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Does Acupuncture Reduce Stress Over Time? A Clinical Heart Rate Variability Study in Hypertensive Patients

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ABSTRACT

Background: Heart rate variability (HRV), a noninvasive autonomic measure, has been applied to acupuncture interventions in controlled academic settings comparing points used, types of stimulation, or the HRV parameters measured. There is evidence that acupuncture decreases the stress response in both human and animal subjects, and can increase HRV in the short term (minutes to hours).
Objectives: The goal of this study was to explore an array of HRV parameters during acupuncture sessions and over the course of treatment (weeks to months) in a series of patients being treated for hypertension.
Materials and Methods: This was a retrospective, uncontrolled case study of patients presenting to a private acupuncture clinic. Patients received manual body acupuncture prescribed by the tenets of Traditional Chinese Medicine (TCM) and by published protocols for hypertension treatment. Heart rate was monitored during and after needle placement. The tracings were then analyzed with the Vivosense HRV analysis system. The main outcome measures were were patients' blood pressure measurements and low-frequency–to–high-frequency (LF/HF) ratio of HRV.
Results: Patients tended to have an increase in their HRV during treatment, after needling, and, in some instances, an increase in HRV over weeks to months.
Conclusions: Some patients' HRV increased over weeks to months during the course of acupuncture treatment for hypertension as evidenced by a decrease in their LF/HF ratio. This would indicate a relative decrease in their physiologic stress.

Key Words: Acupuncture and Heart Rate Variability, Acupuncture and Hypertension, Acupuncture Physiology

INTRODUCTION

Ancient Chinese Medicine practitioners recognized what we now know—that a machinelike regularity of heart rate is a sign of disease, age, and stress.

> Variable heartbeat has been considered a sign of good health since the third century by oriental physicians and the scientist Wang-Shu Ho. Ho stated, ''If the pattern of the heartbeat becomes regular as the tapping of woodpecker or the dripping of rain from the roof, the patient will be dead in four days.''[1]

Heart rate variability (HRV) is a noninvasive monitor of autonomic balance (i.e., a measure of physiologic stress). Although there is evidence that acupuncture decreases the stress response and increases HRV in both human and animal subjects in the short term (during and after treatment), data regarding longer-term effects (weeks to months) is scant. This study explores whether or not patients' HRV increases over time with consistent acupuncture treatment. This study is part of an ongoing exploration using HRV as a biomarker of clinical outcomes. The purpose of the inquiry is to have additional tools to confirm efficacy and improve reproducibility of acupuncture treatment. Research so far suggests that, in patients likely to respond to acupuncture treatment, there is a decrease in low-frequency–to–high-frequency (LF/HF) ratio during treatment sessions.[2] Clinical acupuncture nonresponders, who may

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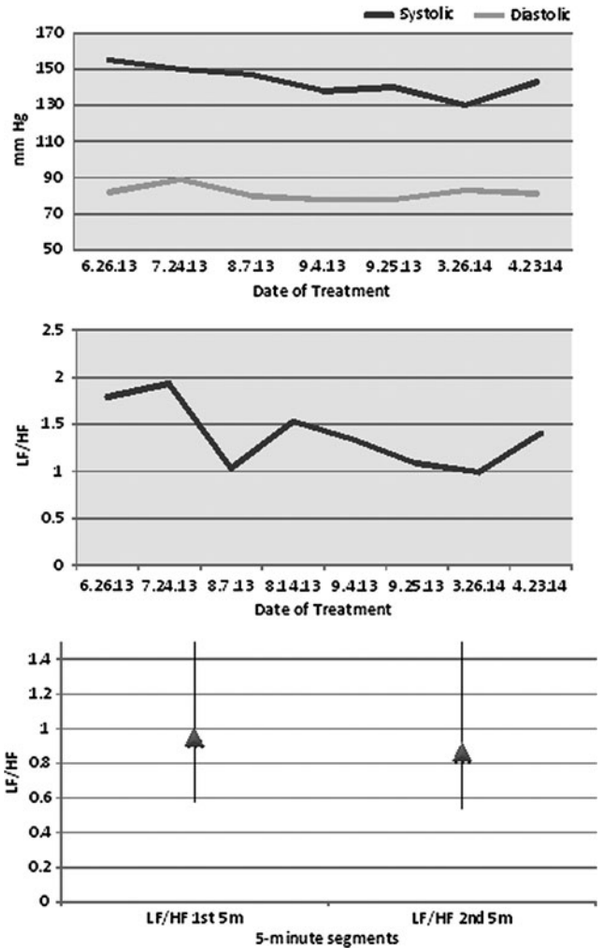

FIG. 1. Results for a 56-year-old male in Group 1. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

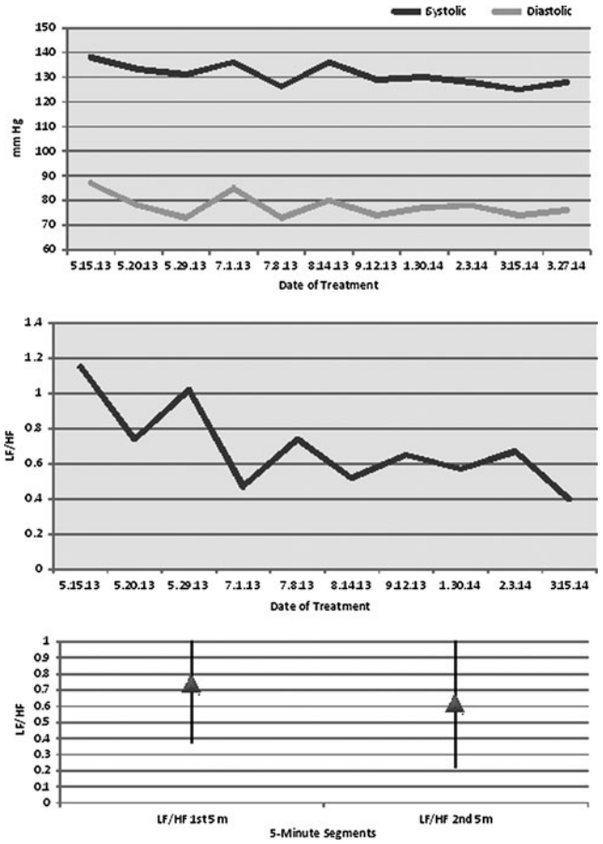

FIG. 2. Results for a 33-year-old female in Group 1. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions. m, minutes.

represent up to 20% of the population, show no decrease, or even an increase, in LF/HF ratio, indicating no change in autonomic balance. Other studies have shown that an increase in HRV correlates with positive clinical outcomes.[3–5] Furthermore, another study suggests that particular needling techniques and point selection may improve the LF/HF ratio during treatment in some patients.[6]

Stress has negative impacts on the immune system,[7,8] aging,[9,10] mood,[11] inflammation,[12] and pain. Acupuncture has been shown to affect all of the above. Recent acupuncture and neuroimaging[13] studies have confirmed that acupuncture can affect the autonomic nervous system (ANS).[14–17] Indeed, acupuncture brain-imaging research reveals central nervous system (CNS) involvement of areas suggestive of a shift in the ANS balance.

Although HRV testing is exacting and sensitive to artifact, its ease of application in the clinic gives HRV potential as a biomarker for treatment. HRV has been correlated with other accepted and precise physiologic markers of stress and inflammation relevant to acupuncture treatment (e.g., cortisol,[18] norepinephrine, epinephrine, Il-6,[19] IFN-γ,[20,21] functional magnetic resonance imaging,[22,23] and telomere length[24,25]), suggesting that HRV response may be relevant to clinical outcomes.

The literature is not definitive on which HRV parameter test (nonlinear, frequency, time) is the most representative and least affected by artifact. Some studies advocate SampEn or DFAα1, others Total Power or HF alone. The LF/HF ratio is a frequently used measure of sympathovagal balance, however.[26] HF is mediated by the parasympathetic (vagal) nervous system, and LF by the sympathetic and parasympathetic nervous system. A standard approach is to calculate power in four bands, which is facilitated by readily available software

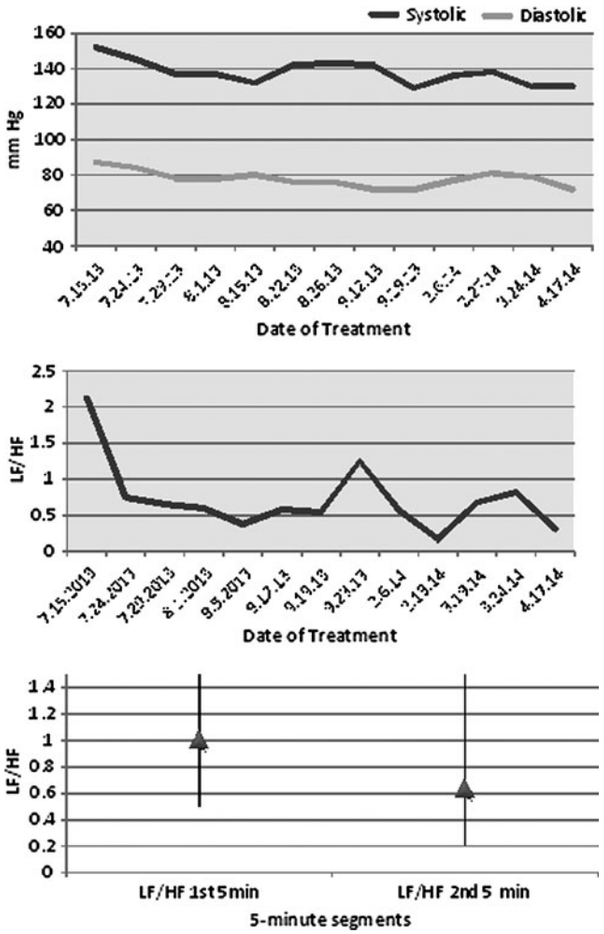

FIG. 3. Results for a 70-year-old male in Group 1. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

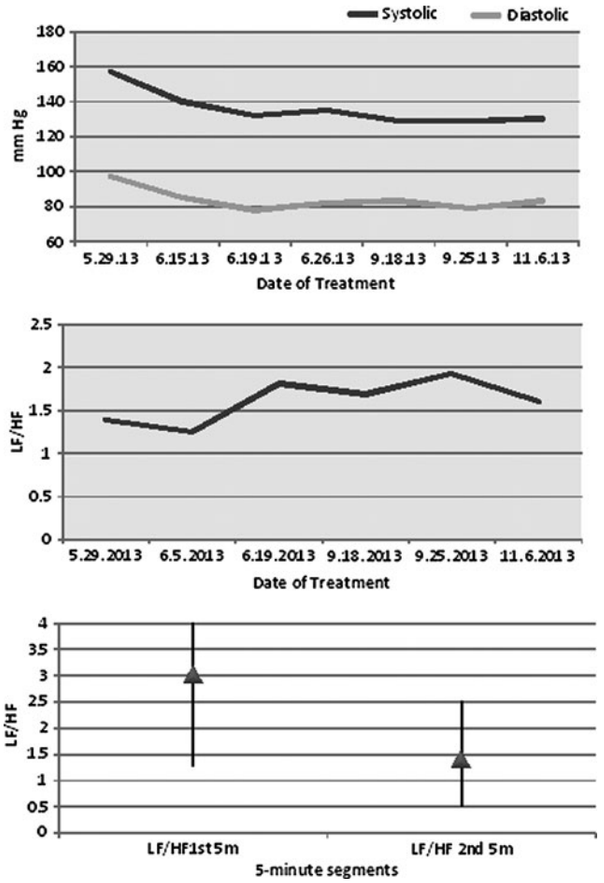

FIG. 4. Results for a 48-year-old female in Group 1. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

programs. The LF/HF ratio is valuable, because it helps control for the inevitable day-to-day variation in absolute values found in HRV measurements.

In addition, HRV measurement may be particularly relevant in studying acupuncture treatment because this measurement is able to capture subtle, nonlinear, complex aspects of HRV response. The emerging field of complexity science recognizes a number of aspects of physiology that the more conventional reductionist view does not address. The National Institutes of Health's National Center for Complementary and Alternative Medicine has emphasized application of the principles of complex systems to acupuncture studies and the importance of capturing the global state of a system through parameters such as HRV.

MATERIALS AND METHODS

Methods

This was a retrospective clinical case series of 6 patients, ages 33–72, who underwent clinical acupuncture treatment for hypertension. As this was an observational study, blinding and control interventions were not performed. ◀AU2

Subjects rested supine for 5–10 minutes; then, their blood pressure (BP) was measured. Subjects were needled with body acupuncture using the Longhurst and Tjen-A-Looi[27] protocol (2-Hz electrostimulation at ST 36 and ST 37 *and* LI 11 and LI 10 *or* PC 6 and PC 7) and according to their presenting Traditional Chinese Medicine patterns and diagnoses. Usually 3–4 additional points were selected according to the patients' clinical patterns. The needles, 0.22–0.25 mm (DBC Spring) were manually stimulated, and rotated clockwise and counterclockwise for 2 seconds each, at initial placement and

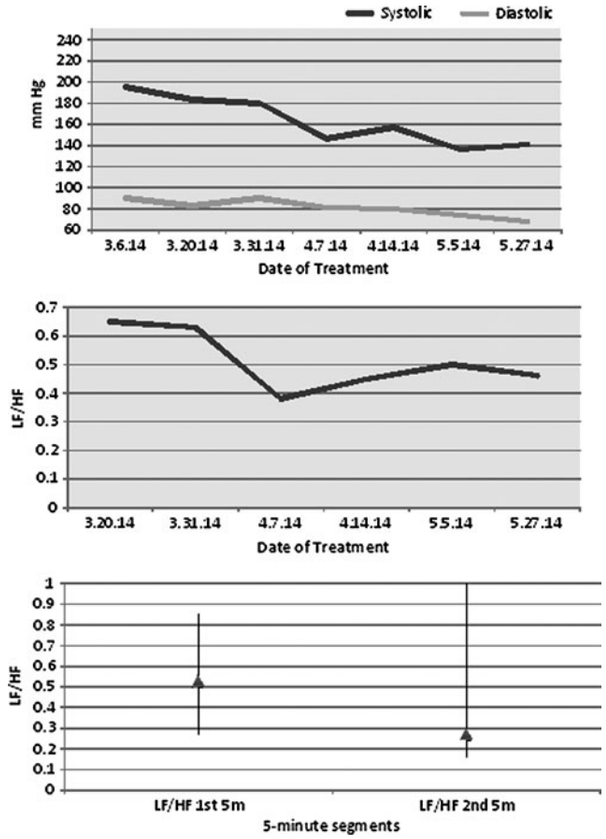

FIG. 5. Results for a 68-year-old female in Group 1. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

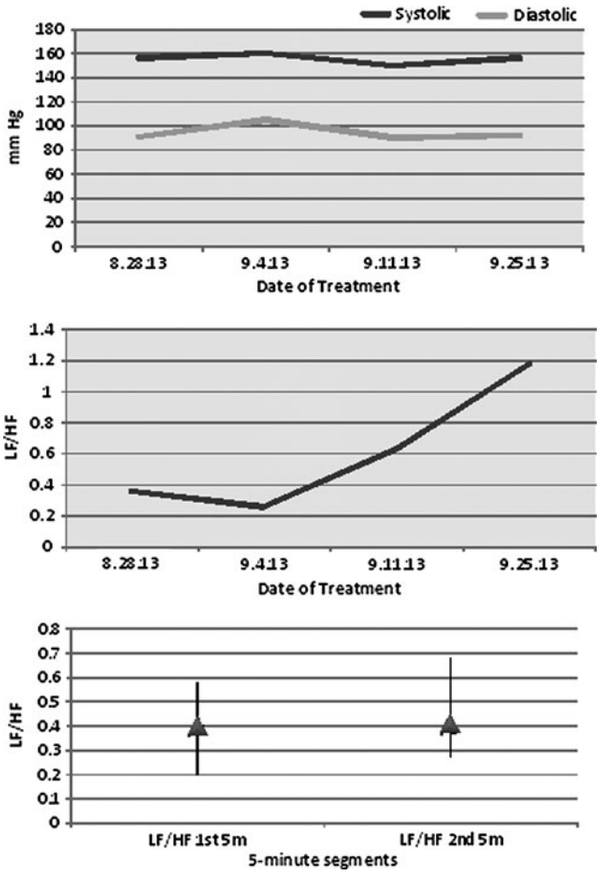

FIG. 6. Results for a 47-year-old female in Group 1. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

immediately before removal. Electrostimulation (2-Hz EStim II, Mayfair Mfg., China) was initiated after manual stimulation at the Longhurst points. Treatment duration was 20 minutes. In some patients, electroacupuncture was not tolerated by the patient because of discomfort or pain. In these instances, manual acupuncture at the same points was used.

The treatment routine was twice weekly for 2 weeks, then weekly for 6 weeks, and then monthly.

Patients were informed that the study was a monitoring study only, and verbal consent was obtained. Written consent was obtained on admission to the study. Patients' data were excluded from this report if it was inadequate (artifact or arrhythmia) or if too few sessions in succession occurred.

Needling was performed by a physician with 16 years of clinical acupuncture experience.

Outcome Measurements

Outcome measures were patients' BP and HRV analysis. Heart rate was measured using a Nonin pulse oximeter or a J and J Engineering EKG monitor during treatment after needle placement for 20 minutes. The data were analyzed using Vivosense software and artifact management. For HRV measurements over weeks to month, the entire 20-minute treatment session was analyzed. For intratreatment measurement, 5-minute segments were tabulated. LF/HF charts were selected for this study, although other parameters (Sample Entropy [SampEn], LF, HF, Poincaré plots, DFα1, and total power) were also measured.

HRV Monitoring

Nonin OEM Evaluation Program Rev. 15, from Nonin Medical, Inc. was used either on the right forefinger or right first or second toe for heart rate measurement connected wirelessly to a standard laptop computer. The heart rate data as stored as a text file and then uploaded to Vivosense Heart Rate Variability Analysis 2.4 software from Vivonoetics, for analysis.

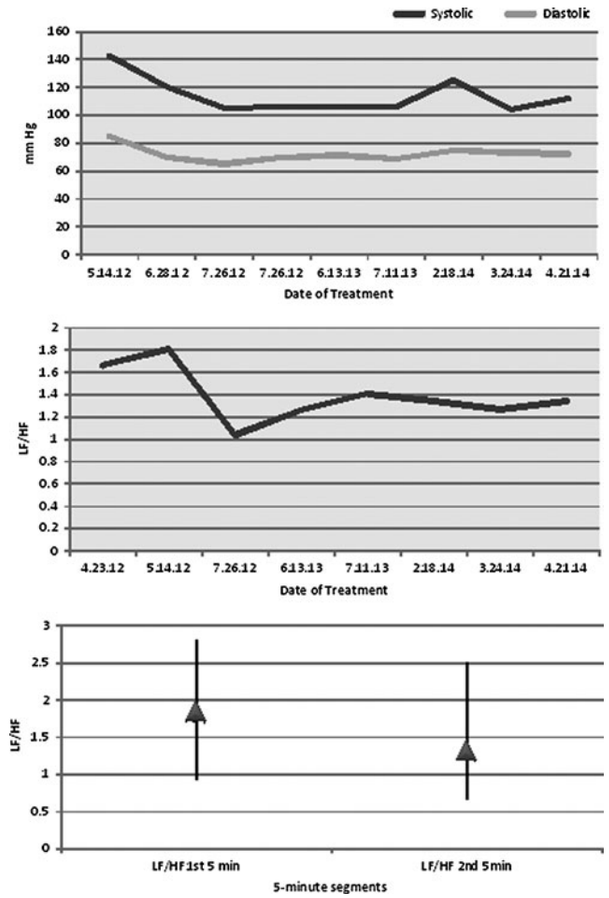

FIG. 7. Results for a 36-year-old female in Group 2. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

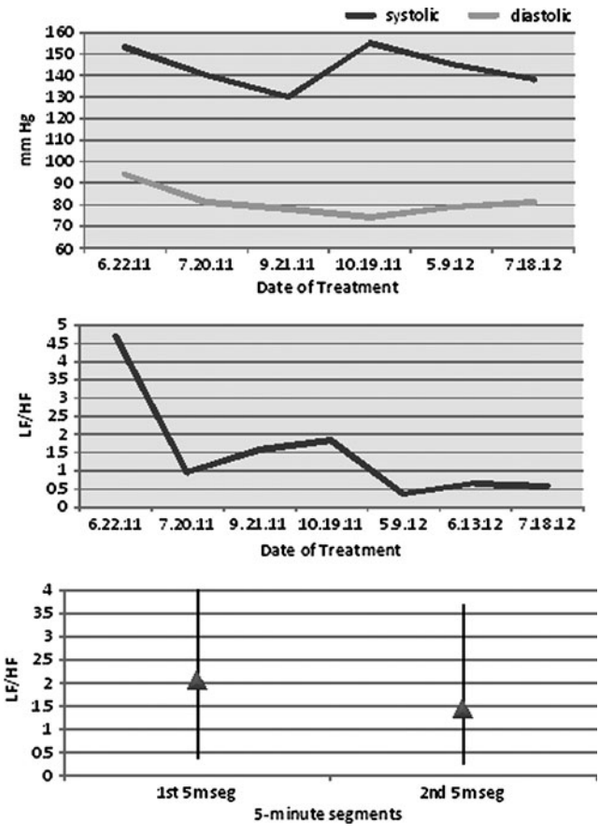

FIG. 8. Results for a 65-year-old male in Group 2. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

HRV Data Analysis

HRV was quantified using registration of percentage changes in *R–R* intervals in the time domain as well as the changes in the frequency range by analysis of electrocardiographic power spectra. Parameters are recommended by the task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology.[28] Calculation of EKG, or pulse oximeter peak-to-peak measures of power spectra are thought to provide a representation of the contributions of the sympathetic and parasympathetic systems on HRV.

RESULTS

Group 1: Patients Evaluated from Beginning of Treatment Series

From the beginning of the treatment series 5 of the 6 patients had a decrease in their BP, 3 of the 6 had an increase in HRV (a decrease in LF/HF) over time, and 5 of the 6 had an increase in HRV (a decrease in LF/HF) during treatment. These results are shown in Figures 1–6. ◀F1 – F6

Group 2: Patients Monitored After Treatment Series Underway

In the patients who were monitored after the treatment series was underway, 3 of 4 had a decrease in BP, 2 of 4 had an increase in HRV (a decrease in LF/HF) over time, and all 4 had a decrease in HRV (decrease in LF/HF) during treatment. These results are shown in Figures 7–10. ◀F7 – F10

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DISCUSSION

There were many limitations of this clinical study. The study was not blinded, and there were no controls. The point prescriptions and treatment regimens were not uniform, which is customary practice in a clinical setting. This study,

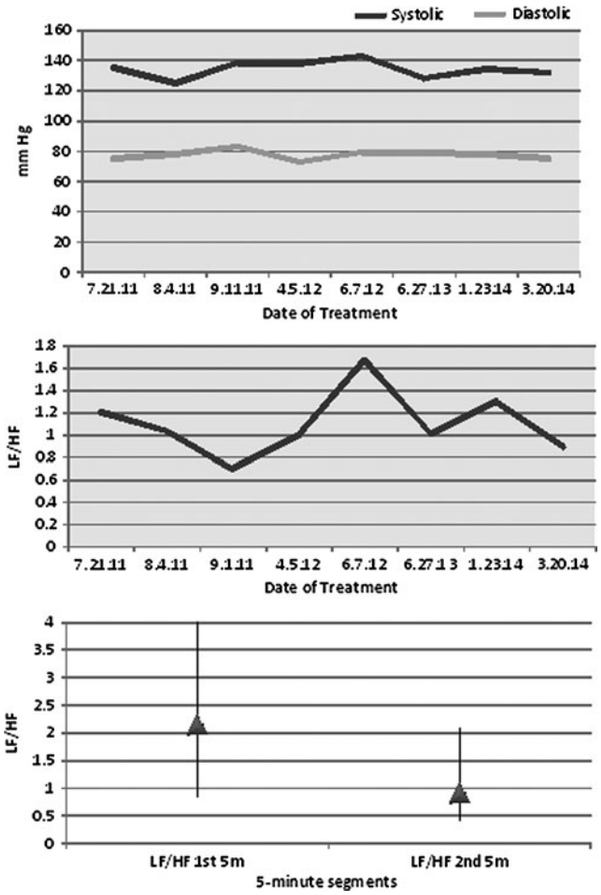

FIG. 9. Results for a 72-year-old female in Group 2. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

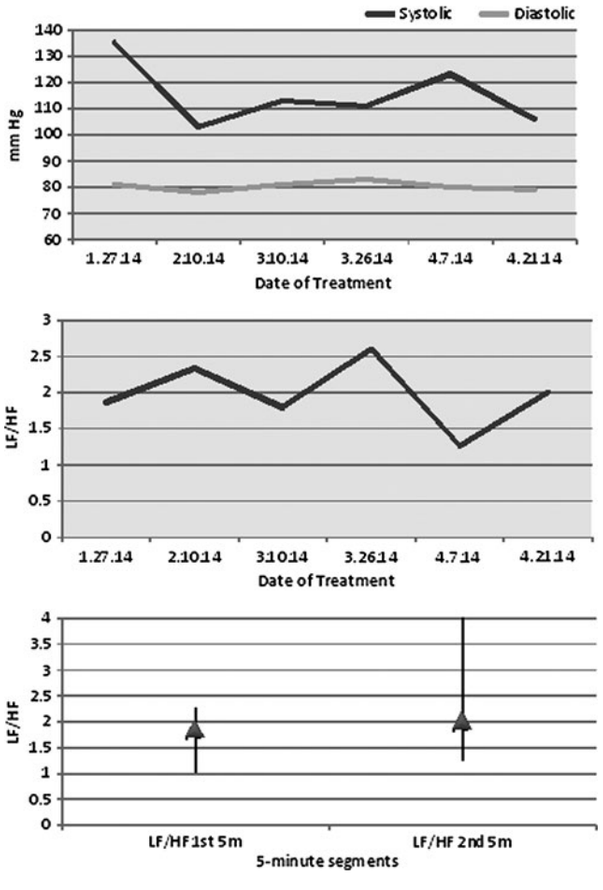

FIG. 10. Results for a 44-year-old female in Group 2. *Upper graph:* Systolic and diastolic blood pressure taken on each visit by date *Middle graph:* 20-minute (m) measurement of LF/HF (low-frequency–to–high frequency) ratio after needling with needles in place. *Lower graph:* Intratreatment LF/HF first 5 minutes to second 5-minute segment as an average over all treatment sessions.

did provide a database of HRV response over time, however, and may be useful as a source of hypothesis generation. Although no hard and fast conclusions can be drawn—and more questions are raised than answered—it is hoped that these data will lead to fruitful discussion.

What is the timeframe of acupuncture's effects on the ANS? Napadow et al.[29] provided evidence that the ANS responds within seconds to verum acupuncture while Longhurst[30] found that ''autonomic influence of acupuncture is slow in onset but prolonged in duration, typically lasting beyond the period of stimulation.'' Litscher et al.[31] and Fasmer et al.[32] documented HRV changes during acupuncture treatment. Litscher et al. showed a similar drop in LF/HF from the first to second 5-minute segment during acupuncture treatment in burnout patients. Fasmer et al. demonstrated an increase in SampEn during acupuncture treatment in patients with a variety of presenting conditions. The first-to-second 5-minute segments results suggest that LF/HF decreases quickly once acupuncture is initiated, in turn, suggesting that a direct causal mechanism may be responsible. Given that there are no controls in this investigation, the data presented here could represent simply the therapeutic effect of clinic visits, but, nonetheless, the data suggest that in some cases LF/HF decreases over weeks to months, indicating a decrease in stress response with consistent acupuncture treatment.

Does HRV reflect the changes in ANS representing a potential link between the CNS and the vascular response? Why do there seem to be cumulative changes over time? Does this development reflect additional physiologic changes taking place?

Is there any clinical significance of a decrease in LF/HF or an increase in HRV with acupuncture? This question remains unanswered. A review of the literature[33] yielded only 3 studies that considered whether or not a change in

HRV correlated with clinical outcomes. The researchers' previous studies suggest that positive clinical outcomes correspond with a decrease in LF/HF during a treatment session. If it can be verified that a decrease in LF/HF during a treatment session also corresponds with a longer term reduction (weeks to months) in LF/HF, and hence stress levels, this would be significant.

Is complexity science relevant to acupuncture treatment and practice? This is a fascinating question—one that is highly relevant to the current study. Complexity science arises from a number of different fields, but they all share a common theme of nonlinearity—a concept maintaining that the size of an output is not proportional to the size of an input. For example, this concept helps to explain how small perturbations can have large and sometimes unpredictable effects. HRV and its analysis can theoretically reflect the multiple inputs on the heart—both neural and hormonal. Another crucial aspect of acupuncture that complexity science explains is the concept of ''robustness'' or ''adaptability'' by providing an important bridge between the qualitative and the quantitative. So in addition to measuring autonomic balance, we are measuring the subtle shift occurring during the acupuncture treatment itself, and/or the underlying adaptability of the patients we are treating.

An excellent review[1] concerning this topic, in an introduction, suggests that, ''the heart theoretically should be responsive to, and exhibit increased complexity across, multiple time scales in concert with fluctuations in these elements.''…

Furthermore:

> In the real world, small inputs can have large effects, processes are dynamic, interactive effects can span across many temporal and spatial scales, and transformations from one state to another can happen gradually or precipitously. Because heart rate is dynamically balanced through many elements, including the autonomic nervous system, respiration, hormones, and other physiologic systems, the heart theoretically should be responsive to, and exhibit increased complexity across, multiple time scales in concert with fluctuations in these elements.[1]

It is highly speculative, but possible, that the decrease in the stress response reflected in the decrease in the LF/HF ratio during treatment, would predict a decrease in the LF/HF ratio over weeks to months. Through complexity science, we may also explain the dramatic and relatively rapid response to acupuncture as in the case of Patient 5 in the current study (Fig. 5). Her long term LF/HF has not yet declined as of this writing, and her intratreatment decrease and dramatic clinical response suggest that there might be a longer-term decline.

Also of interest is that Patient 6 (Fig. 6) represents a classic nonresponder. Her BP did not decrease, and her LF/HF—both during treatment and over the longer term—increased instead of decreasing. Granted, her treatment series was short, a casualty of clinical practice. Two patients who did not have a decrease in their LF/HF, Patient 9 (Fig. 9) and Patient 10 (Fig. 10), had been treated on an ongoing basis, so they may have entered a plateau phase. ◀AU2

Also as a side note, some patients could not tolerate electroacupuncture, which is a requirement of the Longhurst protocol, and were treated with manual acupuncture for some of their treatments. These patients still had a decrease in LF/HF ratios during treatment, and the patients' BP remained controlled. This is consistent with previous work suggesting that some patients respond to gentler needling, and, indeed, cannot tolerate vigorous needling.

By using HRV to evaluate each treatment, the hope is to optimize strategies and point prescriptions to achieve ever better acupuncture reproducibility and outcomes. If evaluating HRV provides information about the underlying adaptability of patients or their stress levels over time, the results will be germane to clinical practice. In addition, given that stress levels[34] influence multiple disease states, it is relevant to determine if acupuncture can optimize stress levels acutely and over time.

CONCLUSIONS

This study is part of an ongoing exploration using HRV as an additional biomarker for acupuncture effectiveness. This small case series suggests that HRV increases over weeks to months in some patients being treated successfully for hypertension with acupuncture.

DISCLOSURE STATMENT

No competing financial interests exist.

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AUTHOR QUERY FOR ACU-2014-1050-VER9-SPARROW_1P

AU1: What happened to the other 2 patients who were in the study?
AU2: How can there be Patient's 9 and 10, if only 6 patients were in the study? Aren't the 4 patients in Group 2 simply the patients that were in Group 1 originally and then re-checked during treatment?
AU3: Provide Month, dates, city, and state or country for meeting cited in ref. 6.