

## Detailed Heart Rate Variability, Exercise Tolerance, Cortical and Vas Pain Scale Analysis of Two Forms of Electro-Therapy Applied to a Patient with Chronic Back Neuropathic Pain

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### Abstract

Heart Rate Variability (HRV) and stress are closely related to health and well being in humans. The purpose of this study was to determine the influence of different electro therapy currents on various autonomic nervous system and hormonal stress markers. A detailed comparison of autonomic nervous system response to Alternating Current (AC) and Direct Current (DC), was undertaken on a single patient with a history of chronic neuropathic back pain. Evaluations entailed a baseline pain score (VAS pain scale), status of autonomic nervous system functions and hormonal cortisol levels all repeated subsequent to electro therapy using 2 separate electro modalities (AC-TENS and DC (Microcurrent Point Stimulation - MPS). MPS was applied twice, once as a non acupuncture trigger control and thereafter to active acupuncture trigger points. AC-TENS was applied transcutaneously to the same active acupuncture trigger points. The autonomic nervous system response with MPS showed a measurable improvement in parasympathetic tone, and reductions in the pain score compared to baseline measurements compared to using AC TENS. MPS significantly decreased salivary cortisol levels with both non acupuncture trigger and active acupuncture point's application, whilst AC TENS provided negative outcomes with cortisol levels, no improvement in the pain score and marked deterioration in some of the scores of sympathetic outcomes as compared to baseline. Further cohort studies are warranted to determine the validity of these outcomes. The positive results of MPS in this case study could have applications to other pathologies in consideration of the impact of sympathetic nervous system activation on the body.

**Keywords:** Alternating Current (AC); Cortisol; Direct Current (DC); Heart Rate Variability (HRV); Chronic neuropathic pain

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[11,12]. Real time analysis of HRV and sympathetic upregulation may be now accurately measured in two ways by HRV and cortisol levels [7,13,14].

HRV is able to distinguish between patients with different types of neuropathy depending on the involvement of parasympathetic or sympathetically influenced parameters [15,16]. Furthermore, this method is able to unmask early manifestations of neurological disorders prior to their detection by neurological function tests [16]. Low HRV levels have been detected in diabetic patients, especially in those with peripheral neuropathy, 30% of whom had abnormal HRV, while patients where HRV is normal, autonomic neuropathy is virtually excluded [16]; whether this is also true for peripheral neuropathy in diabetes is not known.

Traditionally, the modality of choice for electro pain management has been AC [17,18]. However, there are two known types of electrical currents, AC and DC. DC is uni directional and is applied microamp or millionth of amp (10-6 amperes) range and is called microcurrent [19-25]. AC moves back and forth and is applied in the miliamperage range (10-3 amperes), and usually called TENS or electro acupuncture [17]. It is theorized that AC and DC electro currents have different modulating affects on the autonomic nervous system [22-25].

This case study investigates the influence of AC and DC electro stimulation on autonomic nervous system functioning and stress levels of a single neuropathic back pain patient using both non acupuncture and active acupuncture points. This case study addresses the question of the scientific efficacy of various modalities of electro stimulation as there is no consensus in the literature identifying the best

### Introduction

Peripheral neuropathic pain can be caused by nerve injury or disease. Important causes include lumbar radiculopathy ("sciatica"), diabetic neuropathy, HIV related neuropathy and chronic postsurgical pain [1-3]. The impact of nerve fiber injury includes a change in nerve function both at the site of injury and areas around the injury [3].

It is widely accepted that imbalances of the parasympathetic (rest and healing, calming) and sympathetic (flight/fight/stress) branches of the autonomic nervous system are directly linked to wide variety of pain and diseases [4-10]. The sympathetic system is designed for short term survival creating a cascade of neurophysiological responses. However, it is "upregulation" or persistent tone in this system that is believed to be related to chronic diabetic disease and neuropathies

practice measures for electro stimulation on chronic neuropathic pain or stress in these patients.

Materials and Methods

Case presentation

JA is a 57 years old man with a 15 years history of low back problems who main presenting symptom was chronic pain, with accompanying weakness and tingling in the lower extremities (paresthesia). He had severe head injury in 1981 that hospitalized him for 7 days. He has had multiple broken noses, was involved in a car wreck where he suffered injuries, a motorcycle accident injuring his mouth and teeth, and received lower back surgery in 1991.

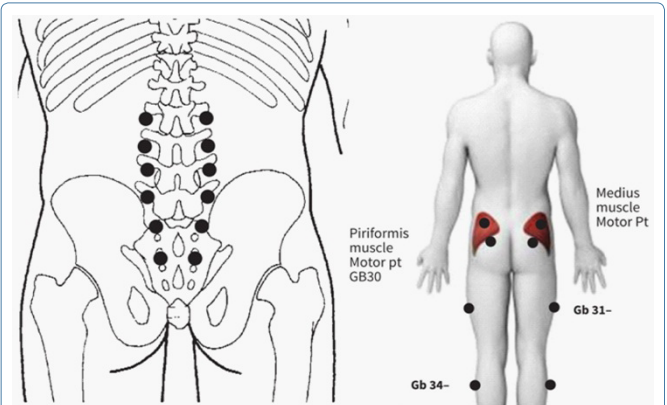
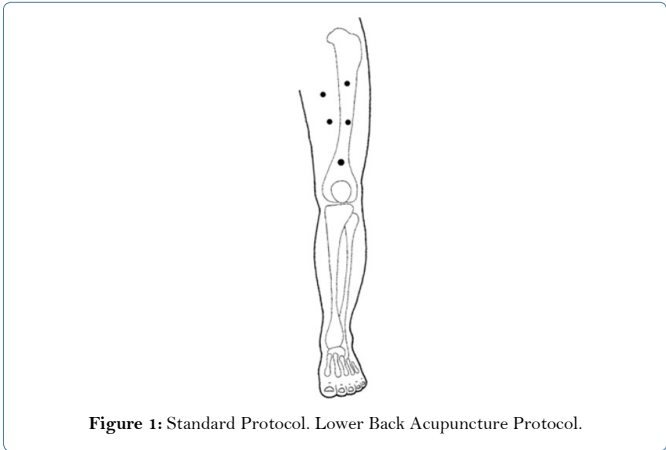
In 1996 he complained from swelling and pains his right knee, for which he underwent arthroscopy. There are no other medical issues currently other than hypertension for which he is on anti hypertensive medication.

Examination revealed signs of neuropathic degeneration with feet allodynia, paresthesia and numbness of the legs and lower back sub clinical radiculopathy from L3-L5.

His current pain is a constant of 5 out of 10 on the VAS scale. He does light activity and exercise, has a family, and is involved in community and social activities. His low back pain varies upon the type and force of activities he engages in; pain lessens with rest and short periods of stretching. He denies any changes in bowel or bladder function.

Methodology

Two modalities in total were used; first DC Microcurrent was applied by Point Stimulation (MPS) to placebo points, then traditional AC TENS (applied via pads) was applied to low back acupuncture points, then lastly DC microcurrent applied by point stimulation MPS to same low back points [17,20,21]. All treatments lasted 30 minutes, with TENS pads placement and MPS applied to the acupuncture trigger points located in par spinal muscles along the lower length of the spine (Figure 1). For placebo application, the patient was instructed and observed to randomly apply MPS to non acupuncture and non trigger points in both thighs for a period of 30 minutes (Figure 2). All treatments and data were collected immediately after electro therapy applications in single afternoon, within a 5 hours period.



**Figure 2:** HRV- TPWR - total power. Total power has been determined to be the main indicator of ANS activity and is reflective of variations in time intervals between heart beats, known as Heart Rate Variability (HRV). Low numbers indicate increased risk for heart disease.

**Autonomic Nervous System (ANS):** Assessments were taken immediately before and after electro stimulation with the ANS1 (Bio-sensor Equipment LLC, Houston TX), a sophisticated FDA approved Electrocardiogram (ECG) device that measures HRV, sympathetic, parasympathetic, adrenergic and cardiovagal functions. The ANS1 utilizes a multimodal approach to assessing both the sympathetic and parasympathetic nervous systems, galvanic skin response functions through an autonomic nerve assessment, an arterial assessment, and an assessment of cardio metabolic markers [26,27]. Included are measurements of 27 physiological “markers”, placing each patient measurement categorically into abnormal, borderline and optimal goal columns.

**HRV-total power:** Has been determined to be the main indicator of ANS activity and is reflective of variations in time intervals between heart beats, known as Heart Rate Variability (HRV). Lower than normal HRV values are associated with negative outcomes in heart disease and increased risk for diabetic neuropathy [10,28,29]. High vales (>=780) are associated with health and vigor [30,31].

**HF: High Frequency indicator of parasympathetic vagal nerve activity:** Vagal tone is an internal biological process referring to the activity of the vagus nerve which serves as the key component of the parasympathetic branch of the autonomic nervous system. Research suggests that decreased vagal activity or tone is associated with increased stress vulnerability and poor health [32]. A low value (< 220), suggests sympathetic system predominance and possibility of stress or mental anxiety [33].

**Visual Analogue Scale (VAS):** The VAS Numeric Pain Distress Scale (NPRS) was used to evaluate the patient’s pain. The NPRS is an 11 point scale from 0-10 with 0 being no pain and 10 being the most intense pain imaginable table 1. The patient verbally selects a value that is most in line with the intensity of the pain that they have experienced in the last 24 hours or is often reported as a rating during a specific movement pattern or functional task. The NPRS has good sensitivity and excellent test retest reliability [34-37].

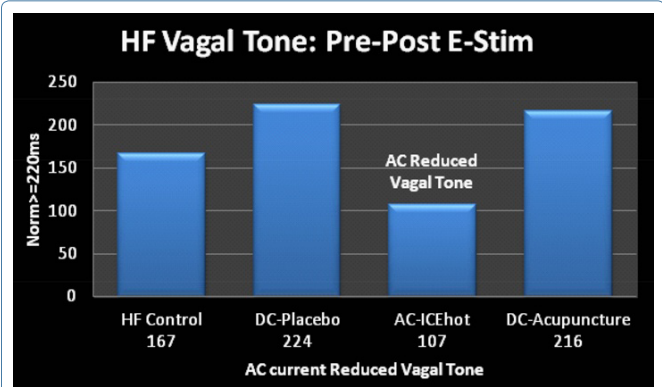
**Saliva cortisol:** Salivary cortisol evaluations were done pre post MPS sessions. Access Medical Labs (Jupiter, FL) is one of the nation’s largest full service medical laboratories offering high quality diagnostic testing solutions.

Scales	Control	MPS Placebo	HI-TENS	MPS
VAS Pain 0-10	6/10	6/10	6/10	0/10
HRV Norm $\geq$ 780ms	2524	2877	628	2153
HF Norm $\geq$ 220ms	167	224	107	216
Cortisol	1.16	0.37	1.04	0.25

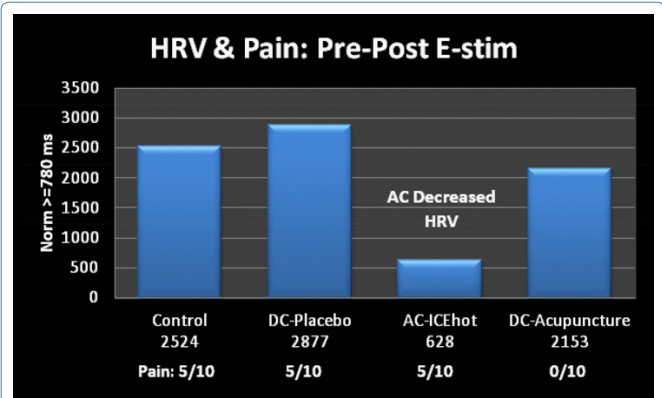
**Table 1:** VAS Numeric Pain Distress Scale (NPRS) was used to evaluate the patient's pain. The NPRS is an 11-point scale from 0-10 with 0 being no pain and 10 being the most intense pain imaginable.

## Results

No significant Improvements were evidenced in indicators of autonomic nervous system function after application of AC TENS. Widespread significant Improvements were evidenced in indicators of autonomic nervous system function after DC microcurrent point stimulation (Figures 3-5).



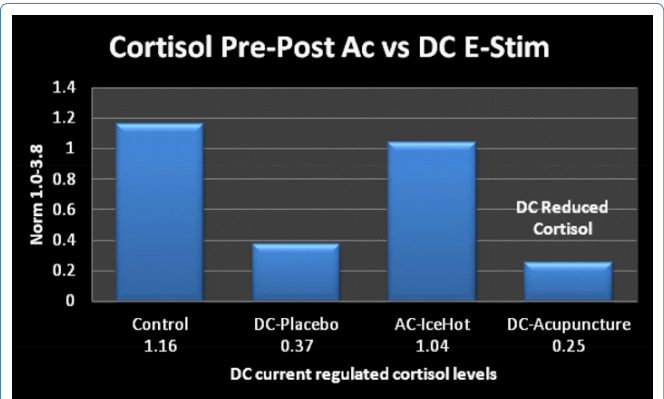
**Figure 3:** Cortisol is the stress hormone, with high levels associated with increased levels associated with elevation of blood pressure, obesity, hyperinsulinemia, hyperglycemia and insulin resistance. Lowered cortisol levels are beneficial to health.



**Figure 4:** HF is associated with parasympathetic nervous system-vagal activity-tone, with higher levels associated with maximal aerobic capacity and increase HRV.

Significant improvements were noted in HRV (Figure 3), Sympathetic, HF-vagal tone (Figure 4), Sudomotor and cardio metabolic risk markers with the MPS modality. Parasympathetic, stress and HRV Markers showed negative influence after AC TENS. AC TENS stimulation provided no recordable pain relief as measured on a VAS pain scale. DC MPS provided significant pain relief, reducing patient pain levels to a 0 (nil) from a 5/10 (Figure 1).

Salivary cortisol levels showed marked decline with both placebo and acupuncture related DC MPS stimulation whilst these levels were not significantly different from baseline control after AC TENS



**Figure 5:** Cortisol Pre-Post AC Vs DC E-Stim.

stimulation (Figure 5). Cortisol is the stress hormone, with high levels associated with increased levels associated with elevation of blood pressure, obesity, hyperinsulinemia, hyperglycemia and insulin resistance. Lowered cortisol levels are beneficial to health.

## Discussion

The autonomic nervous system is a fast component signaling system controlling the whole body metabolic homeostasis by coordinating different organs and tissues, aimed to precisely match oxygen demand and supply in response to external challenges. Persistent Sympathetic up regulation often equates to stress and pain which can make our daily lives miserable and can lead to significantly impaired physical health [38]. Both can be difficult to understand and up to now, even harder to measure. Technology such as advanced autonomic testing can now provide real time scientific evidence as to the inner workings of our bodies nervous systems in ill-health and disease permitting the collection of quantifiable data for the purpose of science and education [4,16].

The results from this case study clearly show that the application of AC current applied by pads did not produce any positive modulations within the autonomic nervous system. More importantly, AC TENS produced negative influence on some nervous system markers, suggesting further investigation is warranted to assess its efficacy. In comparison, the application of MPS significantly restored a more normal physiological state throughout the various nervous systems when applied to both non acupuncture trigger and active acupuncture points.

There was marked improvement in the cortisol stress levels, vagal tone and HRV/Total Power scores with MPS to non acupuncture trigger points. The patient's improvement in these parameters indicate significantly improved autonomic nervous system response compared to baseline and minimal target values, and should reflect an improvement reduced neuropathy symptomology, as lower than normal HRV values are associated with negative outcomes in heart disease and increased risk for diabetic neuropathy [38,4,12]. The significant improvement in the Vagal tone represents a marked improvement of his sympathetic nervous system (i.e., down regulation). Research suggests that decreased vagal activity or tone is associated with increased stress vulnerability and poor health [12].

It is noteworthy that even after improving nervous system health, MPS applied to placebo points did not influence patient's pain levels,



suggesting a separation between sympathetic down regulation and chronic pain.

Complete relief from neuropathic pain was reported after MPS was applied to active Acupuncture trigger points, suggesting there is a stronger influence on neuropathies from the peripheral than autonomic nervous system, but this is an area where further investigation is required. The safety and non-invasive nature of DC microcurrent therapy with its favorable impact on autonomic nervous system could have a major bearing on outcomes and could be a significant positive adjunct to conventional therapies in diabetes and metabolic syndromes. Only large, long term studies integrating these two modalities will verify this.

It is suggested in literature that low amplitude DC current mimics human bio cellular communications, and its application may produce regulation of the autonomic nervous system, resulting in body wide therapeutic benefits [21-23]. It is also further suggested that low frequency DC microcurrent may activate the pituitary to release endorphins [39]. Both these biochemical processes may provide a plausible explanation for the pain and stress relief after DC microcurrent, and is an area where future research is required.

In conclusion, this case study shows that high amplitude AC applied by pads provided no positive overall influence on the autonomic nervous system. DC microcurrent point stimulation provided overall improvements various parameters of autonomic nervous system function, suggesting a possible future role in the management of stress related disease. The significant differences in outcomes between devices suggest that the amplitude of current may have a stronger influence on the results of autonomic nervous system stimulation. However, further investigation is warranted with a much larger focus group to confirm these results and to assess their duration.

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