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The Cellular Physiology of Tissue Self-Repair by Micro-Current Technology

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Electrical resistance of tissue with pathology (after the initial acute phase) becomes higher than that of the immediately surrounding area, which is either normal or less pathological. Regeneration is a series of endothermic, electrochemical reactions. This means that electricity, in miniscule quantities, is necessary for the cells to complete the regenerative process.

The tissue in the area of pathological involvement needs "fuel" in the form of electricity to return to a healthy, normal state. The patients' body contains more than a sufficient quantity of energy to produce the desired effect. Unfortunately, the electrical resistance in the area of involvement when incompletely healed becomes so high that the body's energy flow will not enter the area. This phenomenon occurs because the primary laws of physics require that energy travel only via the path of least resistance.

As a result, electrical currents traveling in the body will circumvent the area of prolonged pathology. It will always take the path of least resistance, which is around, rather than through, the area of involvement. To assist the body, we must enable the micro-electricity to pass into the area of pathology while still obeying these laws. We can do this by increasing the body's ability to generate electrical activity and store additional energy in the area of involvement.

This is done, by charging the tissue in a manner similar to "jump starting" a battery. Living tissue cells, just like battery cells, have the ability to hold an electrical charge. The greater the charge on the cell, the less resistant it is to the flow of electrical current. As the cell charge increases, the molecular kinetic energy in the cell increases. The electro-vibratory rate (EVR) of the cell's molecular structure must increase with the increased kinetic activity (energy of movement).

An increased EVR will be coupled in direct proportion with increased electro-conductivity (decreased electrical resistance). While functioning like a battery, the charged cell provides some of the energy which is involved in the energy flow equation. In other words, the addition of electrical energy to an area of pathology increases the electrical conductivity of the area and hence allows the body's own micro-electricity to enter the area and affect the tissue.

The term for the quantity of charge that a cell can maintain is "capacitance." As the general health of the cell improves, the capacitance increases. Biologically, the capacitance of the cell is directly proportional to the concentration of ATP in the cell and ranges from about .1 to 3 microfarads.

ATP is at least partially responsible for binding electrons, which cumulatively represent the electrical charge and usable energy of the cell. Areas of the body, which manifest pain, are often deficient in ATP. It follows then, that the electrical energy of these areas must be below standard because the body's electrical flow cannot penetrate the resistance.

ATP concentration serves a direct vital function in the active transport mechanism known as the Sodium Pump function. Active transport means that this system, which is directly responsible for the transmembrane movement of sodium, potassium, calcium, metabolic waste and metabolites, requires large amounts of energy to move vital ions in and out of cells. Metabolic waste builds up in toxic concentrations when a cell is not respirating properly. The energy which is released, when ATP breaks down to ADP, fuels the reactions which establish balanced membrane potential gradients. It also brings vital metabolites into the cell in exchange for metabolic wastes, which are dumped into the general circulation to be detoxified and excreted. What we have when the Sodium Pump is not functioning is a hypo-polarized, toxic, starving cell.

Re-establishment of the Sodium Pump function occurs when the increase in intracellular current increases mitochondrial function. The increased EVR of the mitochondria enhances the production of ATP in the cytoplasm. The ATP provides the fuel for the transmigration of metabolite and metabolic waste across the cell membrane, as well as the reestablishment of cellular bio-electronic ionic concentration gradients (re-polarization).

What this means is that cell membrane potential (normally .85mv in healthy tissue) is reestablished, levels of intracellular metabolic waste (i.e. lactic acid, etc.) are reduced and fresh concentrations of usable cellular metabolites are introduced into the exhausted cell. At this point the cell can enter its regenerative phase, pain levels are noticeably reduced and tissue regeneration functions are reestablished.

The investigations of living cells based on electrical concepts and using electrical techniques have been amazingly successful. For over a half-century, the membranes of cells have been researched and described. In 1991, two German scientists won the Nobel Prize for their Cell Channel findings. Their research, particularly the development of a technique called the "patch clamp," which allows the detection of electrical currents of a trillionth of an ampere in the membrane, or surface of a cell, has revolutionized modern biology.

The electrical parameters of cellular metabolism are well known facts and include: resting potential, capacitance, resistance, conductance, impedance, polarization, current density, inductive reactance and electrical phase angle, to name a few common terms.

According to Biophysicist Mark Biedebach, Ph.D., if the integrity of the epidermal tissue is broken by a wound, there will be a net flow of ionic current through the low resistance pathway of the injured cells and the fluid exudates which lines the wound. Therefore, it is tempting to hypothesize that the ionic current flow pattern between normal and insulted tissue plays an important role in stimulating plasma membrane repair processes, essential to the restoration of that tissue to a normal functional state. It follows logically that the rates at which these processes occur may be accelerated by judicious imposition of an electric current from an outside source.

Cellular physiologists are now recognizing that stimuli which activate the most energy-requiring processes within cells do so via an increase in intracellular calcium. An increase in intracellular calcium following membrane depolarization occurs because: (1) voltage sensitive Ca channels allow extracellular Ca to enter (2) current entering the cell can cause Ca release from cellular organelles.

Biedebach suggests that the best way to alleviate pain and inflammation would be to accelerate the rate of repair of the damaged tissue cell membranes that are responsible for releasing pain-producing substances. Damaged plasma membranes release arachidonic acid, a component of the phospholipid structure of the membrane itself. From this, prostaglandins are synthesized, triggering a cascade of reactions resulting in the release of histamine and bradykinins. This can stimulate pain endings as well as partake in the inflammatory response.

Current that does eventually enter a cell alters the cell membranes' voltage in such a way that it allows influx of ions, which can turn on and accelerate biochemical processes, essential to cellular repair. If we used only DC current, the intracellular current would flow only through discrete pores or ion channels, through a low resistance pathway called tight junctions. If we use pulsed current, there will be an additional pathway for current to enter a cell through membrane capacitance. Current flow through this additional pathway increases the ratio of intracellular to extra-cellular current flow, making the current more effective.

Pulsed current with a rapid voltage rise-time is more effective because: (1) pulsed voltage must rise to its maximum value before membrane capacitance has had time to "charge up." The time it takes for membrane capacitance to charge up is a fraction of a millisecond. Therefore, it is desirable for the loaded stimulus pulse voltage to rise to its maximum in 50 microseconds or less. (2) Voltage sensitive Na and Ca channels stay open only (0.5) milliseconds after they have been opened, and they don't reopen for a brief time following closure. The stimulus pulse needs to stay on long enough so that cell membrane capacitance can charge to its maximum value before the pulse turns off. Therefore, duration should last several milliseconds to meet known cellular time constraints. These parameters are appropriately delivered by the Electro-Acuscope and Myopulse.

The Discovery, Research and Role of Micro-Currents

In the 1830's, Carlos Matteucci, proved that an electrical current was generated by injured tissue. Existence of wound currents was first experimentally observed by Dubois-Reymond in 1843, where approximately 1 microampere of current was measured from a wound in human skin. Illingsworth and Barker, (1980) some 120 years later measured the current generated by the amputated stump of a child's finger tip. These stump currents were found to be within the range of 10-30 micro-amps per square centimeter. Their findings were repeated by several researchers (Borgens et al 1980; Barker, Jaffe, and Vanable 1982) although only recently have we been able to understand the implications of these findings and to therapeutically apply these micro-currents.

Micro-current first gained popularity in treatment of wounds, nonunion fractures and bone implants, where it has become an accepted procedure with orthopedic surgeons. Most of the published research on the effects of micro-

current on soft-tissue injury have described the accelerated healing of skin ulcers and associated suppression of bacterial growth. (Illustrated studies available upon request)

One of the first studies documenting the positive effects of micro-current stimulation on wound healing and bone fractures was the team of Wolcott, et al, in 1969. These researchers applied stimulation in the range of 200 - 800 micro-amps to a wide variety of wounds.

A control group was treated with ordinary wound care methods. The treated group showed 200 - 350% faster healing rates than controls, with stronger tensile strength of scar tissue and antibacterial effects in infected wounds. Gault and Gatens used a similar procedure in 1975 - 1976 on patients with diagnosis including quadriplegia, CVA, brain tumor, peripheral vascular disease, burns, diabetes, TB, fracture and amputation. Their results demonstrated healing times in the treated group about half that of the controls. Many other researchers followed variations of these models and published similar results.

Micro-amp stimulation has also been called “bio-stimulation” or “bio-electric therapy” because of its ability to stimulate cellular physiology and growth. In a study with important implications for micro-current electrotherapy, Cheng et al (1982) studied the effects of electric currents of various intensities on three variables critical to the healing process:

At 500 micro-amps, ATP generation (or cellular energy production) increased about 500% and amino acid transport was increased by 30 to 40 percent above control levels using 100 to 500 micro-amps. When currents were increased to the milli-ampere range, ATP generation was depleted, amino acid uptake was reduced by 20-73 percent and protein synthesis was inhibited by as much as 50%. These findings suggest that the higher milliamp currents inhibit healing whereas the lower microampere currents promote healing.

Additional studies with isolated tissue or cultured cells provide compelling evidence that the intracellular rates of ATP re-synthesis, protein synthesis and DNA replication are increased as a result of direct electrical stimulation of human fibroblasts.

“Weak stimuli increase physiologic activity and very strong stimuli inhibit or abolish activity.” Arnold- Shulz Law (Dorland 1985)

Other studies have demonstrated the effects of micro-current in accelerating healing of bone, tendon repairs, and collagen remodeling. The Nobel prize that went to the two German scientists in 1991 for their work in detecting subtle electrical currents in all types of cell membranes throughout the body, opened the way for greater understanding of the mechanisms through which externally applied currents can affect organic functions.

William Stanish, M.D., physician for the Canadian Olympic team, found that implanted electrodes delivering 10-20 micro-amps of electrical current hastened recovery from ruptured ligaments and tendons. Using micro-current stimulation, Stanish shortened the normal 18-month recovery period to only 6 months. (Stanish 1984).

The first commercial device outputting micro-current stimulation was the Dermatron, developed in the 1960’s by Dr. Reinhold Voll of Germany. Although this device was primarily used for electro-diagnostic testing, it was also used to apply therapeutic micro-current stimulation to the body.

Through the research of Dr. Voll and his colleagues, the following effects of micro-current on the body were documented: 1) Spasmolysis of smooth muscles of the circulatory, lymphatic and hollow organ systems; 2) Tonification of elastic fibers, for example, increasing lung capacity in emphysema patients; 3) Reduction of inflammatory processes through reducing infiltrative, proliferative, and exudative processes; 4) Reduction of degenerative process by restoring diffusion-osmotic equilibrium; 5) Restoration of polarization to the nerves; 6) Stimulus of ATP function in freshly injured striated muscle.

To obtain these effects, micro-current in the 0.5 - 1.0 Hz range were applied to whole limbs or selected acupuncture points. Voll and his colleagues were able to chart specific frequencies in that range that had pronounced effects on different tissue systems. This very low frequency range, which is resonant with the normal electrical activity of the human body and the primary frequency of the natural earth, is the main domain of modern micro-current therapy.

Another explanation of the efficacy of micro-current is through comparison to acupuncture. Many of the effects of acupuncture have been documented in the Journal of the American Medical Association. A “meridian,” or energy communication system connecting all parts of the body, has been described by traditional Chinese and Japanese acupuncture. The work of Becker and Nordenstrom in particular recognize the action of subtle electrical currents, via the perineural cells and circulatory system, respectively, in explaining at least part of the meridian phenomenon.

Needle acupuncture is the original micro-current therapy, as traditional acupuncture needles generate measurable

electrical charges when twirled in the skin by a doctor's fingers, and needles left "in situ" tend to drain off excess electric charge from tense or inflamed tissue. Modern micro-current therapy offers a simplified and non-hazardous, non-invasive method for all types of medical practitioners to offer the benefits of acupuncture stimulation to their patients.

Micro-Current Therapy with the Acuscope and Myopulse

It was in the late 1970's that brought the development of the Electro-Acuscope and Myopulse system; the first in a line of intelligent neural micro-amperage technology. It is a multidimensional analytical microprocessor, constructed electronically to evaluate the transient electrical behavior of the living cell membrane.

By application of advanced bio-processor technology, the Acuscope and Myopulse system has the capability of providing instantaneous, moment by moment, feedback-assisted computer-modulated electronic pulse trains of infinite variation to induce bio-electronic harmony in disrupted tissue.

The heart of the system is an analog to digital conversion processing unit assisted by P.A.L. (programmable-array-logic-gates) technology. The input-output loop is the key feature that sets it apart from all other electro-therapeutic instrumentation. This feature utilizes "space-age" technology to integrate electronics with feedback, allowing for two-way communication between tissue and instrument(s). In other words, biofeedback devices combined with solid state circuitry (computer microprocessors with preprogrammed memory of tissue equilibrium values) enables the body itself to automatically control the necessary treatment parameters required for healing by regulating output voltage levels from the instrument based on amplified and filtered input of biological events.

All biological events observed within the input-output loop are defined in accordance with the master program -- a neural network thermodynamic model which performs high-speed formulations. This technology communicates with the body by monitoring and transmitting corrective treatments based on existing conductivity, cellular capacitance, and other electromagnetic events.

This is accomplished by the design of equilibrium principles, stored in a unique, proprietary circuit microchip and other discrete components. These complex units acquire the actual value of the treatment area through the input electrodes and then compare them to the desired value. If there is any difference between the actual tissue value and the preset equilibrium principles, a digital signal is sent out to another component to process and initiate appropriate responses to achieve a steady state and promote normal cell membrane resting tension. By normalizing cell membrane resting tension, other cellular dependent electrical characteristics such as capacitance, polarity, resistance and Ph can be normalized.

Using a computerized procedure called Fast Fourier Transform Analysis, it is possible to determine numerous parameters from current and voltage waveforms. The Acuscope and Myopulse samples a series of data values from the waveforms of the stimulus current, as well as the voltage between the electrodes. Analog-to-digital conversion circuitry continuously computes magnitude and phase angle of the impedance characteristics over the range of frequencies that they vary. If these characteristics are different than those found in normal tissue, or if changes occur during stimulation, the digital program then adjusts the delivery of pulses (rise time, phase angle, current overshoot, etc.) to deliver optimal current formation to stimulate intracellular repair processes in the most beneficial way.

If adjustments are not made in magnitude and waveform, there is no assurance that the current, which flows intra-cellularly, is maintained at optimal value during treatment. This makes monitoring of the impedance values (or tissue conductance) highly desirable and necessary in order to promote cellular repair and the advantage of using computer-assisted circuitry (such as that found in the Electro-Acuscope and Myopulse) to regulate and continually adjust the magnitude and/or wave-shape of the stimulus pulses.