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Research Paper

Ultra-low microcurrent in the management of diabetes mellitus, hypertension and chronic wounds: Report of twelve cases and discussion of mechanism of action

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Abstract

Oxidative stress plays a major role in the pathogenesis of both types of diabetes mellitus and cardiovascular diseases including hypertension. The low levels of antioxidants accompanied by raised levels of markers of free radical damage play a major role in delaying wound healing. Ultra-low microcurrent presumably has an antioxidant effect, and it was shown to accelerate wound healing. The purpose of the study is to investigate the efficacy of ultra-low microcurrent delivered by the Electro Pressure Regeneration Therapy (EPRT) device (EPRT Technologies-USA, Simi Valley, CA) in the management of diabetes, hypertension and chronic wounds. The EPRT device is an electrical device that sends a pulsating stream of electrons in a relatively low concentration throughout the body. The device is noninvasive and delivers electrical currents that mimic the endogenous electric energy of the human body. It is a rechargeable battery-operated device that delivers a direct current (maximum of 3 milliAmperes) of one polarity for 11.5 minutes, which then switched to the opposite polarity for another 11.5 minutes. The resulting cycle time is approximately 23min or 0.000732 Hz and delivers a square wave bipolar current with a voltage ranging from 5V up to a maximum of 40 V. The device produces a current range of 3 mA down to 100 nA. Twelve patients with long standing diabetes, hypertension and unhealed wounds were treated with EPRT. The patients were treated approximately for 3.5 h/day/5 days a week. Assessment of ulcer was based on scale used by National Pressure Ulcer Advisory Panel Consensus Development Conference. Patients were followed-up with daily measurement of blood pressure and blood glucose level, and their requirement for medications was recorded. Treatment continued from 2-4 months according to their response. Results showed that diabetes mellitus and hypertension were well controlled after using this device, and their wounds were markedly healed (30-100%). The patients either reduced their medication or completely stopped after the course of treatment. No side effects were reported. The mechanism of action was discussed.

Key words: Diabetes mellitus, hypertension, wound, ultra-low microcurrent

Introduction

Diabetes mellitus and cardiovascular diseases are challenging medical and social problems. Patients with diabetes mellitus are at a higher risk of developing vascular dysfunction and hypertension. The real etiology of these diseases is not well understood. However, cumulative evidence suggests that oxidative stress may play a key role in the development of diseases. It has been found that oxidative stress is associated with several cardiovascular diseases, including atherosclerosis, hypertension, heart failure, stroke, and diabetes, and plays a fundamental role in endothelial dysfunction associated with these diseases (1-6). Further, oxidative stress plays a major role in the pathogenesis of both types of diabetes mellitus. High levels of free radicals and the decline of antioxidant defense mechanisms lead to damage of cellular organelles and enzymes, increased lipid peroxidation, and development of insulin resistance (7). The vascular and systemic complications in diabetes are associated with hyperglycemia-induced overproduction of reactive oxygen species (8,9). Other studies showed that overproduction of reactive oxygen and nitrogen species, lowered antioxidant defense and alterations of enzymatic pathways in humans with poorly controlled diabetes mellitus can contribute to endothelial, vascular and neurovascular dysfunction (10). Insulin resistance is associated with reduced intracellular antioxidant defense, and therefore diabetic patients may have a defective intracellular antioxidant response that causes diabetic complications (11-13).

The combination of the low levels of antioxidants and raised levels of free radical play a major role in delaying wound healing in aged rate and diabetic rats (14). It has been found that chronic leg ulcers contain localized oxidative stress (15). The recent finding revealed that insulin resistance is associated in humans with reduced intracellular antioxidant (11). Interestingly, antioxidants improve insulin sensitivity and help in wound healing (16,17).

Along with others, the investigators have used microcurrent for treatment of chronic wounds and ulcers (18-20). In an earlier work, The Electro Pressure Regeneration Therapy (EPRT) device which produces a current range of 3 mA down to 100 nA, was used for treatment of chronic wounds and ulcers associated with chronic disease (21). The device used in the experiment was supposed to deliver electrons to tissues and then saturated free radicals with required electrons. The actual tissue regeneration, along with concomitant improvement noted in the general condition of the patient, points to a highly potent antioxidant effect on local tissues, as well as on tissues in general. This reduces free radicals and might facilitate tissue repair. This device is used as a model to deliver electrons to the body, including mitochondria and presumably working as an antioxidatant device. It was thought reasonable to use on patients with diabetes mellitus, hypertension and chronic wounds, to test whether delivering electrons to the body might help eliminate underlying oxidative stress, stabilize mitochondria and prevent further formation of excess free radicals.

Patients and methods

Electro Pressure Regeneration Therapy Device

The EPRT device is an electrical device that sends a pulsating stream of electrons in a relatively low concentration throughout the body. The device is noninvasive and delivers electrical currents that mimic the endogenous electric energy of the human body. It is a rechargeable battery-operated device that delivers a direct current (maximum of 3 milliAmperes) of one polarity for 11.5 minutes, which then switched to the opposite polarity for another 11.5 minutes. The device was designed to switch the direction of current flow halfway through the cycle. The resulting cycle time is approximately 23min or 0.000732 Hz and delivers a square wave bipolar current with a voltage ranging from 5V up to a maximum of 40 V. The device produces a current range of 3 mA down to 100 nA. Electrodes are applied in 2 layers, and tap water is used as the conducting medium. The wraps cover a large surface area, thus reducing resistance and allowing an optimum number of electrons to flow freely into tissues.

Patients and treatments

Case 1: The first patient was a 74 year old female with poorly controlled non-insulin- dependent diabetes, hypertension, and hypercholesterolemia. She was seen with vomiting, diarrhea and gangrene of second toe on left foot. Two weeks prior to admission, the patient had sustained fall in the bathroom resulting in a left ankle fracture with vomiting and diarrhea for seven days. The patient was treated with metformin and augmentin. Upon examination, the patient was afebrile with stable vital signs, and femoral pulses were present bilaterally. Popliteal and pedal pulses were absent bilaterally with poor capillary refill. The left foot was red and inflamed up to and including the medial malleolus. The lateral aspect of the great toe and second toe turned black. Laboratory investigation revealed elevated blood glucose (17.9 mmol/L) and hyponatremia (Na+ 128 mEg/L). The

patient underwent a medial forefoot amputation as part of her management. Within 28 days after surgery, the 4th and 5th toes become discolored, dusky purple and black. The patient also developed a large blood blister over her heel. Vascular opinion was for a below knee amputation. The patient was self- discharged against medical advice. The patient was started on treatment by Electro Pressure Regeneration Therapy device (EPRT) while she was in hospital. She continued daily treatments on the EPRT device at home, along with a diabetic diet. The left foot continued to improve and heal, and her remaining gangrenous toes eventually fell off. Her blood pressure at admission was 166/53 with use of Lisinopril, which was dropped and eventually ceased as her BP continued to drop; 146/68, 129/64, 144/67 in second, third and fourth weeks after treatment, and to 128/66 during 6th to 8th weeks post-treatment while the patient was on no medication. Her blood sugar was improved and HbA1c was dropped from 9.8 before treatment to 7.6, 6.5, 5.9 and 5.5 during 9 months after commencement of treatment. The patient eventually stopped diabetic and hypertensive medications. To date her HbA1c remains below 6 on diet alone.

Case 2: The second patient was a 65 year old male with a long history of non insulin dependent diabetes and hypertension. Diabetic neuropathy had affected his feet and he could not feel the shoe rubbing. A small superficial ulcer developed on his 5th toe which became infected and subsequently, the 5th toe was amputated. His condition rapidly deteriorated and he developed necrotizing fasciitis and osteomyelitis. Consequently, he had surgery removing tendons, skin and the capsular linings of joints from his right foot. The patient was discharged after ten weeks in hospital with a large, infected, open wound requiring community nurses to do wound management. The patient was treated by the Electro Pressure Regeneration Therapy device; the wound was healed completely without further management and the diabetes was well controlled. HbA1c dropped from 7.3 to 6.6 after treatment. His blood pressure was 202/99 before the treatment, which was dropped to 155/73 after two weeks. His blood pressure continued within normal range with the use of the Electro Pressure Regeneration Therapy device 2-3 times weekly.

Case 3: A 70 year old female was diagnosed with hypertension, epilepsy osteoarthritis and rheumatoid arthritis. Her blood pressure was 147/84 which was dropped to 138/72 three weeks after the treatment with the Electro Pressure Regeneration Therapy device. She continued using the EPRT device twice weekly and her blood pressure was under control without the use of antihypertensive medications.

Case 4: A 77 year old female with hypertension, hypercholesterolemia, hypothyroidism, and type 2 diabetes (NIDDM) was treated with the Electro Pressure Regeneration Therapy device. Her blood pressure before treatment was 158/81 which was dropped to 125/65 after 1 week. Her blood pressure continued to be normal with use of the EPRT device despite discontinuation of antihypertensive medications. HbA1c was 7.8 before treatment which decreased to 6.9 and continued to be low during one year follow-up.

Case 5: A 67 year old female with hypertension and osteoarthritis was treated with the Electro Pressure Regeneration Therapy device. Her blood pressure was 157/91 which dropped to 149/86 after 3 weeks.

Case 6: A 70 year old female with hypertension, fibromyalgia, hepatitis, hypercholesterolemia, tuberculosis and a stroke was treated with the Electro Pressure Regeneration Therapy device for her hypertension. Her blood pressure was 134/84 before treatment which was dropped to 117/73 within 4 weeks after treatment despite discontinuation of her antihypertensive medication.

Case 7: A 75 year old female with hypertension and benign postural vertigo was treated with the Electro Pressure Regeneration Therapy device. Her blood pressure was 157/86 before treatment, which was dropped to 138/76 and continued within normal limits while receiving one treatment per week.

Case 8: A 53 year old female with type 1 diabetes (IDDM) from the age of 12, suffered renal failure as a result of her diabetes and underwent a kidney and pancreatic transplant in 1994. She also has hypercholesterolemia, left ventricular failure, renal failure and a history of a coronary artery bypass graft. She then started treatment with the Electro Pressure Regeneration Therapy device. While she is not considered to currently have diabetes her HbA1c dropped over the time period she was receiving treatments from 5.4 to 5.1. This was matched by her Blood Sugar Level (BSL) which also stabilized while she was receiving treatment over this period of time.

Case 9: A 32 year old female with type 1 diabetes (IDDM) and no other concurrent health problems was treated with the Electro Pressure Regeneration Therapy device. She received 8 treatments over a two week period. HbA1c before treatment was 8.1 and was dropped to 7.1 after treatment. Her insulin requirement was also reduced.

Case 10: A 59 year old female with type 2 diabetes (NIDDM), hypertension, fibromyalgia, chronic active hepatitis, and Bowens disease was treated with the Electro Pressure Regeneration Therapy device.

Her blood sugar was normalized and HbA1c dropped from 7.2 to 6.3 after the treatment. Her HbA1c showed a slight increase to 6.4 within three months after therapy was discontinued.

Case 11: A 70 year old female with type 2 diabetes (NIDDM), osteoarthritis, chronic pain and multiple operations was treated with the Electro Pressure Regeneration Therapy device. Her average Blood Sugar Level (BSL) before treatment was 9.8, and dropped to 7.4 and 7.1 after three and six months of treatment. She was treated twice weekly with the EPRT device.

Case 12: A 68 year old male with type 2 diabetes (NIDDM), hypertension, stroke, chronic pain and polio was treated with the Electro Pressure Regeneration Therapy device. HbA1c before treatment was 7.8, which was dropped to 6.6 during treatment. He was treated three times per week most weeks during a six month period. Upon discontinuation of therapy HbA1c increased to 7.8.

Discussion

The results of this preliminary trial showed that ultra-low microcurrent has apparent therapeutic effects on diabetes, hypertension and wound healing. Presumably, one of mechanisms of action is its antioxidant activity. The action of EPRT is to produce electrical pressure rather than an electrical jolt as produced by a Transcutaneous Electrical Nerve Stimulator. Whereas Transcutaneous Electrical Nerve Stimulator device can produce a current varying from 1uA to 100 mA, the EPRT ranges from 100 nA to 3 mA. Moreover, Transcutaneous Electrical Nerve Stimulator frequency range is from 0.5 to 40,000 Hz with a range of cycle times from 2 seconds to 0.025 milliseconds. The EPRT has a frequency of approximately 0.000732Hz which gives a frequency time of 22.77 minutes. Namely, Transcutaneous Electrical Nerve Stimulator with power of 10 mA and a frequency of 1 Hz is delivering approximately 6x10 (14) electrons per cycle. As the cycle is 1 second all these electrons were delivered in that period as a jolt. The EPRT at a setting of 100 nA is delivering 8.129x10 (14) per cycle. But as this amount is being delivered over a 23 minute period (at rate of 6x10 (11) electrons per second) this behaves as a pressure instead of a jolt. This steady stream of electrons is what makes the EPRT a super antioxidant and not only does this correct malalignments in the cells electrical system but it also eliminates free radicals and then stimulates the mitochondria to produce ATP.

Microcurrent has been successfully used to enhance soft tissue healing and to treat fracture nonunion (22,23). Microcurrent relieves myocontracture and can enhance conventional rehabilitation programs for children with cerebral palsy (24). Studies from the 1980s suggest that microcurrent therapy is effective at relieving the side effects of radiation therapy (25). The investigators have found that direct electrical therapy was effective in healing gum abscess and accelerated wound healing (20). Substances that increase electrical field, such as prostaglandin E_2, enhance the wound healing rate and increase cell division (26-28). Electrical fields stimulate secretion of growth factor (28). Low mA current stimulates adenosine triphosphate production (26). It is discovered in another study that microcurrent stimulates dermal fibroblasts and U937 cells to secrete transforming growth factor-β_1, a major regulator of cell-mediated inflammation and tissue regeneration (29).

Insulin resistance plays a major role in the development of several metabolic abnormalities and diseases such as type 2 diabetes mellitus, obesity and the metabolic syndrome (30). In these conditions there is an elevation of both glucose and free fatty acid levels in the blood and an increase in oxidative stress (30,31). The high degree of oxidative stress might have an important role in decreasing insulin responsiveness (31-33).

Many studies have suggested that ß-cell dysfunction results from prolonged exposure to high glucose and elevated free fatty levels (33). High glucose concentrations induce mitochondrial reactive oxygen species, which suppresses the first phase of glucose-induced insulin secretion (34). ß-cells are particularly sensitive to reactive oxygen species because they are low in antioxidant enzymes such as catalase, glutathione peroxidase, and superoxide dismutase (35). Therefore, the oxidative stress might damage mitochondria and markedly blunt insulin secretion (34). Recent studies suggested that ß-cell lipotoxicity is enhanced by concurrent hyperglycemia and that oxidative stress may be the mediator (36,37). An increase in insulin, free fatty acid, and/or glucose levels can increase reactive oxygen species production and oxidative stress, as well as activate stress-sensitive pathways (33). Many studies show that postprandial hyperglycemia is associated with oxidative stress generation (38). Repeated exposure to hyperglycemia and increased levels of free fatty acid can lead to ß-cell dysfunction that may become irreversible over time. It has been suggested that oxidative stress might be the mediator of damage to cellular components of insulin production (33,39).

A major source of cellular reactive oxygen species is mitochondria, whose dysfunction contributes to pathological conditions such as vascular complications of diabetes, neurodegenerative diseases and

cellular senescence (40-45). Source of reactive oxygen species in insulin secreting pancreatic β-cells and cells that are targets for insulin action is considered to be the mitochondrial electron transport chain. Hyperglycemia and lipotoxicity in obesity and related disorders are associated with mitochondrial dysfunction and oxidative stress (46,47). Oxidative stress–induced activation of NF-κB signaling might be associated with the pathogenesis of insulin resistance and type 2 diabetes (48-51). In obesity and type 2 diabetes it has been reported that antioxidants and IKK-B inhibitors protect against insulin resistance (52,53).

Data show that increased lipid peroxidation in NIDDM has implications for vascular disease in diabetes (54). Oxidative stress plays an important role in the pathogenesis of cardiovascular diseases including hypertension (55). Clinical studies suggest the occurrence of increased reactive oxygen species production in humans with essential hypertension (56,57). Oxidative stress is considered to be a unifying mechanism for hypertension and atherosclerosis (58,59).

Oxygen free radicals play a major role in the failure of ischemic wound healing, while antioxidants partly improve the healing in ischemic skin wounds (60). Oxygen free radicals mediate the inhibition of wound healing following ischemia-reperfusion and sepsis (61). It seems that diabetes mellitus, cardiovascular disease, such as hypertension, and delayed wound healing have a common important basic pathogenesis, which is related to imbalance between free radical production and removal. The use of ultra-low microcurrent might help in stabilizing mitochondria, working as antioxidants and therefore, enhancing normal function of β-cells and vascular tissue. Several clinical trials have demonstrated that treatment with vitamin E, vitamin C, or glutathione improves insulin sensitivity in insulin-resistant individuals (16,62). The acute effects of hyperglycemia-dependent endothelial cells dysfunction are counterbalanced by antioxidants (63-65). But clinical trials with antioxidants, in particular with vitamin E, have failed to show any beneficial effect (66). However, antioxidant therapy with vitamin E or other antioxidants is limited to scavenging already formed oxidants and may be considered symptomatic instead of a causal treatment for oxidative stress (67). Interruption of the overproduction of superoxide by the mitochondrial electron transport chain would normalize the pathways involved in the development of the oxidative stress (68).

If our findings are proven by further studies involving a larger number of patients, ultra-low microcurrent therapy might change the concept of management of chronic disease. Conclusively, oxidative stress and oxidative damage to tissues are common pathology of chronic diseases, and using antioxidants, such as the EPRT device used in this experiment, might change the concept of management of chronic diseases.

Conflict of Interest

The authors have declared that no conflict of interest exists.

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