer wavelengths have less energy and therefore less penetrance (Table 48-1).

The physiologic effects of radiant heat are identical to those of conductive heat.

Table 48-1. Various ranges of the electromagnetic spectrum

Type of radiation	Range of wavelengths (Å)
Long-wave infrared	12,000-1500
Short-wave infrared	1500-770
Visible	770-390
Near ultraviolet	390-290
Far ultraviolet	290-180
Grenz X rays	5-1
Diagnostic X rays	0.3-1.2
Therapeutic X rays	1.2-0.5
Gamma rays	01.-0.2

Sources of radiant heat include luminous or visible infrared bulbs, which emit near infrared, and nonluminous radiators, which are metallic coils or wire covered with refractory materials and emit far infrared. Some light may be visible with the coils and always is with bulbs. Bulbs are available for home use, but caution must be exercised against burns or fire.

Diathermy and ultrasound[12]

Physics

High-frequency currents are generated by an oscillator that in addition to a current source requires a capacitor or condenser and an inductance coil. The patient circuit is coupled to this apparatus. This circuit can produce electromagnetic waves that have frequencies described as short and ultrashort (microwave), as compared to long radio waves. The same basic generator coupled to a piezoelectric crystal (transducer) produces high-frequency sound waves.

The short waves or microwaves create microcurrents in a field that develops between the plates of the coupled capacitor or within an inductance coil.

A piezoelectric crystal placed between capacitor plates will be subjected to expansions and contractions with each oscillating half cycle. Placing a patient between coupled capacitor plates produces capacitor heating, or inductance heating where a wire is either coiled or looped about a part. The "short" wavelengths fixed by the Federal Communications Commission at 27.33 mHz have a length of 12.2 cm.

Microwaves are generated off directors described as A, B (hemispherical—4- and 6-inch diameters) and C and D (dihedral—4.5 × 5 and 5 × 21 inches). The directors are connected by a coaxial cable to the oscillator as is the U.S. transducer.

The term "diathermy" is a misnomer because the microcurrents do not go through the body but, like any current, move through a volume conductor along the lines of least impedance (resistance in high-frequency fields) or across its surface. They usually penetrate to the subcutaneous fat where high resistance exists in the water molecules.

Diathermy

The currents generated inside a capacitor field vary according to the capacitor size, the distance between the plates, the material between the plates, and the voltage and frequency applied. The quantification of the current within the field (patient circuit) cannot be accurately measured. Meters on the apparatus only define the "resonance" or tuning of the patient and generator circuits. The patterns of the heating fields are different for condenser pad, inductance coil, and microwave directors, but they all have the effect of developing heat at or slightly below the skin's surface. The depth of penetration varies with the technique or apparatus employed and the thickness of the subcutaneous fat.

Microwaves are applied in a similar manner to an infrared lamp, and some of the energy is scattered, reflected, absorbed, and refracted. The heating patterns vary with different directors and differ according to their size and design.

Because microwaves have greater frequency than short wave diathermy, they penetrate to a greater depth.

Ultrasound[27]

Ultrasound energy is mechanical oscillating waves (800,000 to 1 million cycles/sec and 0.15 cm) that produce vibration, shearing, compression, rarefaction, and frictional forces above the audible range (17,000 cycles/sec). The energy is generated by particle collisions and therefore cannot be generated in a vacuum.

Coupling ultrasound to the body surface by such agents as oil, gel, or water ensures transmission of the energy. A space or gap of air dissipates the energy. The energy absorbed by the tissues is transmitted by conduction. Metallic implants, except those close to the skin, are good conductors and their presence is therefore not a contraindication to therapy because they rapidly transmit the heat and do not reach toxic temperatures. Ultrasound should not be used in the presence of methyl methacrylate (bone cement) because the interface and binding may be broken.

Sound waves, including ultrasound, penetrate deepest of all the diathermy modalities. They can penetrate to depths such as the hip joint or through the body as is the case when listening with a stethoscope.

The primary energy produced by ultrasound is thermal, which can cause alteration of membrane configuration or possible membrane destruction. Trapped gas molecules may expand and coalesce (cavitation) and with the interface reaction contribute to membrane rupture. The compressive-rarefaction phenomenon creates streaming, which may also alter membrane or cellular functions and be beneficial in accelerating diffusion of injected medication.

Equipment and dosage. The generator produces high-frequency alternating current on the piezoelectric crystal. The latter may be quartz or barium titanate, which is in the treatment head. The intensity is expressed as watts/cm^2, which describes the field of energy under the transducer. It is derived by dividing the maximal total wattage output by

the size of the applicator's radiating surface in square centimeters. Thus a machine with 30 watts total output and a radiating surface of 10 cm^2 has an average intensity of 3 watts/cm^2. The sound head must be coupled to the area under treatment and moved slowly to avoid local buildup of thermal reactions, which patients usually describe as sharp pain.

The dosage should be at maximal tolerable levels. These levels change along the line of movement of the transducer, and dosage can be corrected by concomitantly modifying the wattage. Tolerance increases during the course of treatment, and greater intensities may be applied. Sessions of up to 20 minutes may be given for acute injuries. Twice daily treatments may resolve acute problems within 3 to 5 days.

Contraindications

Contraindications for diathermy, microtherm, and ultrasound are the same as those mentioned for thermotherapy. Microthermy causes a high temperature concentration in the presence of edema, on adhesive tape or a wet dressing, and over bony prominences. Malignancy is not a contraindication. Short wave diathermy should not be applied over metal implants.

Bryan[6] reported electromagnetic radiation interference with cardiac pacemakers in the microtherm frequencies. He noted this effect from microwave ovens, and this precaution should be observed with microwave diathermy.

Cold[26,45]

Reduction of skin or body temperature is used in rehabilitation for local analgesia, anti-inflammatory effect, control of pyrexia, and possibly control of spasticity.

Physics

The physics of hypothermia is identical to that described for heat. However, the patient and the part treated act as the heat source and the applied agent or ambient temperature absorbs the calories. Lowering body temperature over an extended time period is hypothermia. Cryotherapy uses extremely low temperatures (near or below zero degrees centigrade) for a short time such as seconds to a minute. Heat transmission away from the body or tissues is by conduction or radiation, depending on the agent and the method employed.

Physiology

Reduction in metabolism with lowering of entropy reduces the mechanical, chemical, and electrical energy of molecules. Understandably, intracellular and extracellular dynamics decreases as does that of membranes or end organs. Details of the specific physiologic reactions can be found in the noted references.[36,41] Physiologic reactions to cold are affected by the rate, extent, duration, and degrees of temperature reduction.

The reaction to lower temperature locally is immediate vasoconstriction and, if the temperature difference is significant (10° to 15° C lower), protein degradation or cryoglobulin precipitation. Reactive hyperemia may follow mild superficial application of cold. Systemic effects of hypothermia are directed toward conserving energy and later creating calories because this may elevate a lowered core temperature. The conservation mechanisms of the skin are vasoconstriction and reduced sweating. The cardiopulmonary mechanisms are bradycardia, hypocapnia, and hypotension.

The most notable energy-creating response to cold is shivering, which creates calories. The inability of infants to shiver contributes to their poor tolerance to hypothermia.

Increased fat metabolism occurs in the liver, the greatest heat generator in the core area. Fifty percent of basal oxygen consumption is in the viscera, and 25% of this is by the liver.[4] Eskimos have hepatomegaly and prefer high-fat diets. The subcutaneous fat acts as an insulator, and when it is absent or deficient as in infants, the elderly, or debilitated patients, the intolerance for hypothermia occurs.

Neuromuscular activity is modified by lowered action potentials and delayed motor conduction velocities. A 1° C drop in temperature reduces conduction velocity by 2.5 to 4 meters per second. Paresis or paralysis may occur when myoneural transmission is compromised at approximately 5° C.

In cold temperatures, muscle tension is increased, which may be due to increased spindle excitability, as well as lowered viscoelastic properties of the fibers. Analgesia occurs because of depressed activity in both end organ and fiber conduction. The cerebral reactions may include lethargy, narcosis, and depression of neurohumoral activities.

Transudation is decreased so that edema formation is reduced. This reaction to hypothermia is very effective in treating acute soft tissue and sport injuries.

The toxic effects of hypothermia or cryotherapy may be tissue death. Before this occurs, ventricular fibrillation and shock as a consequence of hypotension may develop.

When frostbite or severe hypothermia occurs, slow rewarming with systemic fluids, anticoagulants, and appropriate antibiotics is the appropriate procedure. Using temperatures slightly higher than skin or core temperature is recommended for rewarming.

Indications

Anti-inflammatory effect. The application of any object cooler than an inflamed area draws off calories and modifies the progress of the tissue reaction. This applies to acute reactions from trauma, physical agents, acute burns, or infections. Temperature can be lowered in an acute burn by the immediate application of ice and may reduce the degree of tissue damage.[43] Cold is effective for capsular and soft tissue inflammation.

Analgesic effect. Cooling with either vapor or ice reduces pain in soft tissue injuries. Patients can be instructed in icing technique for home programs.

Antipyretic effect. The antipyretic effect of cooling, using cooling mattresses or blankets or a cold tub bath, is often effective for refractory temperature elevation. Quadriplegic and paraplegic patients may have this problem, and cooling augments antibiotic and other medical measures. The failure of their autonomic mechanisms in the affected skin limits their conducting or radiating temperature capacity.

The technique of slow, gradual cooling is equivalent to that described by Simon Baruch in his *Epitome of Hydrotherapy*[2] 60 years ago for the treatment of sun (heat) stroke. He described it as the St. Vincent's Hospital treatment. The patient is covered with wet cool sheets. This is essentially what is currently recommended, with the addition of the supportive measures for possible circulatory failure.

Spasticity.[30,34] Lowering muscle temperature to 32° C affects the sensory motor pathways. Gamma fiber potentials, which initially may be increased by shivering, are slowed after 20 minutes of cooling. Neuromuscular transmission is also slowed and partially blocked.[8] When muscle temperature approaches 12° C, spasticity is reduced or eliminated for several hours.

Burns. The immediate application of ice may reduce the tissue damage in a burn.[43]

Contraindications

Ischemia, with inadequate transport of metabolites to and from tissue, may cause necrosis when cold is applied to areas with obliterative arterial or impaired venous circulation.

Anesthesia of an area may allow longer exposure to be tolerated, with resulting tissue damage.

Patients with vasculitis, dermatomyositis, systemic lupus erythematosus, diabetes, and Raynaud's phenomenon have both vascular and immunologic factors that affect cold sensitivity, thus contraindicating the use of cold.

The aged, infants, or cachectic individuals also tolerate cold poorly. Constitutional reactions with urticaria, purpura, and possibly collapse may occur.

Indolent wounds are compromised by the vasoconstrictive effect of cooling, and healing is further delayed.

Sources

Vapor-coolant or evaporation technique uses ethyl chloride or fluorimethane sprayed on the area to be treated. A modest frost, accomplished by holding the spray container approximately 1½ feet from the area for 15 to 20 seconds, is well tolerated. Repeating this two or three times at short intervals should produce analgesia. Stretching and deep tissue massage for relief of pain in trigger points can then be performed.

Ice packs, bags, or compresses can be applied to an area for 5 minutes or longer in acute sprains.[3] Repeating this at 10-minute intervals two or three times will often be effective.

Immersion of a limb in ice water may be tolerated for only 1 minute. If repeated with intervals similar to those noted for ice packs, it may be equally effective.

Cooling pads, or blankets attached to pumps of cooling liquid such as saline or alcohol, may be applied for several hours and are an effective means of lowering body temperature. This is used at times for spinal cord–injured patients.

Summary

The physiologic effects of superficial heat are subcutaneous vasodilation and elevation of metabolism in cellular and extracellular compartments. Deep heat may elevate muscle temperature. The analgesic, spasmolytic, anti-inflammatory, and soporific effects of heat are the major indications for its use.

Cold is anti-inflammatory, analgesic, antipyretic, and capable of reducing spasticity. It depresses physiologic activity by reducing the heart and respiratory rate and can lead to coma and death.

ULTRAVIOLET RADIATION[50]

Biophysics

Ultraviolet rays range from 180 to 400 nm. The range closest to the visual is identified as UVA (3600 to 4000 Å). Ultraviolet rays have properties similar to those of other electromagnetic waves but differ by having photons of greater energy. The quantum of energy of a photon is directly related to its frequency and is expressed by the equation E = hn or energy in ergs equals Planck's constant *h* (6.625×10^{-25} erg sec) times the frequency per second. The energy of the ultraviolet photon is therefore several times greater than that of visible light or infrared. Ultraviolet rays penetrate only to the capillary bed of the dermis and cause photochemical changes. Infrared effect is essentially molecular excitation or heat.

Ultraviolet energy varies with different wavelengths. The action spectra indicate the most efficient wavelength for specific biologic effects. These effects are accomplished by either direct or indirect reactions.

Direct reactions occur when the absorbing molecule, such as melanin, changes chemically or a photosensitizer is raised to a higher energy state capable of enhancing the activity of other compounds. Photosensitizers may be foods, drugs, or disease toxins. PUVA therapy (psoralen, a photosensitizer taken by mouth, followed by exposure to ultraviolet irradiation) is recommended for psoriasis.

The indirect effect is the transduction of light energy, such as visible light to photoreceptors in the retina. Neural signals in neuroendocrine pathways and neurotransmitters in the hypothalamus, spinal cord, pituitary, and pineal body can depress the synthesis and secretion of melatonin in the blood and cerebrospinal fluid. This results in elevation of hormonal activity in the pituitary,

ovaries, adrenal, and other endocrine glands and can produce estrus.

Physiology[15]

Penetration of ultraviolet rays is approximately 0.1 mm, varying with skin thickness and coloring. The absorbing substances in the skin are proteins or nucleic acid. The photochemical reactions may be erythema, tanning, epithelialization, bactericidal effects, vitamin D_3 synthesis, and neurohumoral effects.

Erythema is noted within several hours after exposure. It is due to direct or thermal effects on capillaries and the possible release of denatured proteins into the prickle layer of the skin. The action spectrum for erythema is 2500 Å to 2970 Å, and none is produced beyond 3300 Å. This response is used for dosage control. The minimal erythemal dose is the minimal time of exposure that gives the faintest reddening effect 4 hours later and clears in 24 hours.

Tanning is the increase of melanin granules in the prickle cell layer, which contains the keratinocytes. Within a few minutes after photo-oxidation, melanocytes divide and secrete melanosome bodies, which contain the melanin granules and deposit them in the keratinocyte layer. This is immediate tanning and reaches a maximum in 1 hour. Delayed tanning, which involves an increase in functioning melanocytes, occurs in 72 hours. Their number, size, and transfer to keratinocytes produce the delayed tanning. The action spectrum is between 3000 and 4400 Å. After 2 to 3 days the tan fades as the keratinocytes slough off. Tanning may provide some protection against later ultraviolet exposure.

Epithelialization or cornification results from accelerated cell division of the epidermis. With excessive exposure, this may progress to desquamation.

Bactericidal effects of ultraviolet rays occur in the 2600 Å range. The energy alters mitosis in some skin pathogens, causing lethal mutations. This effect can be beneficial in treating infected ulcers.

Vitamin D_3 (cholecalciferol) in the skin and subcutaneous tissue is formed when 7-dehydrocholesterol absorbs ultraviolet light. Wurtman[50] described the improved ability of an experimental group of men in a soldier's home to absorb calcium after daily ultraviolet irradiation. Using total body irradiation to modify osteomalacia is supported by other studies described in his article. Its use in geriatric practice should be encouraged.

The neurohumoral action of ultraviolet light is described above. The relationship of this action to the seasonal effects of sunlight on the reproduction cycle is but one example.

Toxic reactions

Burns result from overexposure to ultraviolet light, usually from wavelengths in the 3200 Å (ultraviolet B).

Sunburn may result from ignorance that ultraviolet rays can penetrate light overcast clouds and be reflected from sand, snow, or water. The action spectrum for sunburn is 2500 to 2790 Å. Common complications in addition to the burn are conjunctivitis and photophthalmia. The sensitivity of the conjunctiva and retina to natural and artificial ultraviolet requires eye shields or protective goggles.

It is better to prevent sunburn than to treat it. The application of a sunscreen that filters ultraviolet A reduces the likelihood of burn.

Ultraviolet A (3900 to 3200 Å) tans; ultraviolet B (3200 to 2900 Å) burns. After para-aminobenzoic acid (PABA) is applied topically before exposure, ultraviolet B is essentially blocked. Some broad-spectrum screens additionally contain oxybenzene, which blocks ultraviolet A.

Prolonged or excessive exposure can age skin or cause skin cancer.

Special protection should be exercised for exposure of the eyes, lips, and nipples. The length of time one can tolerate sunlight depends on one's native skin tolerance. Sensitivity, general health, age, medications, and nutrition also affect tolerance. The latitude, time of year, time of day, and weather should be considered, since each affects the ultraviolet radiation intensity.

Dry skin, as occurs after frequent exposure to sunlight and excessive washing, should also be recognized as a possible cause of greater reactions to sunlight. Photosensitizers to ultraviolet light are listed in the box on p. 780.

The effects of overexposure or sensitivity to ultraviolet light are as follows:

1. Pain
2. Edema
3. Bulla formation
4. Fever, chills, weakness
5. Conjunctivitis and photophthalmia
6. Desquamation
7. Infection
8. Shock, possible death
9. Cancer; wavelengths between 2800 and 3400 Å are carcinogenic, particularly with chronic exposure

Sources

The artificial sources of ultraviolet light are carbon or mercury arc lamps where electrons from carbon electrodes or a tungsten cathode ionize gases (argon, krypton, neon, or mercury vapor). These emit wavelengths that have a high concentration in the ultraviolet range. They are either under low pressure (cold quartz) where the electron temperature is higher than the mercury vapor temperature or high pressure (hot quartz) where these are equal.

The envelope may be quartz, fused quartz, high silicate, or calcium phosphate glass. Some are coated with phosphors (tungstates, silicates, borates, or phosphates of magnesium, calcium, cadmium, or zinc). These phosphors fluoresce and reemit ultraviolet wavelengths of broader bands including visible rays. A reflector directs and concentrates the rays.

PHOTOSENSITIZERS OF ULTRAVIOLET LIGHT

I. Diseases
  A. Endocrine
    1. Insulin
    2. Thyroxine
    3. Adrenalin
    4. Pituitrin
  B. Metabolic
    1. Pellagra
    2. Erythropoietic protoporphyria
    3. Porphyria
  C. Vasculitis
    1. Scleroderma
    2. Lupus—systemic, discoid
    3. Polyarteritis nodosa
    4. Polyvinyl chloride
II. Infections
  A. Herpes
  B. Tuberculosis
III. Cardiorenal failure
IV. Dermatologic diseases
  A. Eczema
  B. Urticaria solaris
  C. Hereditary xeroderma
  D. Vitiligo, albinism
  E. Epidermolysis bullosa
V. Drugs
  A. Eosin
  B. Perfumes
  C. Green soap
  D. Coal tar
  E. Antibiotics
    1. Tetracyclines
    2. Riboflavin, griseofulvin, nalidixic acid
    3. Methotrexate
    4. Quinine
    5. Phenylbutazone
  F. Phenothiazines
    1. Chlorpromazine, prochlorperazine (Compazine), trifluoperazine (Stelazine), chlordiazepoxide (Librium)
    2. Barbiturates
    3. Heavy metals: gold, mercury, iron, bismuth
    4. Phenothiazines
    5. Chlorthiazides (Hydrodiuril)
    6. Estrogens and progesterones, cyclamates)
    7. Sulfonylurea (Orinase, Diabinese)

High-pressure hot quartz lamps have a broad spectrum and produce bactericidal effects (2537 Å), erythema (2500 to 2970 Å), or pigmentation (3400 Å). A cooling jacket of circulating air or water (Kromayer lamps) permits close approximation of the lamp to the skin.

Ninety percent of the radiation from cold quartz mercury lamps has a wavelength of 2537 Å (bactericidal). These are used when air sterilization is desired. A sodium barium silicate with nickel oxide glass (Wood's filter), with a low-pressure cold quartz lamp, transmits rays of 3700 to 3800 Å. This causes hair infected with tinea capitis to fluoresce a bright green. Hair with pediculosis capitis or pubis similarly fluoresces.

Professional models are large, gas-filled tubes. They cover greater areas and are used for general irradiation. Narrow tubes, straight or wound into coils, are available for orificial or sinus tract irradiation.

Sunlamps are silica glass tubes coated with phosphors. They are usually several bulbs in a reflector and are available for home or solarium use. They produce a spectrum of 2800 to 3500 Å and cause erythema and mild pigmentation. The use of such lamps without eye protection has caused severe eye problems. These episodes have occurred in commercial tanning facilities where appropriate precautions were not exercised.

Indications

The application of ultraviolet therapy is for bactericidal effect, enhancing calcium metabolism, or treating psoriasis or neonatal jaundice.

Bactericidal effect

Using ultraviolet irradiation adjunctively for routine wound care often helps resolve refractory or indolent wounds, such as decubiti or varicose ulcers. After the areas are cleansed with saline or a medicated whirlpool, local ultraviolet irradiation is applied four or five times daily to reduce bacterial infection and encourage epithelialization. As epithelium develops at the edges of the wound area, the time and frequency of the exposure are reduced. A shield around the edges of the wound to avoid burning the developing epithelium is necessary.

Enhancement of calcium metabolism

The beneficial effects of ultraviolet irradiation on calcium and vitamin D metabolism suggest that general body irradiation in elderly infirm patients should be considered. It is a relatively inexpensive technique and may reduce the problems of osteopenia.

Treatment of psoriasis and icterus neonatorum

Parrish and co-workers[37] described the use of PUVA: a photosensitizer (8-methoxypsoralen) followed 2 hours later by 10-minute exposure to ultraviolet light (3650 Å). After several exposures the psoralen as a photosensitizer enhances

lymphocyte chromosomal abnormalities and epidermal reactions such that the skin lesions are cleared. It is more acceptable than the previously employed coal tar ultraviolet treatment.[19]

A modification of this technique employs sunlight filtered through 0.005-inch mylar plastic. Patients are exposed for 3 hours, from 11 AM to 2 PM, 2 days a week. Two to 3 hours before exposure the patient is given 40 mg of 8-methoxypsoralen. Bruce and Walters[5] reported that 22 of 23 patients with histories of the disease for 10 to 24 years had complete clearing of their lesions.

Bilirubin can be bleached and destroyed by ultraviolet light.[9] The mechanism is complex. It is possibly an intermediate reaction of photosensitization of circulating riboflavin to enhance albumin binding the bilirubin. Neonatal hyperbilirubinemia is significantly modified by exposing affected infants to ultraviolet light.

Contraindications

The toxic photosensitizing effects of food, diseases, or drugs are the contraindications for using ultraviolet irradiation.

Prescription

Dosage initially requires establishing the minimal erythemal dose (MED). The MED is usually 15 seconds for a standard high-pressure mercury arc quartz burner. An exposure, usually on the volar surface of the forearm, produces a mild erythema or first-degree erythema after 2 hours. The erythema disappears in 24 hours.

Dosages are in multiples of the MED and are written as, for example, 3 MED or 4 MED. Treatment is usually on alternate days so any concomitant erythema may subside.

Summary

Ultraviolet light produces photochemical reactions in and on the skin. In rehabilitation medicine it is employed for bactericidal and vitamin D_3 production. Its employment in treating psoriasis and hyperbilirubinemia of infancy suggest possibilities for a greater application in clinical medicine using specific photosensitizers.

ELECTROTHERAPY

At present the clinical applications of electrotherapy are for motor disturbances, pain, pacemakers, functional electrical stimulation, biofeedback, electrophoresis or phonophoresis, and diagnosis.

Motor disturbances[46]

Denervated muscle demonstrates histologic changes analogous to atrophy of disuse. These include decrease in fiber diameter, proliferation of sarcolemmal nuclei, loss of striation patterns (late in atrophy), thickening of intramuscular arteries, and venous stasis. Later there is increase in connective tissue and finally, after several years, dissolution of muscle fibers, with residual fat, blood vessel, and connective tissue replacement into the area.

If reinnervation occurs within the first year, a fairly good functional recovery may be achieved. If the atrophy can be retarded, the degree of recovery may be increased.

Medical and surgical management of peripheral neuropathies has improved the prognosis for many patients with lesions previously considered incapable of recovery.

The inclusion of a program of electrical stimulation can enhance recovery and reduce the changes described. Ten to 15 isometric contractions in the muscle under slight tension, using a current delivering 1000 to 2000 cycles/sec and repeating these three or four times daily, 5 days a week, is recommended. Denervated muscles respond to frequencies of 10 to 30 cycles/sec or an interrupted galvanic (DC) current. The treatment is similar for innervated muscles.

Home stimulators are available, and self-treatments should be encouraged, since such programs may extend for many months. However, the benefits of these programs over longer periods is questionable. As a maintenance measure, with its concomitant circulatory and tensing benefit on residual muscle fibers and their attachments, electrotherapy's benefit is still to be proved.

Pain control

Percutaneous high-frequency currents have been used to relieve pain for many years. Applying currents up to 80 milliamperes at frequencies of 80 to 180 Hz over painful areas, dermatomes, or distal sites may suppress pain. Fifteen to 30 minutes of application may be effective for 24 hours of pain suppression.

Melzack and Wall's description of the gate theory with these currents shutting the gate was initially proposed as an explanation.[32,48] Now we are trying to relate the effect on suppression of inflammatory effectors such as the prostaglandins. Another possibility is the effect on neuroendocrines such as enkephalin and endorphins. No comprehensive explanation has been forthcoming. These devices are applied at times for 24 hours. Excoriation of the skin, as well as habituation similar to that observed with narcotics, may occur.

The effectiveness of electrotherapy varies. Success has been claimed in a wide variety of syndromes, but hard data supporting its effectiveness are not yet forthcoming. The technique is no more successful than any other effort, either in acute or chronic pain situations. The decision to use it should be carefully considered, and the patient would probably best be served if it were not prescribed at all.

Artificial pacemakers

Stimulating the phrenic nerve[40] as a respiratory aid and stimulating the bladder detrusor for micturition or anal sphincter for incontinence control have been successful.

These techniques are limited by the tissue tolerance for the electrodes and the problems of power source.

Functional electrical stimulation[21]

Functional electrical stimulation is the stimulation of paralyzed muscles to produce muscular contraction or useful movement. Initially it was employed on paralyzed patients with the objective of restoring lost movement using surface electrodes on leg muscles of patients with hemiplegia and footdrop. This was offered as an alternative to the use of orthoses. At present a multichannel electric stimulation device to mobilize paraplegics is being evaluated.[24] The technique also has been attempted in multiple sclerosis, in cerebral palsy, and for hand functions in selected patients.

The application of functional electrical stimulation requires a trained staff and prolonged training of patients. Adequate maintenance service is required when necessary. These requirements limit application to patients who have the necessary medical and technical services available. The limited tolerance of the skin to the repeated local chemical actions at the electrode site remains a limiting factor. A detailed description of the technique is to be found in the noted reference.[21]

Biofeedback

Biofeedback[25,42] is the training technique that attempts to modify autonomic functions, pain, and motor disturbances by acquired volitional control. It is a form of behavior modification. Using monitors that demonstrate electrical activity on a screen or with audioamplification may help a patient acquire the ability to lower blood pressure; slow pulse rate, respiration, and spasticity; recover or control motor functions; or eliminate pain. Many patients cannot succeed in these efforts. Furthermore, some of these functions are beyond conscious control and limit the use of this technique.

Coupling a patient to an electromyograph so that the sight and sound of action potentials are presented, and using these stimuli to restore conscious control of motor function, is reinforcement or muscle reeducation. When used in treating hysteric paralysis or selected cases of paresis for varied neuromuscular-musculoskeletal disorders, it may enhance recovery.

The staff, equipment, and time required to provide this training restrict it to programs where staff and time are available.

Iontophoresis

Iontophoresis drives molecules into the skin by ion transfer with direct current. The necessity, effectiveness, or value of this technique is limited by the drug's chemical characteristics, ionic charge, and penetrability through the skin. The recent development of drug patches for absorbing medications limits these techniques. Harris' description and critique is recommended to the interested reader.[23]

MASSAGE[11,16]

When intelligently applied, massage is an effective modality for relieving pain or reducing swelling or muscle tightness. It is most frequently employed for soft tissue injuries.

Technique

The manual movements in massage include stroking (effleurage), compression and pretrissage, and percussion (tapotement rhythmically striking the underlying tissue). These movements can be augmented with machines attached to the hand or by machines alone. The pressure and force applied can be varied and should be guided by the diagnosis and tolerances of the patient and the part being massaged.

Physiologic effects[49]

Hyperemia from the frictional effects on the skin is the most notable physiologic effect of massage. An analgesic effect may be related to hypotensive effect of the skin hyperemia.

Pressure on intravascular and extravascular compartments may produce an increased rate of fluid movement. Whether kneading or deep pressure breaks up fibrositic nodules is questionable. Light stroking or fingertip massage over muscle tendon or ligament is often effective in relieving pain and permits subsequent stretching to a greater extent.

The relaxing, soporific effects of massage are widely recognized. This may be an effective means of relieving muscle spasm, tightness, or "tension." The explanation of this effect remains empiric, since such reactions are not universal. Cost containment often forces us to use tranquilizers, relaxants, soporifics, analgesics, or antiinflammatory drugs where massage might be as effective.

Indications

Soft tissue injuries with pain, stiffness, spasm, and muscle tension are the usual disorders for which massage is ordered. Articular pain, with or without swelling, can also be helped, as can arterial or venous insufficiency. Scars may be loosened. Massage after exercise, stretching, or vigorous activities is often beneficial in relieving pain and stiffness.

Contraindications

Patients with infection, hemorrhagic or clotting disorders, or inflammatory disease of muscle should not receive massage.

MANIPULATION[33]

Manipulation is stretching of periarticular tissues bimanually along the anatomic axis of a muscle or across a joint. It differs from stretching and traction in that it is a brief

application of a distracting force with sharp pressure above and below the region treated. Prior application of heat, massage, and rest increases its effectiveness.

The benefit of manipulation in refractory problems of neck and back pain cannot be discounted. When correctly employed on properly selected and prepared patients, the procedure often is very effective.

STRETCHING AND TRACTION[10,28]

Stretching and traction produce a lengthening of periarticular soft tissues, tendons, or muscles by manual or mechanical means. Application in chronic problems where motion is incomplete is the only effective measure, other than surgery, that may restore full arcs of motion. Dynamic splinting of selective areas such as tight finger flexors is often effective as a stretching technique.

The contraindications are acute inflammation, painful sprains or strains, fracture, or other acute painful musculoskeletal, articular, vascular, or skin diseases.

The technique of stretching is the application of a stretching movement, using the patient's body mass as a counterforce. Knowledge of the anatomy of the tight structure, be it muscle, tendon, or joint capsule, defines the desired direction of the forces. Thermotherapy, massage, an analgesic, or anti-inflammatory medication before traction enhance its effectiveness and increase the extent and patient tolerance of the procedure.

Preparation of the patient for traction is similar to that for stretching. A counterforce of up to 50 pounds applied to the neck, or 75 to 100 pounds to the pelvis, is used to stretch periarticular soft tissue.

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Detailed descriptions of the techniques and applications of each of the modalities discussed can be found in available manuals. Referral to registered physical and occupational therapists is recommended, since their skill and training ensure optimal and efficient care. Their role as instructor and supervisor of assistants, aides, family, and patient is invaluable and can save time and reduce costs.[14]

DIAGNOSTIC TESTS

The monitoring of energy transduction requires a sensor that can demonstrate the energy on a visual record or meter. The energy may be from the body's surface as in thermography or dermohmetry or fluorescence as in the ultraviolet effect on the lesions of ringworm, or after injection of a fluorescent material in a limb with circulatory impairment.

Imposing an energy such as ultrasound onto the body provides a technique for sonography where the varying densities of the tissue transmit differently to a sensor that converts these variations to visual records.

Applying heat or cold can affect blood pressure, change action potentials as in myasthenia gravis, or alter neurologic signs as in multiple sclerosis.

Reactions of nerve and muscle to electrical stimuli of varying strength and duration can be used to establish the strength/duration curve with the chronaxie rheobase values.

Thermography

A thermograph scans the skin and records on film the emitted infrared radiation intensities. The details of the technique are described by Barnes.[1]

The merit of thermography is its safety: the patient is not exposed to any ionizing radiation or invasive component. The ability to visualize vascular and inflammatory reactions not otherwise easily assessed or scaled is another merit of this test. An obliterative lesion can be easily identified without any contrast media required, and repeating the study after therapy can provide a record of results.

Infrared photography is a simpler, less expensive technique that monitors energy at shorter wavelengths.

Dermohmetry[29]

Dermohmetry is an electrical test of skin resistance. The conductivity of the skin is reflected by a change in current flow that occurs with any disorder of autonomic controls. Direct current with constant voltage increases or decreases with a change in skin resistance. When a meter is calibrated for measurement in ohms, dry cold skin averages 1 megohm and moist, warm skin is in the range of 1 to 2000 ohms. The data from the affected area is compared with data from unaffected areas. Dermohmetry is easy to perform, and the equipment is not expensive. Disease, such as peripheral neuropathy, that produces vasomotor change results in elevated skin resistance.

Skin resistance should be lowered by warming and wetting before electrotherapy or testing. The least amperage is then required and discomfort is reduced.

Fluorescence

The employment of the fluorescent effect of ultraviolet through Wood's filter in the diagnosis of ringworm is described above.

The use of intravenous injection of fluorescent dye in diagnosis of vascular disease has been replaced by arteriography and venography. However, its low incidence of local or systemic reactions makes it a method of choice in selected situations.

Temperature changes

Heat

Raising body temperature in a patient with neuromuscular disease alters axonal and end-plate activity. Multiple sclerosis[39] patients have a notable sensitivity to heat and this is used as a provocative test; the patient exposed to heat frequently develops signs such as nystagmus, increased reflexes, or sensory losses that otherwise were not noted.

These reactions are not exclusive to patients with demyelinating disease and are often described by patients with other nervous system disorders.

Cold

The repetitive stimulation test in myasthenia gravis elicits a decrement of the action potentials after the third to fifth stimulus. The potentials are restored by cooling the muscle and are decreased with warming, suggesting that quanta of transmitter substance may be stored with cooling[13] or degradation enhanced with the heat of contraction activity.

Low volt testing[18,31]

Low volt testing records the strength and duration of stimuli that elicit a minimal twitch of a muscle. The stimuli are applied either to the nerve or, in denervation, to the muscle belly.

Recording the values on a graph provides a curve for each with their different values. The details of the method of performing the test are described by Goodgold and Eberstein.[20] The test is somewhat uncomfortable but is relatively simple to perform, readily reproduceable, and noninvasive. It has largely been replaced by electromyographic studies, but there are occasions when it may be employed. When used in the third or fourth week after onset of paralysis, this technique may provide adequate data in pediatric patients with facial palsy and does not require needle insertions.

PRESCRIPTION WRITING

Goals

In all plans for therapy the hierarchy of goals is (1) palliation, (2) prevention, and (3) correction. These goals are equally applicable in medicine, surgery, psychiatry, and physiatry. They are evident when therapy is being prescribed. Often physical therapy precedes the other rehabilitation modalities in any prescription.

The initial goal in any therapeutic endeavor is to palliate. For example, a prescription for physical therapy for postdislocation capsulitis of the right shoulder would read as follows:

Diagnosis: Post dislocation capsulitis (R) shoulder
℞: 1. Thermotherapy 20 min. (R) shoulder
2. Gentle passive stretching (R) shoulder
3. Active assistive exercise (pulley)
4. Instruct patient in home program.
3 × wkly 2 wks, 2 × wkly 3 wks

This example reflects the role of thermotherapy as a palliative measure before the passive stretching and active exercises. Also, the importance of instructing the patient and family in the home program is reflected in this prescription.

The first order in this prescription was deliberately written "Thermotherapy." This allows for either heat or cold to be applied, and heat may be radiant (infrared), diathermy, ultrasound, moist packs, or other heating agents. Where specific agents are necessary, they should be spelled out. This might then be written "Ultrasound 10 min. 1.5 watts/cm. sq." or "I.R. at 30 inches for 20 min."

As another example, the following prescription might be written for a patient with radial palsy and wristdrop:

Diagnosis: Radial palsy (post compression), wristdrop
℞: (1) Moist packs 10 min. forearm (R)
(2) D.C. stimulation to wrist/finger extensors 15 min.
(3) Passive stretch shoulder, elbow, wrist/finger joints
(4) Cock-up splint
(5) Shoulder arm sling
(6) Instruct in (a) home low volt stim technique
(b) stretching
(7) Instruct in A.D.L.—writing
Daily 1 wk, 2 × wkly 2 wks, 1 × wkly 2 wks

The objective of cost containment can be met only when the patient or family is trained to assume responsibility for the daily treatments they can perform.

In this prescription "moist heat" is employed both for palliative purposes and for reduction of skin resistance before application of electrical stimulation to artificially mobilize the paretic muscles. The exercises here are made possible by use of the electrical stimulation. Stretching, splints, sling, and activities of daily living instructions follow the initial palliative and preventive objectives to reduce atrophy, paresis, and contractures.

Diagnosis: S/P below knee amputation (R)
Etiology: Diabetes mellitus, peripheral arterial thrombosis—gangrene. Flexion contracture stump.
℞: 1. Radiant heat 30″ 15 min. (R) knee
2. Gentle passive stretch hamstring
3. Strengthening exercises quadriceps
4. Instruct patient in quad setting exercises
5. Splint to knee to maintain extension range
6. Crutch walking 20 ft
Daily 1 wk, 3× weekly 2 wks, 2× wkly 3 wks
Caution: Observe skin for any thermal reaction i.e., erythema, blistering. [In all prescriptions, cautions must be noted particularly where anesthetic areas or arterial insufficiency exists. Here the arterial insufficiency and possible hypalgesia of the skin could cause a burn, but this is unlikely to happen because the area being heated can be observed and appropriate reduction of time of exposure made. Were a hot pack employed, this visual monitoring would be denied the therapist.]

All three examples demonstrate the therapeutic goals of palliation, prevention, and correction. They include the application of the modality heat as a palliative or as a means to increase the extensibility of inelastic collagen in tendon or capsule.

The electrical stimulation of paretic muscles retards muscle atrophy and also acts to maintain some kinesthetic sense.

Therefore this is used as a preventive measure.

Correction in the three examples is achieved by exercises and training in self-care. Modalities do not correct any disorder, but stretching, exercises, functional training, and use of appliances or apparatus may correct or substitute for any physical or functional deficiencies imposed by the disorder or physiologic impairment.

The most challenging problem to physicians is that of chronic pain. Acute pain can be dealt with quite effectively by any practitioner, but chronic disabling pain requires the involvement of a team that includes the physiatrist. Modalities such as heat, cold, transcutaneous electrical nerve stimulation, massage, stretching, and exercises are all employed individually or in combination with medications and possibly surgery and counseling. This is described in more detail in Chapter 37.

PRECAUTIONS

The following precautions should be taken before any therapy:

1. Diagnosis. Pathology, age, nutrition, and physiologic problems of cardiopulmonary sensory systems should all be identified and considered when determining the duration, frequency, and number of treatment sessions. Anaesthesia is not a contraindication but requires a careful monitoring.
2. Comprehension. The patient must demonstrate understanding of what the treatment involves and how to signal if discomfort develops.
3. Equipment. All wires, heating elements, bulbs, switches, dials, and timers must be in working state and in the off or zero position when treatment is started and ended. Apparatus should be unplugged when not in use. Only Underwriter's Laboratory approved equipment should be used.

The following general rules apply when ordering physical therapy:

1. Do not use physical therapy if medication, surgery, or psychiatry is more effective.
2. Select the simplest, safest, least complicated modality, requiring the minimal involvement of personnel.
3. Use a device that allows easy observation of the treated part.
4. Use home therapy whenever possible.
5. Have specific goals.
6. Limit the number of treatments, and if no benefits are noted, consider these measures.
   a. Repeating the series
   b. Reviewing the procedure to ensure that it conforms to your order
   c. Changing the dosage or frequency (two or three times daily, 5 or more days a week)
   d. Discontinuing the treatment

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