ISSN 0894-588
JAME E7 8(2) 83-152 (1995)

Journal of
ADVANCEMENT
IN
MEDICINE

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Sponsored by the American College for Advancement in Medicine

Volume 8 Number 2 Summer 1995

Journal of Advancement in Medicine
Volume 8, Number 2, Summer 1995

The Basis for Microcurrent Electrical Therapy in Conventional Medical Practice

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ABSTRACT: The use of electricity in medicine is not new. Clinicians used it over 150 years ago to treat non-union bone fractures. Electomedicine and nutrition, abandoned early in this century, have been recently revived. Most physicians are unaware of their therapeutic benefits. Electrotherapy, especially microcurrent electrical therapy (MET) is useful for a variety of clinical conditions. Indeed, it may be the best treatment for many pain-related disorders, providing fast relief of symptoms and quickly promoting healing. It has significantly less side effects than drugs in chronic conditions. The more advanced MET devices can often demonstrate effectiveness with a simple two minute office procedure, allowing validity to be quickly assessed.

Introduction

Pain is a serious problem that only recently has been getting the attention that it deserves. It and its associated symptoms have a potent economic impact. The Interagency Committee of New Therapies for Pain and Discomfort estimates that chronic pain affects more than 40 million Americans and costs the US economy over $65-70 billion annually. At least 10% of Americans suffer chronic, handicapping pain. The average chronic pain patient has suffered for seven years and has had 3 to 5 surgical operations, spending $50,000 to $100,000 or more. Lost productivity due to pain is estimated at over 700 million workdays per year (1).

Although pain may be an important warning of a disease process, it

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often has limited diagnostic value and remains a difficult problem for the physician. A recent study (2) examined visits to eclectic and alternative medicine practitioners. It reported that non-reimbursable costs were about $10.3 billion in one year, comparable to the $12.8 billion hospital expenses during the same time period. In 1990, Americans made an estimated 425 million visits to these eclectic practitioners, while making only 388 million visits to all US primary care physicians. Many patients cite the side-effects and short-term relief of drug therapy as the primary reason that they seek alternative medical care. New development in electromedical technology offers physicians an effective treatment for pain-related disorders for many of them.

Traditional Therapy and TENS

Electrical modalities have been used for many years to control both acute and chronic pain. Clinicians also routinely use neuromuscular electrical stimulators to rehabilitate injured athletes (3,4). Transcutaneous electrical nerve stimulation (TENS) and other similar devices use a mild form of electrically induced pain to block the body's ability to perceive the pain that is being treated (5,6). When patients receive TENS at unmasked low frequencies (eight pulses per second or less) their production of endorphins may increase, thus producing temporary relief, possible in approximately 50 per cent of people. The effect of TENS is believed to stimulate A-beta pain-suppressing nerve fibers to overwhelm chronic pain-carrying C fibers (7). Similar results can be achieved by repeatedly tapping the painful areas with a blunt object. Massage, ice and heat relieve pain this way. The ampere (amp) is the measure of electron movement or current past a fixed point over time. Interferential, TENS, and high-voltage pulsed galvanic stimulators deliver currents in the milliamp range, stimulation which generally exceeds nerve firing thresholds, resulting in sensation ranging from a gentle tingling to intense muscle throbbing.

Traditional TENS only works if the current is strong enough to feel, using a current up to 80 milliamps. Patients are advised to set the current at the maximum comfortable tolerance, but the nervous system gradually accommodates to this high level of current, causing tolerance similar to that of chemical analgesics. Increasing the current causes mild electrical burns in about one third of the patients. The technique provides no significant residual effect.

Microcurrent Electrical Stimulation (MET)

Microcurrent electrical therapy represents a significant improvement in rapid pain control and acceleration of healing. It uses current in the microampere range, 1000 times less than that of TENS and below sensation threshold. The pulse width, or length of time that the current is delivered with a microcurrent device is much longer than previous technologies. A typical microcurrent pulse is about 0.5 seconds, which is 2500 times longer than the pulse in a typical TENS unit and a good microcurrent unit has approximately ten times the electronic circuitry of a TENS unit.

Unlike TENS, MET is usually administered through hand held probes positioned so that current flows between them, through the painful area, for ten seconds. The vast majority of pain problems can be treated with less than 10 applications of 10 second probe treatments. Many patients are free of their pain in less than two minutes and there is generally a significant residual effect, often lasting from at least 8 hours to as long as 3 weeks or more (8).

The first homecare MET stimulator was introduced in 1982.* It provides at least the same results as more expensive models (9). It is a pocket-size device for home use and patients find it easy to learn to use it, as necessary, to control their pain.

How Microcurrent Works

MET works because of its ability to stimulate cellular physiology and growth. One classic study (10) showed that it could increase ATP generation by almost 500%. Increasing current actually decreased the results. This study also demonstrated its ability to enhance amino acid transport and protein synthesis.

One can see an illustration of the true therapeutic effect of MET through the mechanism in which trauma affects the electrical potential of damaged cells (11). The injured area has a higher electrical resistance than the surrounding tissue. This results in decreased electrical conductance through the injured area and decreased cellular capacitance (12), leading to impairment of the healing process and inflammation.

Correct application of MET to an injured site augments the endog-

* (Alpha-Stim: Electromedical Products International, Inc.)

enous current flow, allowing cells in the traumatized area to regain their capacitance. Resistance is reduced, allowing bioelectricity to flow through and reestablish homeostasis. This process helps to initiate and perpetuate the many biochemical reactions that occur in healing. Muscular spasm, occurring as a reaction to trauma, causes reduction in blood supply, resulting in local hypoxia, accumulation of noxious metabolites, and pain. This, in turn, leads to reduction of ATP synthesis. Thus, MET stimulation results in replenishment of ATP (10).

Rapid Pain Management

One of the greatest values of MET is in pain control (8,9,12). It also reduces inflammation, edema and swelling, increases range of motion, strength, and muscle relaxation, and accelerates wound healing (13,14). It is exceptionally useful in soft tissue injuries, such as sprains (15,16), wounds, post-surgical trauma, and particularly in treatment of long-term residual pain due to post-surgical scars.

It is effective for treatment of headaches, temporomandibular joint syndrome, neuropathies, arthritis, bursitis and tendonitis. Clinical experience indicates that it is an adjunctive therapy in earaches, sore throats, toothache, sinus congestion, viral or allergic conjunctivitis, post-herpetic neuralgia, skin ulcers, post-CVA spasticity, and compression neuropathies such as carpal tunnel syndrome. It has also proven useful in preventing the delayed muscle soreness that is common after heavy exercise (17). Improvement in post-exercise muscle fatigue was achieved by applying the current over the exercise muscles for twenty minutes after exercise. In a minority of patients MET does not work or only provides brief palliative relief. Its full potential is yet to be defined.

It has been used to control hypertension (18), failed back syndrome (19,20), arthritis (21), Raynaud's phenomenon (22,23), tinnitus (24-26), and post-anesthesia emesis (27). Dentists have used it as a substitute for local anesthesia (28,29) and to control pain associated with orthodontic treatment (30).

Cancer Pain

Intractable pain in patients with head and neck cancer has been successfully treated with MET, even in some cases that were morphine

resistant (8,12). After only 10 minutes of MET, pain relief lasted from 8 hours to more than 3 weeks. The technique has been used successfully at the University of Texas MD Anderson Center (31).

Fractures

About 5% of long-bone fractures in the United States result in non-union (32). Electrical stimulation of the fracture provides a non-surgical option for repair. It is also being investigated for use in osteonecrosis and osteoporosis (33).

Using electrical therapy to heal non-union fractures is not new. It was first reported over 150 years ago (34,35). At the turn of the century, however, a number of medical charlatans, using electrotherapy, forced the Carnegie Foundation to have the Flexner commission review its use. In 1910, the Flexner Report relegated electrotherapy to a scientifically unsupportable position, causing it to fade from medical practice. Further exploration of the technique was reported by Yasuda and Fukuda (36) who found that mechanically stressed bone produces a small negative electrical direct current that stimulates bone production.

Becker (37) performed research that led to applying electrotherapy to the healing of bone fractures (38). By 1976, over 100 articles had been published describing the effects of electricity on bone growth and repair in laboratory animals and in humans (39). As of 1990, more than 100,000 cases of non-union fractures and aseptic necrosis have been successfully treated with electrotherapy (40).

Several methods are available to stimulate bone growth. All require 3 to 6 months of treatment, and have similar contraindications. A gap in the fracture greater than half the diameter of the bone or synovial pseudoarthrosis will result in failure (33).

The first clinical trial of direct current surgical implant in humans in the United States (41) achieved results in 4 months in a large percentage of cases (42). Stainless steel electrodes with 5-20 microamps of current produced the best growth, while current above twenty microamps actually caused bone to die (43).

A noninvasive alternative is inductive stimulation, which works by creating a magnetic field around the non-union site. Pulsing electromagnetic fields (PEMFs) are induced by a treatment coil or transducer. These devices are battery powered and portable. Patients wear them for 3 to 10 hours a day and treatment lasts about 6 months.

Many investigators report 90% healing rates with this method (44). Although PEMFs contain both electrical and magnetic fields, the bone remodeling processes appear to respond mostly to the electrical field component. The magnetic field contributes less benefit to the process (45).

Spectral analysis of PEMF frequencies shows that they range from 1-250,000 Hz. As indicated above, the electrical, *not* the magnetic energy, is responsible for producing bone growth. Investigators tested 150, 75, and 15 Hz sinusoidal electrical field effects on the prevention of osteoporosis (46). They found that the 150 Hz field did not increase bone mass, but inhibited normal bone loss associated with disuse. The 75 Hz field increased bone mass by 5%, while the 15 Hz field actually increased it by 20%. The energy represented by this frequency is less than 0.1% of the PEMF field. This strongly suggests that the vast majority of the energy introduced by PEMF has no beneficial effects on bone regrowth and it is also probable that even lower frequencies, like the 0.5 Hz field produced by MET would provide even more impressive results.

Several devices use capacitive-coupled stimulation which produces an electrical field at the fracture site. They are 9-volt battery units attached to the skin over the fracture site. It has the advantage of not requiring precise placement of the electrodes and can be administered 24 hours a day. Unlike inductive coupling, patients using this treatment can have a full weight-bearing cast and this tremendously enhances patient compliance.

The first capacitive-coupling devices used a 60 KHz sinusoidal wave form and delivered a current of 7 to 10 milliamps (47,48), but subsequent work suggested that non-sinusoidal wave form and much less current is more effective in promoting bone healing (10,11,49). Although clinical experience exists, no studies have been published to date for these applications with MET.

Tendon and Ligament Repair

One of the first studies published on treatment of soft tissue injuries was by Wilson in 1972 (50). Microcurrent delivered in a PEMF format has been helpful in the management of refractory tendonitis of the shoulder (51). Stanish (15,16) used implantable electrodes with constant 20 microamp direct current in severed dog tendons. He ob-

served a 92% return to normal in 8 weeks, compared to 50% in control animals.

Although implantable electrodes were used, it is likely that external electrodes could produce similar results. This could significantly enhance the current treatment of tendon ruptures. Use of MET seems to enhance cell multiplication in connective tissue, and speeds formation of new collagen in injured tendons. Accelerated healing of ligament and tendon injuries has been reported (52) and it has been shown to increase rat tendon healing by over 250%.

Wound Healing

Chronic wounds, of which leg ulcerations make up a major share, are a therapeutic problem. It is estimated that 90% of leg ulcers are due to venous stasis, affecting 0.6 of men and 2.1% of women in their 60s (40,53). Acute soft tissue injury is common and there are 2.5 million burn wounds a year in the US. Of 30 million lacerations, one in 5 are serious enough to require auxiliary treatment (14). Use of MET is simple, safe, and efficient and can have tremendous influence on improving wound healing.

Becker (54) showed that living tissues have multiple direct current surface potentials which are combined to form a steady state bioelectric field. He hypothesized that injury causes a localized shift in the current flow, triggering repair. He called this the current of injury (COI). Although first described by Galvani in 1786, and later by others (14) COI was finally confirmed in 1980 (55). These investigators studied children who had experienced accidental finger amputation, They found that the current peaked at 22 microamperes 8 days after the injury and thereafter slowly decreased back to zero. It is believed that this current of injury triggers biologic repair, and later work established that there is actually a battery-like aspect to the epidermis (56-58) that can influence wound healing. Since membrane potentials are basic in the cell, it is logical to assume that 75 trillion cellular batteries will influence physiology in some way.

Occlusive dressings accelerate wound healing (59). They probably achieve their effects by promoting a moist environment (57) which resurface 40% faster than air-exposed wounds (60). This is possibly related to COI, since a dry wound is less electrically conductive. Electrical stimulation of a wound increases the concentration of growth factor receptors which increases collagen formation (61,62). This may

be important in view of the hypothesis that a major mechanism in causing ulceration is removal of growth factors by venous hypertension (63).

Electricity was first used to treat surface wounds over 300 years ago with charged gold leaf to prevent smallpox scars (64). Use of electromagnetic fields predates the application of direct current (54) and there are several studies showing excellent results using this modality (65-68). Animal experiments have shown, however, that direct current can accelerate epithelialization and result in stronger scar tissue formation (69,70).

The first human study using direct electrical current (71) reported complete healing of chronic venous stasis leg ulcers in 3 patients with 6 weeks of treatment. The most frequently cited study (72) used direct currents of 200-1000 microamps in 67 patients. This was repeated in 1976 (73) in 76 patients with 106 ischemic skin ulcers. In 1985 a randomized controlled study was published (74). All of these studies documented significant accelerated healing with electrical stimulation.

In 1974 Rowley et al. (75) studied a group of patients having 250 ischemic ulcers of various types. The series included 14 ulcers in control subjects. The electrically stimulated ulcers had a fourfold acceleration in healing response compared to controls.

A consistent observation in these studies was that wounds that were initially contaminated with Pseudomonas and/or Proteus were usually sterile after several days of electrotherapy. Other investigators have also noticed similar improvement (75-77) and suggest this technique as the preferred treatment for indolent ulcers. No significant adverse effects resulting from electrotherapy have been documented (78) and MET is clearly an effective and safe supplementary treatment for recalcitrant leg ulcers (79). Although most studies use negative current to inhibit bacterial growth and positive current to promote healing, the studies just mentioned used unipolar currents which alternated between positive and negative. There is support for this technique in one animal study (80), suggesting that bipolar current may be better for wound healing (14).

Potential Mechanisms for Repair Stimulation

Becker (49) demonstrated that an electrical current emanating from a biologic control system is the trigger that stimulates healing, growth and regeneration in all living organisms after injury but that this

system may become less efficient with time. He theorizes that the self-repair inimical to survival in primitive organisms requires a closed-loop system. A specific injury signal is generated which causes another signal to start repair. The injury signal gradually decreases over time as the repair process proceeds until it finally ceases when repair is complete. Such a primitive system does not require demonstrable consciousness or intelligence. This purportedly explains why animals actually have a greater capacity for self-healing than do humans.

Becker maintains that it is helpful to compare the nervous system with a digital computer. Both systems transfer information that is represented by the number of pulses per unit of time. Information is also coded according to where the pulses go and whether or not there is more than one channel of pulses feeding into an area. All our senses are based on this type of pulse system, an arrangement similar to that used in computers. It operates remarkably fast and can transfer large amounts of information as digital "off" and "on" data.

Becker suggests that early organisms did not need to transmit large amounts of sophisticated information and may have possessed something akin to an analog system which works by means of simple DC currents. This represents information by the strength of the current, its direction of flow, and slow wavelength variations in its strength. Although much slower than the digital model, it is extremely precise and works well for its intended purpose.

Becker theorizes that the first living organisms used this kind of electrical system for injury repair and that we still have this primitive nervous system residing in the perineural cells hidden within the central nervous system. Every nerve cell is surrounded by perineural cells which comprise 90% of the nervous system. They have semiconduction properties which allow them to produce and transmit nonpropagating DC signals. This analog system senses injury and controls repair. It controls the activity of body cells by producing specific DC electrical environments in their vicinity. It also appears to be the primary system in the brain, controlling the actions of neurons as they generate and receive nerve impulses.

Cancer

Although there are concerns that some types of electromagnetic field exposure can cause cancer or leukemia (49,81,82), we have strong evidence that MET can normalize cell growth, accelerate cell division

after injury and inhibit cell division when it becomes abnormally accelerated. If a cell is in a normal state of physiologic equilibrium, external electric fields do not appear to affect it (83).

Antitumor effects of DC currents have been reported (84). The current state of electrical cancer research seems to be where bone repair was about twenty years ago. The only studies published used invasive techniques with percutaneous needle electrodes (85-91). All of the studies report significant impairment of tumor growth with electrical treatment.

Contraindications

Caution is advised during pregnancy because electrical stimulation can affect the endocrine control systems and can theoretically cause miscarriage, although this has never been reported. Microcurrent, or any other electrical stimulus should not be used on patients with demand-type cardiac pacemakers. Other than these two conditions, there are no known significant adverse side effects to MET.

Summary

Clearly, much additional work is required to define the role of MET. The results of research published to date strongly suggest that it will have a much more prominent role in the future of health care. In its current form, it can easily and safely control pain and accelerate healing. Due to its ready availability, cost effectiveness, and safety, it is time for physicians to offer it as an option. The 34% of patients who seek alternative medical techniques would be especially appreciative.

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