CHAPTER 38

Thermal and Electrical Agents Used to Manage Arthritis Symptoms

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Physical agents of heat, cold, and electricity are often used to alleviate the symptoms of rheumatic disease. Although no agent is capable of curing arthritis, amelioration of symptoms may lead to improved function. Overall function depends on freedom from impairments, such as weakness, limitation of motion, and pain. Specific treatment goals may include decreasing pain, increasing flexibility, and decreasing swelling. Heat, cold, and electrical stimulation are often used to produce improvement in these impairments in the interest of improving function.

SUPERFICIAL AND DEEP HEAT

Superficial- and deep-heat treatments are used primarily to decrease pain and improve flexibility. Heat contributes to pain relief by increasing the pain threshold, increasing blood flow (1), and washing out pain-producing metabolites. Heat also decreases muscle guarding through its effects on the muscle spindle and Golgi tendon organs (2). It may improve flexibility by reducing pain or by increasing the extensibility of connective tissue (3). The use of heat allows collagen to deform more readily, leading to increased range of motion, especially when combined with low-load, prolonged stretching (4).

Application of Superficial Heat

Superficial heat can be applied by using hot packs, paraffin wax baths, Fluidotherapy (a bath of small solid particles suspended in a stream of warmed air), infrared radiation (heat lamps), or hydrotherapy. Recently, chemical heat wraps that become warm when exposed to the air have come on the market. These continuous low-level heat wraps warm to 104°F in about 30 minutes and stay warm for at least 8 hours (5). Heat-retaining sleeves that reflect the infrared radiation emitted by the body have also been tested (6). Regardless of the source, superficial heat is in the infrared portion of the electromagnetic spectrum. Although it penetrates the skin only a few millimeters, superficial heat application increases skin and core temperature (1). With the exception of the continuous low-level heat wraps and heat-retaining sleeves, superficial heat should be applied for about 20 minutes to elevate skin temperature and activate optimal heat loss responses by the body. Physiologic effects occur through these reflex vascular and neural responses. Superficial heat can be used as needed up to twice daily.

Superficial heat is among the most commonly used methods of self-management by people with osteoarthritis (OA) and rheumatoid arthritis (RA) (7). It is convenient and safe for home use if patients have received proper instruction. Instructions should include the purpose of the treatment; the method of application; the duration, intensity, and frequency of the application; precautions for use; and a telephone number for the patient to contact a professional practitioner with questions and concerns. The practitioner should demonstrate the treatment and watch the patient perform it to ensure proper administration of the procedure.

Application of Deep Heat

Deep heat is provided through short-wave diathermy and ultrasound. Like superficial heat, deep heating elevates temperature, but it reaches deeper tissues, such as muscle and connective tissue. Deep heat is generally used 2–3 times per week. Short-wave diathermy is usually applied for 20 minutes to fairly large areas of the body. Ultrasound, on the other hand, may be focused on very small areas and is applied for shorter periods of time (5–10 minutes) (8). The heat from short-wave diathermy and ultrasound is produced by conversion of electrical or sound energy into heat energy below the level of the skin heat receptors. Consequently, people perceive the warmth from deep-heat sources to be much milder. Deep heat should be used under the supervision of a physical therapist. Sources for providing deep heat usually are not portable, and they are too expensive and hazardous for home use.

Contraindications and Precautions

Because of the mechanisms of heat production and the milder but deceptive heat perception, deep-heat sources can be hazardous. With short-wave diathermy, any condition that concentrates the electric field, such as metal and perspiration, can produce a burn. Ultrasound, if focused too long at a particular site, can also produce burning. Heat applications to large areas of the body, producing systemic heat loss responses, are contraindicated for people with conditions that prevent adequate thermoregulatory responses (such as cardiac insufficiency or impaired peripheral circulation). They are also contraindicated in conditions that could be aggravated or spread, such as swelling, fever, infection, hemorrhage, or malignancy (2). Short-wave diathermy is contraindicated for any patient with a pacemaker or electromedical (internal defibrillators). Local heat applications to small may be safely used in stable cardiac conditions or when applied to areas of the body at a distance from areas of swelling, infection, hemorrhage, or malignancy. Because the amount of heat applied depends on the patient's perception, it should not be applied with people who have impaired sensation or impaired judgment or cognition.

In addition to these contraindications and precautions, there are special precautions associated with the use of heat in persons with acute, inflammatory arthritis. Heat may increase inflammation, thus increasing swelling of the synovial membrane (9). Increasing the intraarticular temperature could damage joint surfaces due to increased activity of collagenolytic enzymes (10). Both joint and skin temperature elevate following superficial heating, especially with the treatment times used in clinical practice (20 minutes) (11,12). Short-wave diathermy also heats the interior of the joint along with the skin, although not as much as superficial heat (12). There is no clinical evidence that heat affects long-term progression of RA as evidenced by elevations in erythrocyte sedimentation rate (13), white blood cell count and phagocytosis (14), or radiography (15); nonetheless, the use of heat in people with acute inflammatory arthritis is best avoided. People with RA often have

Use of Thermal and Electrical Agents

- Superficial heat treatments are safe and inexpensive; patients who feel better or are more active following heat treatments may be encouraged to use them.
- Deep-heat treatments can be hazardous and are expensive; when exercise or superficial heat can accomplish the same goals, there is little rationale for using deep heat.
- Cold treatments are effective in improving range of motion, pain, function, and swelling.
- Transcutaneous electrical nerve stimulation is safe and useful for decreasing pain and stiffness.
- Education by a knowledgeable professional is crucial for correct and safe application.

unstable vascular reactions following exposure to heat. Vasodilation may occur more slowly, causing them to retain heat (16). People with vasculitis associated with RA also may have impaired vasomotor heat-loss responses (17). Therefore, people with RA should be monitored carefully for susceptibility to heat stress when heat is used in their management.

Effectiveness

Some investigators have shown that superficial heat can decrease pain and increase range of motion for patients with RA (18–22) and OA (5,23), but others have found that superficial heat is not effective (10,13,24,25). The new continuous low-level heat wraps have been shown to be effective for pain relief (5,23), improvement in range of motion, and reduced disability in patients with OA as compared with placebo and with nonsteroidal antiinflammatory medications (23). When superficial heat combined with exercise is compared with exercise alone, heat produces no greater effect than that produced by the exercises alone (26,27), except in grip function (18). A systematic review of 7 randomized, controlled trials recently concluded that there are no positive or detrimental effects of superficial heat therapy for patients with RA and recommended that heat can be used in palliative care (28).

Many patients report global improvement following superficial heat treatments, despite lack of clinical evidence for improvement (20). People with RA find heat to be among the most effective means of self-management (7). If the appropriate contraindications or precautions are observed, patients who feel better or are more inclined to be active following heat treatments may be encouraged to use them. There is little danger or cost associated with superficial heat, and no apparent negative effects.

Deep heat appears to be capable of decreasing pain in patients with OA (29) and RA (30); it also has been found to decrease stiffness and increase grip strength, especially in younger patients and those with less severe RA (30). Repeated applications of short-wave diathermy (30 20-minute sessions) have recently been shown to reduce synovial sac thickness and pain in patients with knee OA, an indication of reduced chronic synovial inflammation (31). Repeated applications of continuous and pulsed ultrasound have been shown recently to enhance the effect of isokinetic exercise (32). Three groups of patients with knee OA received exercises 3 times a week for 8 weeks, with one group also receiving pulsed ultrasound and one group also receiving continuous ultrasound. All groups experienced improvement in pain, disability, and peak torque production, but both ultrasound groups achieved increased range of motion and ambulation speed as well. The group that received pulsed ultrasound experienced greater improvements in pain, range of motion, ambulation speed, disability, and torque production at 180°/second than those who received continuous ultrasound. The improvements were retained for the 1-year followup period.

Other investigators have found that deep heat is not effective for patients with OA or RA (33,34), and when combined with exercises, deep heat appears to be no more effective than exercise alone (24,29,35,36). In one study, the only people whose symptoms worsened were those who received short-wave diathermy (29).

Ultrasound is often used for patients with soft-tissue inflammatory conditions, such as tendinitis, bursitis, or epicondylitis. Investigators have shown that ultrasound reduces pain and pressure sensitivity in patients with a variety of periarticular inflammatory conditions (37–39) and contributes to increased range of motion (40). Successful treatment is not universal, however, as other investigators have found no evidence for effectiveness (33,34,41–43). Use of ultrasound in the management of calcific bursitis has been of particular interest. Improvements in pain and function, as well as resolution of calcium deposits, have been demonstrated with ultrasound treatment (44–47), with deposits in the resorptive stage decreasing more than those in the formative stage (48).

Patients who received deep-heat treatment have been shown to perceive a more satisfactory outcome than those who received placebo treatments, even when they have persistent disability (30). However, deep heat must be applied in a clinical setting. Such treatments are expensive and may be hazardous. When exercise or superficial heat can accomplish the same goals, there is little rationale for using deep heat.

There have been 3 recent systematic reviews of randomized controlled trials investigating the use of ultrasound in patients with OA of the knee or RA. Casimiro and colleagues (49) concluded that ultrasound might be useful in increasing grip strength for patients with RA, but noted the poor quality of the 2 trials they located. Similarly, based on a single trial, the Philadelphia Panel (50) concluded that there is insufficient evidence to recommend inclusion or exclusion of ultrasound in the management of OA of the knee. Welch and colleagues (51) reviewed 3 trials (not including a trial by Huang and colleagues [32]) and concluded that there was no evidence of benefit of ultrasound for OA of the knee.

COLD

The primary reasons for using cold applications are to decrease pain, swelling, and inflammation. Pain is decreased by slowing or blocking nerve conduction, decreasing activity of the muscle spindle (2), or releasing endorphins (19). Swelling is decreased through vasoconstriction, which decreases blood flow and capillary pressure. Gentle cooling also blocks histamine release, decreasing inflammation. The intraarticular temperature decreases as skin temperature decreases (12), perhaps reducing collagenolytic enzyme activity and inflammation in the joint.

Application

Cold is applied to the skin through ice or cold packs, ice massage, cold baths, or vapocoolant sprays. It usually is applied for 10–30 minutes, depending on the intensity of the cold source and the depth of the tissue to be reached. Deeper tissues require longer treatment times. Milder cold sources are more appropriate for swelling; very cold sources, capable of producing skin anesthesia, are more appropriate for pain reduction. Care should be taken not to frost the skin. Cold treatments can be used at home with proper instruction. Ice packs, ice massage, and cold baths can be used as needed up to twice daily.

Contraindications and Precautions

Patients who do not have sufficient vasoconstriction capabilities to conserve heat should not use cold treatments. In addition, because cold causes vasoconstriction, its use may delay healing.

Several precautions must be taken when using cold treatments. Cold produces stiffness in connective tissues in laboratory studies (3), but the stiffness does not necessarily manifest clinically in decreased range of motion. Nonetheless, caution must be exercised to move cooled joints more slowly. Force generation also may be affected by cold treatments. After using a cold treatment that is sufficient to cool the motor neurons and block nerve conduction, entire motor units may temporarily cease to function, with resulting weakness.

Some people are hypersensitive to cold; others actually exhibit cold allergy manifested as urticaria. People with RA have been shown to experience increased pain with cold exposure (52), especially if they smoke (53). Patients with RA have more vasomotor instability and get colder and stiffer in response to cold exposure. They also have been shown to cool and rewarm more slowly (16). Raynaud's phenomenon, a condition aggravated by cold exposure, is associated with a history of joint pain (54) and systemic sclerosis (55).

Effectiveness

Cold treatments can be effective in decreasing pain, improving function, and decreasing stiffness (19,20,56). The effect of cold on swelling in patients with arthritis has not been extensively studied. Repeated treatments with cold packs have been effective in reducing swelling in knee OA (27). One small-sample study showed that postsurgical hand volume and pain decreased, but not significantly, following cold treatments (57). A larger study demonstrated that ice massage to acupuncture points for 20 minutes produced significant improvement in pain, stiffness, walking time, and muscle strength of patients with OA of the knee when compared with placebo, although the change in walking time and range of motion was small (58). A systematic review of 3 randomized, controlled trials recently concluded that ice massage is effective in improving range of motion, pain, and function in knee OA, while cold packs are effective in reducing swelling but are ineffective for reducing pain (59).

Heat and cold appear to be about equally effective for managing pain, stiffness, and limitation of motion (19,20). Cold has been shown to produce earlier decreases in pain and stiffness than short-wave diathermy or placebo treatments (56). Heat appears to be better for improving motion, whereas cold may be better for reducing pain (20). Patients often have no clear preference for heat or cold (19,21), although in some cases, patients continue to prefer heat even when cold has yielded greater improvement (20).

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

Treatment with transcutaneous electrical nerve stimulation (TENS) may decrease pain and inflammation. Stiffness may decrease as well (60,61). The use of TENS was originally based on the gate control theory of pain advanced by Melzack and Wall (62). Stimulation of the large sensory fibers is thought to prevent impulses from the smaller pain fibers from being transmitted in the ascending tracks in the spinal cord. Theoretically, impulses from C fibers are blocked better than impulses from other fiber types. Because C fibers innervate the synovium and joint capsule, TENS could prove useful in the treatment of arthritis (61). In addition, most forms of TENS have been shown to cause the release of various endogenous opioids in the midbrain (63,64).

Use of TENS has been shown to raise intraarticular temperature about 0.5°C in rabbits after a 5-minute treatment, but it also decreased inflammatory exudate and joint pressure and volume (65). The decreased inflammation and joint volume may help relieve pain in inflammatory arthritis.

Application

There are several modes of TENS, but the 3 most common are high-frequency TENS, low-frequency or acupuncture-like TENS, and burst-mode TENS. High-frequency TENS stimulates only the sensory nerve endings, using a continuous train of 50–125 μsec pulses in a frequency range of 50–110 Hz (66). High-frequency TENS theoretically works through the gate control mechanism as well as through the release of dynorphin (64). The usual electrode placement for people with arthritis is around the involved joint (61,67–71). Single-treatment duration varies, but a recent study showed that pain relief for patients with knee OA lasted longer and accumulated over several treatment sessions if those sessions were 40 minutes in length (72). Pain relief, if it occurs, has a rapid onset. High-frequency TENS is often used up to 3 times per day and may be used for several weeks.

Low-frequency TENS stimulates the motor endplates of muscles using wider, 250 μsec or longer pulses at a frequency of 1–4 Hz. This mode of TENS has been shown to cause an increase in cerebrospinal fluid levels of metenkephalin (64). Electrodes are placed over acupuncture points or motor points of muscles in the myotomes related to the painful joint.

Burst-mode TENS combines elements of both the high- and low-frequency modes. In burst mode, the carrier frequency of the current is high (70–100 Hz), but it is delivered in small bursts at a low rate (3–4 bursts per second). Burst mode also uses motor-level stimulation with electrode placements similar to those used with low-frequency TENS. This method produces longer-lasting pain relief, apparently through the same mechanisms as low-frequency TENS (66). The advantage of burst-mode TENS is the greater comfort of the current as compared with low-frequency TENS. Low-frequency and burst-mode TENS usually are applied for about 30 minutes. Low-frequency and burst-mode TENS usually are used only once per day but may be used for several weeks.

Contraindications and Precautions

People with cardiac pacing problems, who use pacemakers, or who have internal defibrillators should not use TENS near the heart. Electrodes should not be placed over the carotid sinus or the laryngeal or pharyngeal muscles (66). In addition, TENS should not be used during the first trimester of pregnancy, because the effect on the fetus is unknown.

As with the thermal agents, there are precautions associated with the use of TENS. Persons using TENS should use the joint carefully while being treated. Some people receiving TENS treatments find them uncomfortable. Discomfort may arise from skin irritation from the electrode couplant or adhesion system as much as from the electricity itself.

In a case report, 1 patient with RA reportedly developed paresthesias and increased pain following heat and TENS. These effects were delayed, so patients should be monitored closely by a qualified therapist (73).

Effectiveness

Pain relief from TENS has been found to be 50–90% (58,61,68–70,74). In some studies, pain relief was significantly greater than relief achieved from placebo treatments (58,67,70,71), while in others, both placebo and actual treatments produced similar amounts of relief (67,74–76). One difference in the effectiveness appears to be the number of treatments received, with more treatments being somewhat more effective than fewer treatments. The amount of pain relief attributed to placebo in studies with patients having RA or OA varies from 17% to 55% (71,75). Pain relief beyond that amount may be attributed to the TENS treatment (77). In addition to pain relief, TENS has been shown to contribute to decreased stiffness (58,60), as well as to improved 50-foot walk time, muscle strength, and knee flexion range of motion (58).

In people with rheumatic disease, pain relief from high-frequency and burst-mode TENS has been shown to last from 2.5 hours (70) to 18 hours (69), although patients may remain improved for days (68), weeks (72,74), or even months (78) following termination of treatment. The duration of pain relief from low-frequency TENS has not been reported extensively, but in 1 study, pain relief lasted 4 hours (69). Duration of pain relief appears to be related to duration of treatment, with 40-minute treatments producing longer relief than 20-minute treatments (72).

There is little evidence to favor one mode of TENS over another for patients with rheumatic disease. All 3 modes have been shown to be effective in some studies, with no one mode more effective than another (67,75,79). Other studies have shown that high-frequency and burst-mode TENS produce more and longer-lasting pain relief compared with low-frequency TENS (67,69). In a comparison of burst-mode TENS with high-frequency and placebo TENS in persons with OA, neither mode produced more pain relief than placebo, but the burst mode produced longer pain relief than placebo. High-frequency TENS decreased stiffness better than placebo, and both modes produced longer stiffness relief than placebo. High-frequency TENS reduced knee circumference better than burst mode, and burst mode was better than placebo for increasing range of motion (60). Burst-mode, low-frequency, and high-frequency TENS have all been effective in decreasing stiffness (58,60).

In comparing TENS with other treatments, pain relief produced by TENS has been shown to be longer lasting than that produced by analgesic medications (70). On the other hand, a nonsteroidal antiinflammatory medication was shown to be superior to TENS for patients with OA of the knee (76); however less-than-optimal electrode placements were used in the study. In people with OA of the hip, electrical stimulation alone decreased pain as well as did ultrasound, short-wave diathermy, or ibuprofen (29). Appropriate use of TENS could decrease the need for pharmacologic interventions and would be superior to deep heat, which requires clinic-based application. TENS has also been shown to be comparable to ice treatments for reduction of pain in patients with knee OA (58).

Overall, TENS appears to be useful for decreasing pain and stiffness, and the symptomatic relief may last longer than relief produced by other treatments. Reviewing only randomized controlled trials, Osiri and colleagues (80) and the Philadelphia Panel (50) agreed that there is good evidence for including TENS in the management of pain for patients with knee OA. Because the patient controls TENS treatment, it is a good tool for home use when people are properly instructed and monitored.

SUMMARY

The therapeutic goals for people with arthritis include improved pain, stiffness, swelling, and function. Superficial heat is helpful in achieving these goals, but may not be necessary if patients exercise appropriately. However, if patients who do not have acutely inflamed joints feel better after using superficial heat treatments, there appears to be no reason not to use them. Deep heat is costly, potentially hazardous, and requires clinic visits. Because other, safer means, such as exercise, can meet these goals without aggravating symptoms (especially in inflammatory arthritis), there is little reason to use deep heat in patients with arthritis.

In addition to the goals of symptomatic relief, it may be desirable to decrease the destructive inflammatory process for patients with inflammatory arthritis by cooling the joint. Cold treatments also promote improvement in pain, motion, and swelling. Cold treatments are not often considered for patients with arthritis, and patients may prefer heat, even when their symptoms are relieved better with cold (19,20). Patients should be encouraged to try cold treatments, especially when joints are acutely inflamed.

Use of TENS is effective for decreasing pain and stiffness without the potential hazard to the joint surfaces. The high-frequency and burst modes appear to work best for patients with arthritis. Patient improvement may be long lasting, and patients may be able to decrease medication use.

Appropriate professional supervision and instruction must accompany the use of any of the thermal and electrical agents for patients with rheumatic diseases. Any of these agents can be harmful if improperly applied. Education by a knowledgeable professional is crucial for correct and safe application.

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