Detailed Autonomic Nervous System Analysis of Microcurrent Point Stimulation Applied to Battlefield Acupuncture Protocol

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ABSTRACT

Introduction: This is a detailed comparative analysis of the effects of direct-current (DC) microcurrent point stimulation (MPS) on the autonomic nervous system, when applied in the Battlefield Acupuncture (BFA) protocol for 8 patients with histories of pain.

Methods: Evaluations entailed a standard baseline visual analogue scale (VAS) for pain, saliva cortisol, and a baseline status of 27 autonomic nervous system (ANS) functions, for a total of 29 markers, all repeated prior to and following electrotherapy on this cohort of patients.

Results: The ANS response to microcurrent point electrical nerve stimulation reflected a statistically significant pre–post improvement in 8 of the 29 markers collected: (1) pain on the VAS scale was reduced by 63% (2.0625 points; 95% CI: 1.2745–2.8505; \( P = 0.0001 \)); (2) heart rate variability improved by 42% (662.375 points; 95% CI: –1273.675 to –51.075; \( P = 0.037 \)); (3) high frequency–vagal tone improved by 56% (231.25 points; 95% CI: –430.42 to –31.58; \( P = 0.029 \)); (4) exercise tolerance increased by 22% (9.500 points; 95% CI: –16.747 to –2.253; \( P = 0.017 \)); (5) parasympathetic activity improved by 38% (14.000 points; 95% CI: –23.202 to –4.798; \( P = 0.009 \)); (6) stress was reduced by 27% (39.125 points; 95% CI: 1.945–76.305; \( P = 0.042 \)); (7) the PTGi [photoplethysmography index] cardiac marker of endothelial function, arterial blood flow, and ANS regulation improved by 48% (21.5125 points; 95% CI: –35.44175 to 7.5832461; \( P = 0.008 \)); (8) cardiac marker PTGVLFi [Photoplethysmography very low frequency index]—an ANS regulation marker of endothelial function and an indicator of \( \beta \)-cell activity had a statistically significant reduction of 36% (9.250 points; 95% CI: 1.062–17.438; \( P = 0.032 \)). Salivary cortisol decreased by 14% (0.08286 points; 95% CI: –0.1182 to 0.28384; \( P = 0.352 \)).

Conclusions: The positive and impressive results in this study showed significant improvement in several parameters of ANS function and reduction in pain and cortisol levels. If replicated, this study paves the way for use of DC MPS applied to the BFA protocol for other pathologies that are known to be affected by sympathetic nervous system activation.

Keywords: Battlefield Acupuncture, Microcurrent Point Stimulation, Heart Rate Variability (HRV), Vagal Tone (HF), Stress

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INTRODUCTION

Battlefield Acupuncture (BFA) was developed by Col. Dr. Richard C. Niemtzwol, (MD, PhD, MPH) of Andrews Air Force Base, as a standardized protocol to provide a simple, easy to apply, nonpharmaceutical solution for the Military’s pain-management needs in the clinical and battlefield settings.1–3

The protocol involves the applications of a stimulus to five key acupuncture ear (auricular) points that isolate the autonomic nervous system (ANS) and central nervous system’s (CNS) role in the chronic/acute pain cycle. When these points are treated collectively, it has been reported that a wide variety of neuromyofascial pain syndromes can be relieved effectively on a timely basis.

Acupuncture has been practiced for thousands of years and is commonly used for treating many types of chronic pain.4–7 Electroacupuncture (EA) has been used as an adjunctive to pain management in acupuncture therapy for decades.8 EA has been reported to outperform traditional acupuncture needles analgesically.9 Science has long hypothesized with respect to a scientific explanation of the analgesic successes of acupuncture or EA. Literature supports that acupuncture relieves pain by regulating the ANS,10 activating the release of ß-endorphins,11 regulating the CNS,12 and producing local effects on the peripheral nervous system.13

It is widely accepted in science that imbalances of the parasympathetic (rest/healing/calming) and sympathetic (flight/flight/stress) branches of the ANS are directly linked to wide variety of pain and diseases.14–20 The sympathetic nervous system (SNS) is designed to facilitate short-term survival by creating a cascade of neurophysiologic responses, and persistent tone or upregulation of the SNS is a precipitator of ill health and disease.21,22 Real-time analysis of sympathetic upregulation may be now accurately measured in two ways, heart rate variability (HRV)17 and cortisol levels.23,24

It is well-established that low HRV values (sympathetic overactivity) are implicated in cardiac pathology, morbidity, reduced quality-of-life (QoL), and precipitous mortality.14–20 Optimal HRV values are associated with improved exercise tolerance, cardiovascular health, improved ANS control, better emotional regulation, and enhanced neurocognitive processing.25 In addition to health benefits, optimal HRV has been shown to improve neurocognitive performance by enhancing focus, visual acuity, and readiness, and by promoting emotional regulation needed for peak performance.26

Emerging evidence also supports the neurophysiology of acupuncture as modulating the imbalances created by sympathetic and parasympathetic activities, in order to alleviate autonomic disorders.10,27 Microcurrent therapies involve applying weak direct currents (80 µA–1 mA), and are now being recognized increasingly as adjuncts for pain relief and ANS regulation.28–31 However, there is no consensus in the literature identifying the best practice measures for application of BFA to patients who have chronic pain or stress. Although sufficient evidence supports the application of acupuncture needles for autonomic regulation, there is limited evidence in literature to support the use of electrotherapies for the same purpose. The aim of this pilot study was to assess the impact of microcurrent point stimulation (MPS) on the autonomic nervous and endocrine systems in a sample of patients with chronic pain.

METHODS

Subjects

A diffuse range of patients with neuromyofascial pain syndrome from both sexes was recruited for this study. A total of 8 patients (5 females, 3 males; mean age: 37.75 years; standard deviation [SD]: 18.18) with chronic nonspecific pain (3 with neck pain, 2 with foot pain, and 1 each with shoulder pain, back pain, and fibromyalgia), with a mean pain duration average of 4.855 years (SD 6.13), presented to the current authors for therapy to address their problems. (Table 1) Inclusion criteria was simple: patients who were currently suffering from soft-tissue chronic pain for >3 months, with a recorded 3+/10 visual analogue scale (VAS) for pain score. The diagnoses of pain, location, severity, sex, and previous interventions or surgeries were not considered to be exclusion criteria.

Methodology

MPS was applied to the BFA protocol, using28,29,32 a single Dolphin™ Neurostim device (Center for Pain & Stress Research, Ontario, Canada). This is a U.S. Food and Drug Administration (FDA)–approved device that is used to apply low-frequency, concentrated, microcurrent stimulation (at 10K Ohms) for the relief of chronic pain.32,33 MPS application time was 30 seconds per point, for a total of 10 points in both ears. The device was set to negative polarity (–). The BFA protocol includes the following points: Omega 2; Shen Men; Point Zero; Thalamus; and Cingulate Gyrus (Fig 1).

| Table 1. Breakdown of Pain Location/Diagnosis of N = 8 Pain Sample |
|-----------------|------------------------|------------------------|------------------------|------------------------|
| **Factor**      | **N**      | **Minimum** | **Maximum** | **Mean** | **SD** |
| Age (years)     | 8          | 10          | 57          | 39.75    | 18.18752 |
| Duration of pain (years) | 8          | 0.08        | 16.00       | 4.855    | 6.13738 |
| Initial pain levels (0–10) | 8          | 1           | 6           | 3.25     | 1.8322 |
| Post-treatment pain levels (0–10) | 8          | 0           | 4           | 1.1875   | 1.4126 |

SD, standard deviation.
Autonomic nervous system assessments. These assessments were performed immediately before and after electrostimulation with the ANS1 (Biosensor Equipment LLC, Houston TX), a sophisticated FDA-approved electrocardiogram device that measures HRV, sympathetic, parasympathetic, adrenergic, and cardiovagal functions. The device utilizes a multimodal approach to assess the SNS, parasympathetic nervous system, and galvanic skin response functions through an autonomic nerve assessment, an arterial assessment, and an assessment of cardiometabolic markers.17,34 Included are measurements of 27 physiologic “markers,” placing each patient measurement categorically into abnormal, borderline, and optimal goal columns. The seven ANS markers with 95% CI are:

1. **HRV: 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 HRV. Lower than normal HRV values are associated with negative outcomes in heart disease and increased risk for diabetic neuropathy.18,19 High values (≥ 780) are associated with health and vigor.35

2. **HF: High frequency indicator of parasympathetic vagal nerve activity**—Vagal tone is an internal biologic process referring to the activity of the vagus nerve, which serves as the key component of the parasympathetic branch of the ANS. Research suggests that decreased vagal activity or tone is associated with increased stress vulnerability and poor health.35–37 A low value (< 220), suggests sympathetic system predominance and the possibility of stress or mental anxiety.38

3. **Exercise tolerance: Standard deviation of all normal-to-normal R–R intervals (SDANN)—SDANN is an indicator of both sympathetic and parasympathetic function and, therefore, is an indicator of ANS activity overall in addition to VO2 (maximum oxygen consumption in the muscles). High numbers (≥ 40) are usually seen in athletes, and improvement in this value would indicate an improved ANS response and exercise tolerance.35,39

4. **Parasympathetic activity: Root mean square of successive normal sinus R–R interval difference (RMSSD)—RMSSSD is an indicator of parasympathetic activity and reflects the electrical stability of the heart.40

5. **Stress Index**—The Stress Index measures cardiac muscle oxygen demand related to heart work. The Stress Index is correlated to C-reactive protein (CRP) and is a marker of sympathetic failure.41 CRP is produced by the liver and increases with inflammation. HRV reflects the adaptability of the body to daily internal and external stressors that influence ANS function directly, as well as reflecting the stress the body is experiencing at the present time. High values (≥ 180) indicate a risk for heart disease.42

6. **Cardiac marker PTGi**—PTGi is a cardiac marker of endothelial function, arterial blood flow, and ANS regulation. Endothelial dysfunction, ANS dysfunction, and artery blood flow are known risk factors for diabetes and atherosclerosis.43

7. **Cardiac marker: Photoplethysmography very low frequency index (PTGVLFi)**—PTGVLFi is an ANS regulation marker of endothelial function and an indicator of β-cell activity. β-Cells are insulin producing cells located in the pancreas, and this is a marker for glucose intolerance and microcirculation complications.20 Studies have shown very high correlation with the oral glucose tolerance test and the PTGVLFi.44 High numbers (≥ 33) indicate a risk for diabetes.45,46

**Visual analogue scale.** A VAS was used to evaluate each patient’s pain. The VAS is an 11-point scale from 0 to 10, with 0 being no pain and 10 being the most intense pain imaginable.47–49 The patient verbally selects a value that is most in line with the intensity of the pain that he or she has experienced in the last 24 hours or is often reported as a rating during a specific movement pattern or functional task. The VAS has good sensitivity49,50 and excellent test–retest reliability.

**Saliva cortisol.** Salivary cortisol evaluations were conducted pre–post MPS sessions with all 8 patients. Access Medical Labs (Jupiter, FL), one of the nation’s largest full-service medical laboratories, received and processed the pre–post saliva cortisol tests. Cortisol is a well-known endocrine stress marker.51
Purpose for collecting objective data. The objective data collection was aimed at revealing:

1. If MPS, when applied to the BFA protocol, can modulate any variables within the ANS and VAS pain scale for these patients.
2. If MPS is a valid option for the nonpharmacologic pain management of pain- or stress-related conditions.

RESULTS

The overall responses in this cohort of patients following microcurrent point electrical nerve stimulation to ANS parameters, pain, and cortisol levels reflected a statistically significant pre–post improvement in the following 8 of the 29 markers collected:

1. Pain on the VAS scale—This was reduced by 63% (2.0625 points; 95% CI: 1.2745–2.8505; P = 0.0001; Fig. 2 and Table 2).

![PAIN: MPS Applied to BFA Protocol](image)

**FIG. 2.** Pre–post pain levels with minimum, maximum, mean average, and standard deviation (SD) of N=8 pain sample. Visual representation of pain statistics measures of mean, the sample size, and a measure of dispersion in standard deviation. This graph shows the average pain level before therapy is 3.25 (95% confidence interval [CI]: 1.72–4.78; P = 0.002), compared to the average pain level post application of 1.188 (95% CI: 0.07–2.368; P = 0.002). Pain reduced 2.0625 points or 63% (95% CI: 1.2745–2.8505; P = 0.0001). MPS, microcurrent point stimulation; BFA, Battlefield Acupuncture; Av, average.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Marker of</th>
<th>Normal level (pre–post)</th>
<th>Average levels (pre–post treatment)</th>
<th>Difference in mean levels &amp; SD</th>
<th>Percentage change in mean levels</th>
<th>95% CI/ P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(HRV) total power (ms²)</td>
<td>Overall ANS activity</td>
<td>≥780</td>
<td>Pre = 1577.38 Post = 2239.75</td>
<td>662.375±731.201</td>
<td>+42%</td>
<td>Yes/P = 0.037</td>
</tr>
<tr>
<td>Vagal tone (HF) (ms²)</td>
<td>Parasympathetic activity</td>
<td>≥220</td>
<td>Pre = 412.25 Post = 643.25</td>
<td>231.00±238.534</td>
<td>+56%</td>
<td>Yes/P = 0.029</td>
</tr>
<tr>
<td>SDANN (ms)</td>
<td>Sympathetic activity/Exercise tolerance/VO₂ max to muscles</td>
<td>≥40</td>
<td>Pre = 43.38 Post = 52.88</td>
<td>9.500±8.668</td>
<td>+22%</td>
<td>Yes/P = 0.017</td>
</tr>
<tr>
<td>RMSSD (ms)</td>
<td>Parasympathetic activity</td>
<td>≥35</td>
<td>Pre = 36.75 Post = 50.75</td>
<td>14±11.006</td>
<td>+38%</td>
<td>Yes/P = 0.009</td>
</tr>
<tr>
<td>Stress (%)</td>
<td>Sympathetic activity</td>
<td>≤180</td>
<td>Pre = 145.88 Post = 106.75</td>
<td>−39.125±44.473</td>
<td>−27%</td>
<td>Yes/P = 0.042</td>
</tr>
<tr>
<td>PTGi (Vs)</td>
<td>Arterial &amp; homeostatic marker</td>
<td>≥40</td>
<td>Pre = 44.9 Post = 66.413</td>
<td>21.5125±16.6614</td>
<td>+48%</td>
<td>Yes/P = 0.008</td>
</tr>
<tr>
<td>PTGVLFi (ms²/μSi)</td>
<td>Autonomic nerve marker &amp; endothelial function</td>
<td>≤33</td>
<td>Pre = 25.38 Post = 16.13</td>
<td>9.250±9.794</td>
<td>−36%</td>
<td>Yes/P = 0.032</td>
</tr>
<tr>
<td>Pain (0–10)</td>
<td>Pain</td>
<td>N/A</td>
<td>Pre = 3.25 Post = 1.188</td>
<td>2.0625±9.425</td>
<td>−63%</td>
<td>Yes/P = 0.0001</td>
</tr>
<tr>
<td>Cortisol levels</td>
<td>Sympathetic activity</td>
<td>N/A</td>
<td>Pre = 0.5743 Post = 0.4914</td>
<td>−0.08286±0.21731</td>
<td>−14%</td>
<td>No/P = 0.352</td>
</tr>
</tbody>
</table>

Table 2. ANS1: Pre–Post Chart Results of Indicators of Pain, Cortisol, and ANS Functioning; MPS Applied to BFA Protocol (N = 8).

Notes: ANS1, Biosensor Equipment LLC, Houston TX.
HRV—Total power or HRV; normal range >780 ms².
Vagal tone (HF)—Vagal tone-high frequency; normal range >220 ms.
SDANN—Standard deviation of all normal-to-normal R–R intervals; normal range: 40–80 ms.
RMSSD—Root mean square of successive normal sinus R–R interval difference; normal range: 35–65 ms.
PTGi—Photoplethysmography index of the spectral analysis components; normal range: >40 vs.
PTGVLFi—Photoplethysmography very low frequency index; normal range: <33 ms²/μSi.
ANS, autonomic nervous system; MPS, microcurrent point stimulation; BFA, Battlefield Acupuncture; SD, standard deviation; CI, confidence interval; HRV, heart rate variability; NA, not applicable.
MICROCURRENT POINT STIMULATION FOR BFA

Table 3. Numeric Representation of One Sample t-Test for Initial Pain Levels of N=8 Patient Sample

<table>
<thead>
<tr>
<th>Factor</th>
<th>t</th>
<th>df (2-tailed)</th>
<th>Sig.</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial pain levels (0–10)</td>
<td>5.017</td>
<td>7</td>
<td>0.002</td>
<td>3.250</td>
<td>1.72 to 4.78</td>
</tr>
</tbody>
</table>

df, degrees of freedom; sig., significance; CI, confidence interval.

(2) ANS results—HRV improved by 42% (662.375 points; 95% CI: −1273.675 to −51.075; \( P = 0.037 \)).
(3) HF—vagal tone—This improved by 56% (231.25 points; 95% CI: −430.42 to −31.58; \( P = 0.029 \)).
(4) Exercise tolerance—SDANN increased by 22% (9.500 points; 95% CI: −16.747 to −2.253; \( P = 0.017 \)).
(5) Stress—Stress was reduced by 27% (39.125 points; 95% CI: 1.945–76.305; \( P = 0.042 \)).
(6) Cardiac marker PTGi—This was improved by 48% (21.512 points; 95% CI: −35.441754 to −7.5832461; \( P = 0.008 \)).
(7) Parasympathetic activity—RMSSD improved by 38% (14.000 points; 95% CI: −23.202 to −4.798; \( P = 0.009 \)).
(8) Autonomic nervous and endothelial function marker PTGVLFi had a statistically significant 36% improvement after MPS treatment (95% CI: 9.250 points; 1.062–17.438; \( P = 0.032 \); Table 2.)

Salivary cortisol decreased by 14% (0.08286 points; 95% CI: −0.1182 to 0.28384; \( P = 0.032 \); Table 2.)

DISCUSSION

The data in this case study clearly shows that the application of MPS applied to the BFA protocol provided significantly improved autonomic regulation in the sample of patients studied. MPS applied to the BFA protocol not only provided significant pain relief to all study subjects but also resulted in widespread physiologic improvements throughout the various nervous systems. There was marked improvement in HRV, vagal tone, exercise tolerance, stress levels, cardiac health, and parasympathetic activity post application. It was noteworthy that these changes were reflected within the endocrine system with a decrease in stress hormone cortisol.

The ANS is a fast component-signaling system controlling whole-body metabolic homeostasis by coordinating different organs and tissues, aimed to match oxygen demand and supply precisely in response to external challenges. Persistent sympathetic upregulation often results in stress and pain, which can make patients’ daily lives miserable and can lead to significantly impaired physical health. Both can be difficult to understand and, up to now, were even harder to measure. Technology, such as advanced autonomic testing, can now provide real-time scientific evidence on the inner workings of the human body’s nervous systems in ill-health and disease, permitting the collection of quantifiable data for the purposes of science and education.

ACKNOWLEDGMENTS

This pilot study showed that MPS provided statistically significant overall improvements in pain reduction, HRV, vagal tone, exercise tolerance, parasympathetic activity, and stress reduction when applied to a BFA protocol. Recognizing that this portable, noninvasive procedure had an application time of <5 minutes per patient, these consistent improvements in stress markers suggest a possible significant future role for both MPS applied to BFA for managing pain or stress-related diseases outside of the clinical setting. Chronic pain can limit QoL, and restrict work and social engagements, and is often blamed for the development of drug dependencies of various forms. The changes produced in the ANS functions help validate the potential application of MPS to the BFA protocol as an option to clinicians treating patients with chronic pain- and stress-related diseases. However, further investigation is warranted with a much larger focus group to confirm these results and to assess their duration.

It is suggested that low-amplitude DC current mimics human biocellular communications, and application of this current may create a shift or change in cellular membrane configuration, resulting in a body-wide therapeutic effect. These biochemical processes may provide a plausible explanation for the autonomic modulation after concentrated DC micromoment, and is an area where future research is required.

Table 4. Numeric Representation of One Sample t-Test for Post-Treatment Pain Levels of N=8 Patient Sample

<table>
<thead>
<tr>
<th>Factor</th>
<th>t</th>
<th>df (2-tailed)</th>
<th>Sig.</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-treatment pain levels (0–10)</td>
<td>2.378</td>
<td>7</td>
<td>0.049</td>
<td>1.1875</td>
<td>0.007 to 2.368</td>
</tr>
</tbody>
</table>

df, degrees of freedom; sig., significance; CI, confidence interval.

Table 3 and 4)

Statistical analyses were done by a third-party freelance statistician, using a paired sample t-test in SPSS software, a widely used program for statistical analysis in social and medical science.
AUTHOR DISCLOSURE STATEMENT

None of the authors have any commercial associations that create a conflict of interest in connection with the submitted manuscript.

REFERENCES


50. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual analog scale for pain (VAS pain), numeric rating scale for pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken)*. 2011;63(S11):S240–S252.


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