PAIN MANAGEMENT

A Practical Guide for Clinicians

SIXTH EDITION

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AMERICAN ACADEMY OF PAIN MANAGEMENT

CRC PRESS

Boca Raton London New York Washington, D.C.

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Electromedicine: The Other Side of Physiology

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A fresh look at physiology is needed to better understand the primary medical complaint of pain. Universities are still teaching their students that life is based on a chemical model. Rather than view life processes on a chemical basis alone, it is more realistic to view them on an *electrochemical* basis. All atoms are bonded electrically. This is a basic foundation necessary to understand electromedicine that is taught during the most elementary training in the basic sciences. Further in our rudimentary training we learned that there are voltage potentials across the membrane of all cells. All standard physiology textbooks define the Nernst and Goldman Equations to determine membrane and action potentials. They do not, however, speculate on the staggering significance of these facts.

If batteries are placed in series, their voltage potentials are combined. A simple remote-control device may use three 1.5-V batteries to produce the 4.5 V needed to operate a television. The human body has trillions of cells, each having a 10- to 200-mV potential across their membranes. The overall electrical potential in humans is 2×10^4 V/mm (Kitchen & Bazin, 1996). All good scientists should ask themselves why we find electricity so prevalent in biological systems.

It is already established that bioelectricity plays a major role in physiology. Robert O. Becker, M.D. has spent more than 30 years attempting to determine how trillions of cells with hundreds of subtypes can function harmoniously in the form we call human. The result of that inquiry is a complete revolution in our previous concepts of biology (Becker, 1983).

Becker (1982) found that electromagnetic fields control all living processes. The earliest concept of such field effects can be traced back to ancient China. Traditional Oriental medicine is based on the controlling power of *ch'i* (Qi) or *ki* energy; a concept that predates electricity but appears to be analogous (Kirsch, 1978). Chiropractic also developed based on a similar observation termed *innate intelligence* by Daniel David Palmer in 1895 (Palmer, 1910). Indians use the term *prana* to represent the same concept. Allopathic practitioners are limited to the vague notion of *homeostasis*.

In Western civilization, the first documented use of electricity to manage pain was by the physician Scribonius Largus in 46 A.D. (Tapio and Hymes, 1987). He claimed that just about everything from headaches to gout could be controlled by standing on a wet beach near an electric eel. Not surprisingly, attempts at producing pharmaceutical preparations from dead eels proved ineffective. In 1791, Luigi Galvani discovered that electrical impulses could cause muscle contraction (Smith, 1981). By 1800, Carlo Matteucci showed that injured tissue generates an electric current (Becker and Marino, 1982). The discovery of alternating current by Michael Faraday in 1830 opened the door to the development of manmade devices as sources of electricity. Over 10,000 medical practitioners in the United States alone made use of electrotherapeutic modalities until publication of the 1910 Flexner report, which stated that there was no scientific basis for electromedicine at that time. Flexner's report was originally prepared by the American Medical Association and sponsored by the Carnegie Endowment for the Advancement of Teaching (Walker, 1993). Since the Carnegie family was heavily invested in the young pharmaceutical industry, it is no wonder their report declared allopathic medicine superior.

Since then, arguably the greatest development in the field of electromedicine was when Becker (1981) *electrically induced limb regeneration* in frogs and rats as a model

0-8493-0926-3/02/$0.00+$1.50
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to study bioelectrical forces as a controlling morphogenetic field. Regeneration represents a return to embryonic control systems and cellular activities within a localized area. It can, therefore, be considered a more accessible and more observable form of morphogenesis. The complexity of instructions required to designate all of the details to recreate a finished extremity is impossible to transmit by previously understood biochemical processes alone.

Becker (1983) proposed that a primitive direct current data transmission and control system exists in biological systems for the regulation of growth and healing. His studies of extraneuronal analog electrical morphogenetic fields have eliminated any rational arguments against the importance of bioelectricity for *all* life processes. Becker has laid the groundwork for the medical professions to start to evolve toward a more reasonable integrated view of biology incorporating our understanding of both biochemistry and biophysics.

Björn Nordenström, M.D. (1983, 1998), former Chairman of the Nobel Assembly, also has proposed a model of bioelectrical control systems he calls *biologically closed electric circuits* (BCEC). The principle is analogous to closed circuits in electronic technology. Nordenström's theory is that the mechanical blood circulation system is closely integrated anatomically and physiologically with a bioelectrical system.

Nordenström hypothesizes that ionic and nonionic compounds interact in a way that makes selective distribution and modulation of electrical and other forms of energy possible throughout the body, even over long distances. The biological circuits are switched on by both normal electrical activities of the organs and pathological changes, such as tumor, injury, or infection. Like Becker, Nordenström views bioelectricity as the primary catalyst of the healing process.

Using the vascular interstitial system as an example, Nordenström postulates two branches of this system. The first branch, the intravascular system, proposes that walls of blood vessels act as insulators, much like cables in a battery system. The electrical resistance of the walls of the arteries and veins is 200 to 300 times greater than the blood within.

Delayed available energy, or potential energy, is carried by blood cells that bind oxygen, as well as other chemicals such as glucose, neutral fat, nonpolar amino acids, etc. These are all noncharged packages of energy that arrive at specific sites and are released primarily by reduction/oxidation. Nordenström terms these *ergonars*. The intravascular plasma acts as the conductor, where ions such as sodium, calcium, and chloride supply immediately available energy to the system, primarily by electrophoresis. Nordenström calls these *ionars*.

The second branch addresses the interstitial system. The tissue matrix acts as an insulator while the interstitial fluid acts as a conductor.

Capillary membranes are the main components that close the system. These membranes act as junctions between the interstitial and vascular fluids allowing exchange of ionars and ergonars along gradients of electrical potential.

This theory represents a comprehensive attempt to describe functions of anatomical components in terms of electromagnetic forces, rather than limiting them to chemical interactions. Nordenström further theorizes that similar closed circuit systems exist in the urinary and gastrointestinal systems. Using electrical intervention, Nordenström (1984, 1989) reversed terminal cancer in most of his patients as clinical proof of his theories. Several other researchers are confirming the value of electromedicine for the treatment of cancer (Pallares, 1998; Lyte, et al., 1991; Morris, et al., 1992; Sersa, et al., 1992; and Belehradek, et al., 1981).

The medical community has barely taken notice of these remarkable theories. Few practitioners are even aware of the works of Becker or Nordenström. Nordenström is familiar with this type of ignorance. In the 1950s he pioneered a series of remarkable innovations in clinical radiology (including percutaneous needle biopsy) that were considered radical at the time, but are routinely employed by every major hospital in the world today.

Lack of updated education of healthcare professionals is the main stumbling block to acceptance of the modern theories and practice of electromedicine. The other problem is the wide variety of technologies available. At present, there are well over 100 different models of transcutaneous electrical nerve stimulation (TENS) devices in the marketplace and an increasing number of other electrical devices. Most healthcare practitioners who want to utilize such technology have received little or no training in electrobiology or electrical technology. Hence, when it comes to making an educated decision on what type of instrument to choose for a practice or a particular patient, practitioners are often overwhelmed when meeting with an electromedical sales representative. Purchase decisions are frequently made based on lack of knowledge, misinformation, unsubstantiated claims such as testimonials not backed by solid research, or price. If a device is effective in only 2% of the population, treatment of 1000 patients can result in 20 testimonials. The plural of anecdote is not data. Accordingly, healthcare professionals should rely only on evidence-based technologies supported by double-blind research.

BASIC PRINCIPLES

The basic unit of energy is the electron. In 1600, William Gilbert coined the word *electricity* (Bauer, 1983). Using sulfur and friction to generate electricity, Guericke found that it had several properties in common with magnetic forces, such as repulsion/attraction, transference of properties, and opposite poles. Faraday termed the positive pole the *anode*, meaning "upper route" and the negative pole *cathode*, or "lower route." Electrons flow from negative to positive, or cathode to anode.

Fluid-based biological systems are conductive media. Blood, water, and lymph all conduct electricity. Various molecular ions, such as calcium, sodium, and chlorides, carry current. When current is carried by ions, electrolysis occurs. In this process, electricity breaks the conducting fluid down into its components. In the case of water, electricity reduces the H_2O molecule into its components of two atoms of hydrogen and one of oxygen. The half-reaction for the formation of water is $\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$. The resultant voltage released at a pH of 7.0 is 0.816 V (Segel, 1975). This process occurs within all types of tissue (e.g., nerves, muscle, bone, etc.) throughout the body.

Many interactions of this nature are highly complex and not yet thoroughly understood. Certain types of electrical stimulation have caused neurotransmitters to be manufactured and released. Some of these treatments are even considered to be frequency specific, but there is still a lot to learn before we can specify the biochemical effects of frequencies, or any other individual aspect of a waveform.

Waves and Pulses

In fluids, such as water, the sinusoidal wave is the only basic waveform. However, with electrical technology, different shaped waveforms can be built. These are often referred to as *square, rectangular, triangular, sawtooth,* etc. In actuality, they are composed of thousands of waves known as harmonics. A collection of harmonics within a single electrical activity is called a *pulse*.

Frequencies (Hz) and Pulse Repetition Rates (PRR)

Pulses are measured in cycles moving through a medium in 1 second. One cycle per second is also called a *Hertz* (Hz). In electrical devices, pulses have frequencies. Just as the collection of harmonics is called a pulse, total frequencies (built by the resonance of harmonics) is referred to as the *pulse repetition rate* (PRR). It is the speed at which the pulse moves. For example, a 1 Hz pulse will have harmonic frequencies that build the pulse, ranging from 1 Hz to hundreds of thousands of Hz and beyond, theoretically to infinity. This is often a source of confusion, not only among practitioners, but also among manufacturers of devices as well. In engineering terms, the term *frequency* should only be used with a pure sinewave. Only in this one case, frequency is the same as the pulse repetition rate. With any other waveform (e.g., square, rectangular, triangular, etc.) there is an infinite number of harmonic frequencies generated within each pulse.

The interplay of harmonics identifies a given musical instrument as a particular aural experience. Some people prefer the sound of a specific note on a piano, while others would rather hear the same note played on a violin. Although the note is the same in each case, the harmonics vary. The interplay of harmonics in electromedicine is essential in affecting the results of a given treatment. With this in mind, we can begin to understand why one electromedical device may work for one patient, yet provide poor results for another. If we could predict what harmonics each tissue needed at a given time, we could design devices that would provide more consistent results in pain management, healing, altering consciousness, and regulating biological processes in general.

The body accepts frequencies and pulse repetition rates in a nonlinear, differential manner. For example, low frequencies penetrate greater depths of tissue than high frequencies. Higher frequencies are auto-shielding; that is, they are limited in penetration because the resistance of tissue acts like a faraday cage, forming eddy–repulsion. This eddy current produces a back electromotive force and blocks the penetration. The reflection of input signals in any conductor (in this case the body) is a mirror image of the opposite phase. The higher the frequency, the greater the rejection and the shallower the penetration. Complex frequencies interact in the body causing a diffuse spread of current.

A nonlinear electrical device is called a *diode*. A diode conducts current of one polarity far greater than the opposite polarity. Most living tissue exhibits nonlinear characteristics, functioning somewhat like diodes.

With square and rectangular waves, a shotgun-like distribution of thousands of frequencies occurs simultaneously within each pulse, like buckshot scattering over a wide area. A sinewave, on the other hand, is more like a bullet from a rifle, which must strike a target accurately to be of use. Our present knowledge of electrophysiology is not sufficient to determine the optimum frequencies for specific tissue responses; therefore, the use of sinewaves is not recommended.

Pulse Width

The length of time a pulse lasts is called the *width*. This is usually measured in microseconds. Pulse width really refers to the time the wave is active. This is important with respect to how a given tissue may be affected, and is part of a hypothetical window of optimal electric stimulation.

The body responds to the peak of electrical signals and to the number of electrons in that signal. The maximum charge per pulse is measured in microcoulombs, which is the total energy of each pulse. The definition of a coulomb is the quantity of electric charge carried by 6.25×10^{18} electrons. Returning to our bullet analogy, we can see that a .22 bullet has less energy than a .45 bullet because it is lighter. While the .22 might go faster, the .45 can knock down a bigger target with its increased energy. Consider each spike a bullet and the pulse width the energy carried by that bullet. Taking our analogy a step further, the velocity of the bullet is the voltage, while the mass of the bullet is the energy, measured in microcoulombs.

Biphasic Signals

Because ions dissociate by electrolysis in the presence of electrical current, living tissue can become polarized in a direct current field. This can cause conflict in neural tissues. Therefore, modern stimulators usually provide alternating or biphasic (also known as bipolar) current. That is, current that reverses polarity each half cycle. This is called a zero net current. If the current continued to flow in the same direction, polarity stress could result in irreversible tissue damage.

As an analogy, picture a group of soldiers marching across a bridge. Before they get to one side, an about-face order is given and they return. Before they reach the opposite side, another about-face order is given, and so on, so that they never actually reach a side. By going back and forth, biphasically, there is no net electron flow across the bridge and no soldiers are added or subtracted. They never get across the bridge to cause an irreversible balance in the status quo. Accordingly, a biphasic current does not add electrons to the body; it simply moves them back and forth.

Amperage, Voltage, and Resistance

Electricity travels in a *circuit*. The number of electrons moving per unit of time is called *amperage*. Amperage is a measure of the amount of *current*. *Voltage* is a measure of the pressure in the circuit. *Resistance* to the electron flow in the circuit is measured in *ohms*. A classic analogy of this is water flowing through a garden hose. The amount of water in the hose corresponds to the amperage. The water pressure corresponds to the voltage. The hose can take only so much water pressure at a given time. Any more pressure or water will be met by more resistance from the hose. This concept is mathematically stated by Ohm's law of $E = IR$, where E (electromotive force) is the voltage, I is the current, and R is the resistance. One can increase the current and decrease the voltage by decreasing resistance, just as more water can pass with a lower pressure through a fire hose than through a garden hose. Similarly, more current can pass through a larger diameter wire or through a highly conductive metal such as copper. In both cases, the thicker wire and more conductive metal have lower resistance.

In the case of a human body, resistance is determined by factors such as fluid content, general health, skin thickness, amount of oil on the skin, temperature and humidity in the air, etc. If a person has a higher resistance, less current will flow through. However, voltage can be increased to maintain the desired level of current. The better electromedical devices deliver a constant current by self-adjusting voltage as skin resistance changes.

Conductivity

Skin resistance is several thousand ohms (as high as $100{,}000\ \Omega$ when dry). Wet skin can be as low as $1000\ \Omega$. Resistance between the hand and foot excluding skin resistance is as low as $500\ \Omega$. Overall, tissue conductivity is proportional to its water content as can be seen in Table 60.1.

TABLE 60.1
Water Content of Various Tissues

Tissue	Water Content
Skin	5–16%
Bone	5–16%
Fat	14–15%
Brain	~68%
Muscle	72–75%

CLINICAL ASPECTS OF ELECTROMEDICINE

The correct form of electromedical intervention will often have a profound and usually immediate effect on pain. Although caution is advised during pregnancy for liability purposes and the possibility of inducing a miscarriage, and electrical stimulation should not be used on patients with demand-type cardiac pacemakers manufactured prior to the electromagnetic compatibility standards that went into effect in 1998, there are no known significant lasting adverse side effects to therapeutic electromedical technology. There are, however, a number of contraindications as listed below.

General Overview of Benefits

1. Low incidence of adverse effects.
2. Relatively easy to learn.
3. Can be administered by paramedical personnel.
4. Expands the practitioner's clinical capability.
5. Enhances the total efficacy of clinical efforts.
6. An alternative therapy in cases refractive to conventional methods.
7. Eliminates or reduces the need for addictive medications in chronic pain syndromes.

8. May be applied on a scheduled basis or PRN.
9. Some modalities produce cumulative effects.
10. May be self-administered by patients for palliative care.
11. Noninvasive therapies are less liable to result in malpractice claims than many conventional procedures.
12. Highly cost effective.

General Overview of Contraindications, Precautions, and Adverse Effects

1. Possible interference with pre-1998 demand-type pacemakers. Also, other implanted devices such as defibrillators, morphine pumps, artificial joints, joint screws, etc.
2. Strong stimulation or pressure from probes placed directly on the carotid sinus could result in vaso–vagal syncopé.
3. Some modalities may cause skin reactions (redness through actual burns) due to excessive stimulation, prolonged use of direct current (or polarity imbalance), or simply sensitive skin.
4. Direct currents can cause electrochemical damage (i.e., chemical burns).
5. Contact dermatitis or disease transmission due to unclean electrodes.
6. Electric shock hazard due to device malfunction or improper use.
7. Many modalities contraindicated for use around heart.
8. Most modalities contraindicated for use on head.
9. Excessive stimulation may produce muscular soreness or spasm, or exceptionally vigorous muscle stimulation can cause muscle or joint damage.
10. Some modalities can cause cardiac fibrillation.
11. Shock hazard from sudden interruption of current in some modalities.
12. The use of most modalities has not been researched in pregnancy (possible physiological implications, such as miscarriage; and unsubstantiated legal arguments in case of developmental defects).
13. Masking of pain that may serve as a protective mechanism.
14. Masking of pain that may hinder or delay diagnosis.
15. Some devices can raise or lower blood pressure.
16. Patients may not be able to drive or operate heavy machinery during or after use.
17. Some devices may cause headaches, vertigo, or nausea.
18. Sensations experienced by the patient can cause anxiety, or panic attacks due to fear of electricity.
19. Some devices may cause vasodilation which would be contraindicated in some people due to hemophilia or thrombosis (may detach thrombus).
20. Spreading of acute inflammation due to muscle pumping action.
21. Some devices may increase injury if used for recent traumatic injuries.
22. Some modalities must not be used over the spine.
23. Some devices may be contraindicated in malignancy (while others are designed to treat cancer).
24. As in drugs, tolerance is the biggest problem of most modalities, such as TENS.
25. Metal electrodes may be toxic. Electrode materials may be driven through the skin through iontophoresis.
26. Electricity passing through any substance produces heat. For human skin 1 mA/cm^2 is just below the level at which cell damage due to heat is produced. Higher currents may damage cells (Becker, 1990).

Indications and Contraindications for Specific Electrotherapy Modalities

The following tables may be used as general guides to determine which modality might be prescribed for a given diagnosis. However, this information is far from complete, and certainly will not, in itself, suffice as a complete course in electromedicine. The reader should keep in mind the above list of general contraindications, precautions, and adverse effects, and that quality, consistency of the outputs, and other factors vary widely among products. This information is culled from the author's 3 decades of training and experience in electromedicine as well as that of several other leading authorities (Becker, 1990; Benton, Baker, Bowman, & Waters, 1981; Jaskoviak & Schafer, 1993; Kirsch, 1999; Kitchen & Bazin, 1996; Low & Reed, 1994; Nelson & Currier, 1991; Thuile & Kirsch, 2000).

Auriculotherapy

Treatment of ear acupuncture points for pain management and systemic disorders (all acupuncture applications).

Uses low frequency 0.5–320 Hz, < 2 S, < 500 mA.

Cranial Electrotherapy Stimulation (CES)

Treatment of the brain for pain, stress, anxiety, depression, insomnia, and addictions when treated at lower or mid-brain levels (ear lobes). Also may be useful to treat organic brain disorders (e.g., stroke, Parkinson's disease, multiple sclerosis, etc.) when treated on top or above ears. Remove earrings and hearing aids.

Uses low-frequency biphasic currents of 0.5–100 Hz, < 2 S, < 1.0 mA.

Indications		Contraindications
Addictions (alcoholism, cigarette withdrawal, cocaine, heroin, marijuana, methadone, opiates, polysubstance abuse, withdrawal)	Learning disorders	Patients prone to vertigo
Anxiety	Multiple sclerosis	Pregnancy
Attention deficit disorder	Muscle tone/movement/tremor	
Bronchial asthma	Obsessive-compulsive disorders	
Cerebral palsy	Pain (systemic, idiopathic, delusionary or hallucinatory)	
Chronic fatigue syndrome	Phobia	
Closed head injuries	Parkinson's disease	
Cognitive dysfunction	Phantom limb syndrome	
Dental analgesia	Raynaud's disease	
Depression	Reaction time, vigilance	
Eating disorders	Reflex sympathetic dystrophy	
Fibromyalgia syndrome	Rehabilitation (systemic disorders)	
Headaches	Stress	
Insomnia	Stroke	
	Temporomandibular joint disorder	

Cryotherapy

Ice, cold packs, vapocoolant sprays, cold therapy, cold immersions, and cryokinetics. This is included here in opposition to hyperthermia treatment that is a given therapeutic factor of some electromedical modalities.

It takes about 15 minutes for ice to reduce skin temperature from 84 to 43°F, 60 minutes to decrease subcutaneous tissue from 94 to 70°F, and about 2 hours to decrease intramuscular temperature from 98 to 79°F. Use of cold for more than 30 minutes may cause temporary nerve palsy.

Indications		Contraindications
Inhibits bleeding after acute trauma	Angiomas	Raynaud's disease
Reduces pain and reduces the accompanying reflex muscle spasm in acute musculoskeletal injuries	Boils and carbuncles	Coma
Decreases blood flow to areas of acute inflammation	Febrile states	Rheumatoid arthritis and gout
Spasticity	Herpes blisters	Cryesthesia (e.g., tooth decay)
Burns	Sprains and strains	Paroxysmal cold hemoglobinuria
Closed pressure sores	Tumors	
Reduces adverse tissue changes and relieves pain in the first-aid treatment of insect and snake bites	Varicose ulcers	
	Warts	

Electroacupuncture

Pain management, vasodilation, nausea, healing (all acupuncture applications).

Uses low frequency 0.5–100 Hz, 0.2 mS, at microcurrent to TENS-like amplitudes.

Faradic

Functional electrical stimulation (FES) provides tetanic contractions of denervated muscles. Used for impaired movement, muscle strengthening.

Uses low frequency 30–100 Hz, 0.1–1 mS, biphasic currents applied to motor points.

Indications	Contraindications
Brachial plexus injury	Areas of diminished sensation
Difficulty in voluntary movement (post-stroke or head trauma)	Beyond the flexibility of implanted prosthesis
Facilitation of voluntary motor function	Metastatic carcinoma
Guillian-Barré syndrome	Over metallic implants
Maintaining or increasing range of motion	Over open wounds
Muscle spasticity	Over or through heart
Muscle strengthening	Pacemakers
Orthotic training	Pregnancy
Rehabilitation of muscles (post-orthopedic surgery, spinal injuries)	Transcranially

Galvanic

Neuralgia, circulation disorders, myalgia (denervated muscle), alleviates pain, promotes healing. Used for forcing chemicals through the skin via iontophoresis.

Negative electrode (cathode) is generally thought to promote healing; however, recent evidence indicates that the driving electric force of the degrading, energy-liberating, catabolic process of injury fluctuates from anodic into cathodic phases, attenuating toward a state of equilibrium ("healing") as is the case with all spontaneous reactions (Nordenström, 1983). Biphasic devices are safer and may actually be better for promoting healing.

Galvanic currents are continuous direct currents of < 0.33 mA/cm^2.

Primary Effects of Direct Currents

Type of Effect	Anode (+)	Cathode (–)
Physiochemical	Attracts acids	Attracts alkaloids
	Repels alkaloids	Repels acids
	Attracts oxygen	Attracts hydrogen
	Corrodes metals by oxidation	Does not corrode metals
Physiological	Hardens scar tissue	Softens tissues
	Decreases nerve irritability	Increases nerve irritability
	Dehydrates tissue	Congests tissues
	Produces vasoconstriction	Produces vasodilation
		Enhances bleeding
	Retards bleeding	Produces hyperemia
	Produces ischemia	Tends to increase pain at low intensities
	Tends to be analgesic	
		Germicidal effects

Indications	Contraindications
Acute trauma	Carotid sinus area
Adhesions	Impaired cutaneous sensation
Arthritis	Near the heart
Intervetebral disc syndromes	Over any metallic implant (e.g., joints, pins, or IUD)
Joint pain	
Neuritis	Over scars and adhesions
Myalgia	Pacemakers
Sciatica	Pregnancy
Sprains and strains	Transcranially
	Treatment on a metallic table

High Voltage Pulsed Galvanic

Vasodilation, healing of superficial wounds, reduction of edema, pain management, muscle stimulation.

Uses low frequency 2–200 Hz typical (< 1 kHz), < 500 V, 1.2–1.5 mA, 1–600 mS.

Indications	Contraindications
Adhesions	Areas of diminished sensation
Circulatory stasis	Metallic implants
Edema	Metastatic carcinoma
Muscle spasm	Over or through heart
Muscular atrophy	Over open wounds
Pain	Pacemakers
Passive exercise	Pregnancy
Restricted joint movement	Transcranially
Trigger points	

Interferential

Pain due to traumatic injuries, post-operative pain, joint conditions, myalgia and tendinitis, bursitis, edema, hematoma. Nerve blocks via Wedensky Inhibition occur when the frequency of the stimulation is faster than the frequency of the action potential (due to its shorter wavelength), because the nerve cannot recover. With continued stimulation, the nerve becomes partially insensitive. The maximum frequency of an action potential lasting 10 mS is 100 Hz.

Generally uses medium frequency combination of 4000 and 4100 Hz = 100 Hz, at 4–15 mA.

Indications		Contraindications
Anterior tibial syndrome	Myositis	Abscess
Bursitis	Neuralgia	Anxiety
Bronchial asthma	Neuroma	Carotid sinus area
Capsulitis	Osteoarthritis	Circulation block
Causalgia	Pain	Heart area
Cholecyctitis (chronic)	Periarthritis	Hyperpyrexia
Effusions	Phantom limb pain	Menstruation
Epicondylitis	Post-traumatic edema	Metastatic carcinoma
Facial palsy	Prostatitis	Pacemakers
Fibrositis	Psoas syndrome	Pregnancy
Frozen shoulder	Rheumatic disorders	Thrombophlebitis
Hematoma calcification	Sciatica	Transcranially
Hemiplegia	Shoulder–arm syndrome	Tuberculosis
Herpes zoster	Spasm	Varicosities
Incontinence	Spondylitis	
Intermittent claudication	Sprains and strains	
Intervertebral disc syndrome	Spurs	
Ischialgia	Stiffness	
Joint deformity	Sudeck's atrophy	
Low back pain	Synovitis	
Lymphedema	Thoracodynia	
Myalgia	Trigger points	
	Vasospasm	

Laser ("Cold Laser")

Nanosecond pulse widths, usually 500–5000 Hz, 15–25 W (< 25 mW actual). *Avoid eyes.*

Indications	Contraindications
Bursitis	Near eyes
Degenerative joints	Over thyroid gland
Diseases of the oral cavity (stomatitis, post-extraction problems, ulcers, herpes labialis)	Over pacemakers
	Pregnancy
	Tumors
Post-operative or -traumatic musculoskeletal complaints	
Scars	
Ulcers (decubitus and herpetic)	

Microcurrent Electrical Therapy (MET)

Acute, chronic, and post-operative pain, initiating and accelerating healing.

Often references Arndt's Law: Weak stimuli excite physiological activity, moderate stimuli favor it, strong stimuli retard it, and very strong stimuli arrest physiological activity. At 500 μA adenosine triphosphate (ATP) increases by 500%, but drops below baseline above 5 mA (Chang, Van Hoff, Bockx, et al., 1982). At 100–500 mA, amino acid transport rises 30 to 40% above controls.

Uses low-frequency biphasic currents of < 2 S, 0.3–100 Hz, < 1 mA.

	Indications	
Systemic Pain	**Head and Neck Pain**	**Abdominal Pain**
Arthritis	Cervicogenic headache	Bladder pain
Bursitis	Cluster headache	Bowel stasis
Cancer	Dental disorders (periodontal and orthodontic pain)	Diverticulosis
Causalgia	Facial palsy	Dysmenorrhea
Cholecyctitis (chronic)	Migraine	Labor
Decubital ulcers	Sinusitis	Post-operative pain
Effusions	Sprains and strains	Prostatitis
Fibrositis	Suboccipital headaches	
Hematoma calcification	Tinnitus	
Hemiplegia	Temporomandibular joint disorder	
Herpes zoster	Tension headache	
Ischialgia	Torticollis	
Lymphedema	Trigeminal neuralgia	
Multiple sclerosis	Whiplash	
Myalgia		
Myositis		
Neuralgia		
Neuroma		
Osteoarthritis		
Pain (systemic and idiopathic)		
Phantom limb syndrome		
Post-traumatic edema		
Raynaud's disease		
Rheumatoid arthritis		
Scars		
Synovitis		
Trigger points		
Back Pain	**Lower Extremity Pain**	**Upper Extremity Pain**
Coccydynia	Ankle pain	Carpal tunnel syndrome
Failed back surgery	Anterior tibial syndrome	Epicondylitis
Intercostal neuralgia	Foot pain	Frozen shoulder
Intervetebral disc syndrome	Fractures	Hand pain
Low back pain	Joint mobilization	Peripheral nerve injury
Lumbrosacral pain	Knee pain	Shoulder–arm syndrome
Radiculitis	Passive stretch pain	Sprains and strains
Spasm	Sciatica	Subdeltoid bursitis
Sprains and strains	Sprains and strains	Wrist pain
Thoracodynia	Spurs	
Whole back pain	Tendonitis	
	Thrombophlebitis	
	Contraindications	
Carotid sinus area	Demand type pacemakers	Pregnancy

Russian Stimulation

Muscle stimulation primarily for post-operative rehabilitation.

Uses medium frequency 2500–4000 Hz, 50 Hz, 0.2–0.4 mS

Shortwave Therapy (Diathermy)

Increases elasticity in connective tissue (particularly skin), muscles, ligaments, and joint capsules. Generally used for vasodilation, wound healing (use only after 2 to 4 days), arthritis, bursitis, sinusitis, tendonitis, contusion, rupture, fracture, hematoma, herpes zoster, neuropathy, deep muscle pain and spasm.

Diathermy creates heat but does not depolarize nerves. *Remove all metals to a distance of at least 1 m. Contraindicated if there is any implanted metal. Patients should be dressed in a gown with a towel under the electrodes.*

Uses high-frequency >300 kHz, short wavelengths 3–30 m. Typically, 27.12 MHz, 65–400 mS, 32 W average (< 200 W).

Indications	Absolute Contraindications	Relative Contraindications
Amenorrhea	Fractures (recent)	Areas of decreased vascularity
Brachial plexus neuritis	Hearing aids	Arteriosclerosis (advanced)
Bronchiectasis	Hemoptysis, epitaxis, melena, and other hemorrhagic tendencies	Hypothermesthesia
Bronchitis	Malignancy	Infants and debilitated elderly
Bursitis (subacute and chronic)	Menstruation	Intrauterine device (metallic)
Colic	Metallic dental appliances and fillings	Metallic buttons, zippers, hairpins, buckles, clasps, keys, knives, etc.
Contusions	Metallic implants	Nondraining cellulitis
Dislocations	On a metal table	Osteomyelitis
Diverticulitis	Over adhesive strapping	
Dysmenorrhea		
Epicondylitis		
Fibrositis		
Fibrous fixation/ankylosis		

Furuncle/carbuncle	Over casts	Osteoporosis (advanced)
Hypertonia	Over moist dressings	Over growing epiphyseal plate
Intercostal neuralgia	Pacemakers	Patients on anticoagulants, cortisone, gold therapy
Ischialgia (chronic)	Peptic ulcers	Peripheral vascular disease (occlusive)
Intervetebral disc syndrome	Pregnancy	Poliomyelitis (acute stage)
Low back pain	Pyretic states	Polyneuritis with impaired circulation
Mastitis	Rheumatoid arthritis (acute)	Suppurating inflammatory process
Myalgia	Septic arthritis (acute)	Thrombosis
Myositis	Tuberculosis (pulmonary or joint)	Transcranially
Neuritis		Varicose veins
Osteoarthritis		
Pelvic inflammatory disease (subacute, chronic)		
Pleurisy		
Prostatitis		
Pyelitis (subacute, chronic)		
Rheumatoid arthritis (subacute, chronic)		
Sprains and strains		
Tenosynovitis		

Transcutaneous Electrical Nerve Stimulation (TENS)

Acute, chronic, and post-operative pain.

Uses low-frequency biphasic currents of 75–400 mS, 50–150 Hz, < 100 mA.

	Indications	
Systemic Pain	**Abdominal Pain**	**Back Pain**
Bursitis	Bladder pain	Coccydynia
Cancer	Bowel stasis	Intercostal neuralgia
Causalgia	Diverticulosis	Intervertebral disc syndrome
Ischialgia	Dysmenorrhea	Low back pain
Neuralgia	Labor	Lumbrosacral pain
Osteoarthritis	Post-operative pain	Radiculitis
Passive stretch pain		Sprains and strains
Rheumatoid arthritis		Thoracodynia
Synovitis		Whole back pain
Lower Extremity Pain	**Upper Extremity Pain**	**Contraindications**
Ankle pain	Carpal tunnel syndrome	Metallic implants
Foot pain	Epicondylitis	Metastatic carcinoma
Fractures	Frozen shoulder	Near carotid sinus area
Joint mobilization	Hand pain	Over or through heart
Knee pain	Peripheral nerve injury	Pacemakers
Sciatica	Sprains and strains	Pregnancy
Sprains and strains	Subdeltoid bursitis	Transcranially
Tendonitis	Wrist pain	
Thrombophlebitis		

Ultrasound

Promotes blood circulation; improves metabolism, muscle relaxation, pain control; increases elasticity of connective tissues. Used to treat tendon adhesions and scars, post-traumatic injuries, binding tissue contractions (scars), Dupuytren's Contracture, bursitis, capsulitis, tendonitis, and chronic open wounds. Micromassage, microdestruction, and heat generation.

May cause mechanical or thermal tissue damage. Overdose may decrease blood sugar levels, cause fatigue, nervousness, irritability, constipation, and a tendency to catch cold. Do not use over pregnant uterus, heart, testicles, spine, areas of thrombophlebitis, infections.

High frequency mechanical vibrations using piezoelectricity > 20 kHz (typically between 0.8 and 3 Mhz) and 0.1–3 W/cm^2.

Indications		Contraindications
Bursitis (subacute, chronic)	Sprains and strains (subacute, chronic)	Acute infection
Calcific bursitis	Sudeck's atrophy	Areas of thermohypersthesia
Causalgia	Tendonitis (subacute, chronic)	Near hearing aid
Decubital ulcers	Trigger points	Near malignant lesions
Fibrositis (subacute, chronic)	Varicose ulcers (chronic)	Near metallic implants
Fibrotic polymylosis		Near pacemakers
Herpes zoster		Occlusive vascular disease
Joint contractures		Over bony prominences
Myalgia		Over epiphyseal plates of growing children
Neuralgia		Over nerve plexuses
Osteoarthritis		Over suspected embolus
Painful neuroma		Over the eye
Periarthritis (nonseptic)		Over the heart
Radiculitis (subacute, chronic)		Over a pregnant uterus
Raynaud's disease		Over the reproductive organs
Rheumatoid arthritis (subacute, chronic)		Over spinal cord after laminectomy
Scars		Radiculitis (acute)
Shoulder–hand syndrome		Tendency to hemorrhage
Spondylitis		Transcranially

SUMMARY

One must stray from the routine procedures of today in order to create the advances of tomorrow. There is still a lot to learn about bioelectricity and electromedicine. In order to do so, we must first acknowledge that there is another side of physiology. Everyone concerned about health should demand widespread access to conservative, safe, alternative care. To lessen human suffering is a notable goal. That we have not been able to achieve enough of this to date without causing undo harm is a good indication that the answers must lie elsewhere. Biophysics must be better understood to realize the actual basis for the control of the regulatory processes of life.

Even at its present state of evolution, electromedicine offers an unprecedented conservative, cost-effective, fast, safe, and powerful tool in the management of the pain patient. As such, it should be the first priority on the list of treatment options.

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