MEDICAL ACUPUNCTURE
Volume 19, Number 1, 2007

DOI: 10.1089/acu.2006.0000

Analysis of Heart Rate Variability in Acupuncture Practice: Can It Improve Outcomes?

Kristen Sparrow, MD

ABSTRACT

Background: Acupuncture may achieve results partially through altering vagal tone. Heart rate variability (HRV) monitoring is a noninvasive method of observing sympathovagal tone.

Objectives: To explore HRV analysis methods applicable to the acupuncture clinic setting, and to compare intratreatment HRV response in patients who have responded to their acupuncture series with patients who did not respond.

Design, Setting, and Patients: Retrospective, uncontrolled observational study of 27 patients presenting to a private acupuncture clinic.

Intervention: All patients received body acupuncture prescribed by the tenets of Traditional Chinese Medicine (TCM), according to their presenting pattern and diagnosis. Data were analyzed after their treatment course was completed.

Main Outcome Measure: Patients' assessment of progress and functionality, as a function of their LFR/HFR (low frequency to high frequency ratio) HRV intratreatment trend.

Results: Patients who responded to their acupuncture series tended to exhibit a decrease in LFR/HFR during the acupuncture treatment. Non-responders tended to show no change or an increase in their LFR/HFR.

Conclusions: In this study, the correlation between vagal enhancement (decrease in LFR/HFR) during acupuncture treatment and positive response to acupuncture was supported.

Key Words: Acupuncture, Vagal Tone, Heart Rate Variability, Treatment Response

INTRODUCTION

THE AUTONOMIC NERVOUS SYSTEM has been implicated as one of the mechanisms by which acupuncture achieves its results.[1–6] There are multiple reasons why increased parasympathetic activity and decreased sympathetic activity would be beneficial to the patient. It is now well established that stress and elevated cortisol levels coincide with increased sympathetic tone and have an incalculable negative impact on pain, mood, immunity, longevity, and health in general.[7,8]

Though it may be counterintuitive, the variability in heart rate with breathing is an inherent sign of health. This variability decreases with disease, age, and stress. Heart rate variability (HRV) monitoring is a noninvasive method to evaluate and quantify the variation of the heart rate. The components of cardiac neural control can be separated by evaluation of harmonics of HRV, using frequency domain analysis. Moreover, short-term recordings are preferable for application of spectral analysis because acquisition of biological signals during a brief period of time can better comply with the theoretical prerequisites of spectral analysis. These parameters are widely accepted as estimates of short-term components of HRV, strongly reflecting modulations of vagal tone.[9] By quantifying the contributions of different power spectra of the heart rate, one can infer the relative contributions of the sympathetic and parasympathetic input to the SA node. Increase in vagal input to the SA node (an increase in parasympathetic activity) is revealed by a decrease in the low frequency to high frequency power spectra ratio (LFR/HFR ratio). This is the basis for many of the currently available biofeedback devices. Increased complexity (variability) can be quantified by these methods. HRV becomes more complex as vagal tone increases.

Private Practice, San Francisco, CA

Acupuncture is a subtle intervention that achieves its results by triggering multiple neurotransmitters including local and central effects, and it may be possible to detect some of those changes by subtle changes in HRV. In this study, linear power spectra analysis was used to evaluate any change in HRV during acupuncture treatment, and then to examine that variation vis-a-vis patient outcomes. This particular study determined patient HRV response as a function of response to acupuncture.

The tendency of patients who "respond" to treatment or the treatment setting as having a certain physiological vagal profile was a counterintuitive result. This was the result first encountered by the author when looking only at migraine patients.[10] In this retrospective study, the patients were not controlled for point selection nor diagnosis, simply for outcomes.

Acupuncture and the Autonomic Nervous System

There is some evidence to suggest that acupuncture can augment vagal tone/increase parasympathetic input. We know from a Swedish[5] study that uterine artery blood flow impedance is decreased using electroacupuncture twice weekly for four weeks. The flow was increased shortly after the eighth acupuncture treatment and for two weeks following acupuncture. It is suggested that this is due to central inhibition of the sympathetic activity. There is evidence in the literature that acupuncture can lead to immunomodulation of the autonomic nervous system leading to normalization of granulocytes and lymphocytes.[11]

There have been a few studies looking at acupuncture and HRV. In Germany,[12] a group looked at the effects of needle acupuncture on autonomic nervous system function in patients with minor depression or anxiety disorder. Compared with placebo, the acupuncture group showed a decrease in low-frequency component and an increase in high-frequency component, i.e., an overall decrease in LF/HF ratio. Another study from Sweden[13] using HRV showed an increase in parasympathetic and sympathetic inputs after Hoku (dorsal thenar muscle) stimulation. The study also demonstrated an increase in the parasympathetic component only with Lung 1 (LU 1) stimulation in the ear (cavum concha) for 25 minutes and for 60 minutes afterward. Mild acupuncture to Sishencong can lead to a decreased LFR/HFR[14] In other studies, the stimulation of PC 6 increased high-frequency activity and decreased LF/HF activity.[15]

Consequences of Increased Vagal Tone

If one of the effects of acupuncture is to increase vagal tone, the increasing of antioxidants, coenzyme Q, endorphins, nitric oxide,[16] and dopamine may occur. But, most importantly, there may be a decrease in stress hormones, cortisol in particular, which could directly affect the patient's health. Cortisol has been determined to be detrimental to a person's immune defenses, pain tolerance, and mood (depression). Furthermore, an increase in stress hormones leads to an inability to withstand insults to the brain (hypoxia) and can lead to accelerated aging of the hippocampus and the brain glia, which may be implicated in some individuals with Alzheimer disease. For these reasons, an ability to modulate the sympathetic/parasympathetic inputs to the central nervous and cardiovascular systems could be an extremely important piece of the puzzle of acupuncture's effectiveness.

Use of HRV as Prognostic Tool

HRV is currently used as a prognostic tool in a variety of settings more directly impacted by cardiac health. It is found to be a predictor of survival after myocardial infarction[17] and survival in the intensive care unit. Using HRV as a predictor of outcomes divorced from specific heart conditions is much less common, but studies exist.[18,19] A study more germane to this one showed that vagal tone is an indicator of treatment response in major depression.[20]

METHODS

A total of 22 patients were included in this study: 15 women and seven men. The main eligibility criterion was a clearly defined condition with a clearly defined outcome of treatment. The age range was from 23 to 82 years; average age was 52 years. The patients were all receiving allopathic medical care and had been referred by their primary physician or came of their own volition. Patient diagnoses included allergic rhinitis, carpal tunnel syndrome, cervicalgia, Crohn disease, headaches, hypertension, infertility, knee pain, low back pain, migraine, panic attacks, polycystic ovaries, plantar fasciitis, sciatica, sternal pain, tinnitus, transverse myelitis, and urethral pain. History was taken according to Traditional Chinese Medicine (TCM) principles. Pulse analysis and tongue examination were incorporated to establish a constitutional pattern when appropriate, and patients were needled according to prescriptions adherent to the recommendations and acupuncture tenets of TCM. Written consent was obtained and monitoring was explained.

Patients were monitored using a I-330-C2 Biofeedback Monitor (J and J Engineering, Poulsbo, WA; http://www.jjengineering.com). They were monitored every second for heart rate, standard deviation of the heart rate, heart rate variability (in three different power spectra: LF, HF, VLF), skin resistance, and peripheral temperature. Monitors were placed after patient was in position. Monitoring took place at various times of day. Recording was begun after needles were placed. Data were collected for 20 minutes. Recording was terminated and then needles were removed. Data were analyzed retrospectively after a series of acupuncture sessions had been completed.

TABLE 1. HEART RATE VARIABILITY: LFR/HFR (LOW FREQUENCY TO HIGH FREQUENCY RATIO)

		LFR/HFR		
Patient No.	*Session*	*60–360 Seconds*	*525–825 Seconds*	*1st to 2nd Sample**
		Responders		
1	10.31.01	1.12	0.915	1.22
	8.6.02	2.87	0.412	6.97
2	5.17.05	0.9471	1.923	0.49
	6.7.05	1.64	0.937	1.75
3	4.28.05	0.146	0.094	1.55
	5.2.05	0.073	0.112	0.65
	5.9.05	0.379	0.124	3.06
4	5.4.05	1.123	1.044	1.08
	5.9.05	2.497	1.184	2.11
	5.13.05	1.463	1.748	0.84
5	4.15.05	1.069	0.415	2.58
	6.1.05	0.279	0.745	0.37
	6.8.05	1.97	3.335	0.59
	6.13.05	0.533	0.38	1.40
	6.20.05	0.897	2.051	0.44
6	6.29.04	1.236	0.868	1.42
	11.17.04	0.446	0.719	0.62
7	5.12.05	9.3	6.137	1.52
	5.13.05	5.394	6.667	0.81
	6.20.05	4.949	4.867	1.02
8	5.4.05	0.464	0.847	0.55
	5.13.05	0.501	0.278	1.80
	5.27.05	0.54	0.475	1.14
9	10.8.02	1.49	0.581	2.56
	10.8.04	1.217	1.833	0.66
	8.13.04	1.735	0.535	3.24
10	4.26.05	6.212	2.745	2.26
	5.9.05	1.846	4.914	0.38
	5.4.05	4.772	0.708	6.74
11	11.21.01	2.853	0.875	3.26
	4.10.05	4.226	2.7993	1.51
	4.26.05	6.043	2.386	2.53
	8.9.05	7.92	2.386	3.32
12	5.12.05	0.884	0.816	1.08
	5.19.05	0.207	0.239	0.87
13	3.23.05	1.998	1.48	1.35
	3.31.05	2.143	1.527	1.40
	4.11.05	2.711	2.925	0.93
14	3.28.05	7.16	0.822	8.71
Average		2.39	1.62	1.46
		Non-Responders		
15	5.12.05	1.35	4.73	0.29
	5.25.05	0.99	0.89	1.11
16	4.8.05	1.752	0.815	2.15
	4.12.05	0.521	5.578	0.09
	5.17.05	0.461	0.54	0.85
	5.31.05	3.334	3.714	0.90
17	3.30.05	1.437	0.706	2.04
	4.5.05	0.863	0.75	1.15
	4.8.05	1.055	2.066	0.51
18	6.7.05	1.505	1.203	1.25
	8.9.05	2.049	1.846	1.11
	8.24.04	2.062	2.903	0.71
	9.7.04	3.531	3.391	1.04
	10.12.04	0.765	2.065	0.37
19	6.13.05	0.393	0.436	0.90

(*continued*)

TABLE 1. HEART RATE VARIABILITY: LFR/HFR (LOW FREQUENCY TO HIGH FREQUENCY RATIO) (CONT'D)

		LFR/HFR		
Patient No.	*Session*	*60–360 Seconds*	*525–825 Seconds*	*1st to 2nd Sample**
20	10.31.05	1.235	1.723	0.72
	11.2.00	0.491	1.177	0.42
21	10.16.01	1.545	2.388	0.65
	10.29.01	2.834	2.671	1.06
	5.14.01	4.978	5.982	0.83
22	5.17.05	2.428	7.344	0.33
	6.7.05	2.333	5.397	0.43
Average		1.722	2.65	0.65

*Dark shading represents a vagal enhancement (ratio ≥1.20). Medium shading represents an even or equivocal response (<1.20 to >0.8). No shading represents vagal inhibition (ratio ≤0.8).

The only patients included for analysis were those who had completed at least 4 treatment sessions. They also had to have a clearly recognizable and describable symptom or problem. If the outcome was unclear or if the patient did not follow up adequately, that individual was not included. The only patients included for final data analyses were extremely well-known to the practitioner, so that the treatment outcomes could be made with utmost confidence.

Patients were divided into 2 categories: "responders" and "non-responders." Responders experienced a significant diminution of symptoms or complete resolution. Non-responders showed no improvement. There were 14 responders: 11 women and 3 men included for study, with an average age of 51 years. There were 8 non-responders: 4 women and 4 men, with an average age of 53 years.

Linear Power Spectra Analysis

Session reports were produced using J and J Engineering report generator (www.jjengineering.com), the data pasted into Excel spreadsheets for charting. Additional analysis of the heart rate tracing was done using HRV shareware from Kuopio University in Finland. The LFR ratio for the window of 60 seconds to 360 seconds was compared vs a window of 525 seconds to 825 seconds.

RESULTS

QU1 Patients who responded to their acupuncture series tended to exhibit a decrease in LFR/HFR during the acupuncture treatment. Non-responders tended to show no change or an increase in their LFR/HFR. The difference in LFR/HFR trend between responders and non-responders during treatment was confirmed by comparing the averages of the two sampling periods. The average LFR/HFR ratio from the first sampling period (60 to 360 seconds) to the second sampling period (525 to 825 seconds) in responders decreased from 2.39 to 1.615. In the non-responders the average increased from 1.722 to 2.65.

The purpose of this study was to explore HRV monitoring and analysis in the acupuncture clinic, and then evaluate how it correlates with outcomes. The advent of comparing "snapshots" or samples at the beginning (60 to 360 seconds) to samples later in the treatment (525 to 825 seconds) made the LFR/HFR trend much easier to analyze and quantify than in the previous study.[10] Comparing the shading, the reader can see that the "responders" had more vagal enhancement than "non-responders." This is confirmed by comparing the averages of the 2 sampling periods. The average LFR/HFR ratio from the first sampling period (60 to 360 seconds) to the 2nd sampling period (525 to 825 seconds) in responders decreased from 2.39 to 1.62. In the non-responders, the average increased from 1.722 to 2.65.

DISCUSSION

There are a number of ways to interpret these data. It is possible that the responders received a better treatment, i.e., that the point selection was more pertinent to their particular problem. As practitioners we want to give the best, most effective treatment. It is tempting to conclude that the non-responders received less effective, less skillful treatment, and that is why they did not ultimately respond and why they did not exhibit vagal enhancement. As practitioners, we learn stimulation methods and point selection in an attempt to optimize treatment. It would be useful indeed if this monitoring could be used to help guide point selection or even to help determine the optimum "DIPS" of treatment: Duration, Interval, Point selection, and type of Stimulation.

However, it is also possible that the alteration in vagal tone shows an underlying ability of patients to respond, due to a plasticity in their physiology, and is not related to the

acupuncture at all. Since this study was not controlled, we can only say that the responders were responding to their treatment experience. There were no sham treatments or non-treatments given. The lack of vagal enhancement during acupuncture may be a sign of being "stuck," and other interventions might help to facilitate a favorable outcome. (For example fish oil and exercise have been shown to increase HRV. Could they be added, perhaps, to help ensure a better acupuncture outcome?) This type of study of patients and their physiology could provide more insight into a patient's ability to respond, or at a minimum, identify patients who are likely or unlikely to benefit from acupuncture treatment.

This study should be categorized as simply a clinical case study since there are numerous drawbacks from a scientific standpoint. This study would need to be repeated with sham controls and uniform point selection and diagnoses to ultimately corroborate this work. In addition, it would be more useful to monitor results with a visual analog scale as well as with Beckman Wellness Scores. This study, as many others, raises many questions, but if we could harness this technology to give us useful feedback on our patients, it could lead to better results and hence, better outcomes.

CONCLUSIONS

HRV analysis could prove to be a useful adjunct to clinical acupuncture practice and may shed light on the physiological mechanisms involved in successful outcomes. This technique could finds its way in auriculotherapy research where a portion of the ear is innervated with the vagus nerve. Perhaps coupled with fMRI studies, a greater insight into auriulotherapy mechanisms may be elucidated as well as serving as a "tracer" for auriculotherapeutic success or failures.

REFERENCES

1. Ernst M, Lee M. Sympathetic effects of manual and electrical acupuncture of the Tsusanli knee point: comparison with the Hoku hand point sympathetic effects. *Exp Neurol*. 1986;94: 1–10.
2. Anderson S, Lundeberg T. *Med Hypothesis.* 1995;45:273–281.
3. Knardahl S. Sympathetic nerve activity after acupuncture in humans. *Pain*. 1998;75:19–25.
4. Thomas D, Collins S. Somatic sympathetic vasomotor changes documented by medical thermographic imaging during acupuncture analgesia. *Clin Rheumatol*. 1992;11:55–59.
5. Stener-Victorin E, Waldenstrom U, Anderson SA, Wikland M. Reduction of blood flow impedance in the utertinee arteries of infertile women with electro-acupuncture. *Hum Reprod*. 1996;11:1314–1317.
6. Hammar M, Frisk J, Grimas O, Hook M, Spetz AC, Wyon Y. Acupuncture treatment of vasomotor symptoms in men with prostatic carcinoma: a pilot study. *J Urol*. 1999;161:853–856.
7. Sapolosky RM. *Why Zebras Don't Get Ulcers*. New York, NY: Freeman & Co; 1994.
8. SapolskyRM. *Stress, the Aging Brain and the Mechanisms of Neuron Death*. Cambridge, MA: The MIT Press; 1992.
9. Malik M. *Heart Rate Variability*. Oxford, England: Futura Publishing; 1995:120.
10. Sparrow K. Autonomic nervous system activity during acupuncture treatment: a pilot study of patients with migraine. Presented at AAMA Conference; April 2002; Los Angeles, CA. http://www.ksparrowmd.com.
11. Mori, H, Nishijo K. Kawamura H, Abo T. Unique immunomodulation by electro-acupuncture in humans possibly via stimulation of the autonomic nervous system. *Neurosci Lett*. 2002;320:21–24.
12. Agelink MW, Sanner D, Eich H, et al. Does acupuncture influence the cardiac autonomic nervous system in patents with minor depression or onxiety disorders? *Fortschr Neurol Psychiatr*. 2003;71:141–149.
13. Haker E, Egekvist H, Bjerring P. Effect of sensory stimulation (acupuncture) on sympathetic and parasympathetic activities in healthy subjects. *J Auto Nervous Sys*. 2000;79:52–59.
14. Wang JD, Kuo TB, Yang CC An alternative method to enhance vagal activities and suppress sympathetic activities in humans *Auton Neurosci*. 2002;100:90–95.
15. Huang ST, Chen GY, Lo HM, Lin JG, Lee YS, Kuo CD. Increase in the vagal modulation by acupuncture at Neiguan point in the healthy subjects. *Am J Chin Med*. 2005;33: 157–164.
16. Loaiza LA, Yamaguchi S, Ito M, Ohshima N. Elctro-acupuncture stimulation to muscle afferents in anesthetized rats modulated the blood flow to the knee joint through autonomic reflexes and nitric oxide. *Auton Neurosci*. 2002;97:103–109.
17. Carpeggiani C, Emdin M, Bonaguidi F, et al. Personality traits and heart rate variability predict lon-term cardiac mortality after myocardial infarction. *Eur Heart J*. 2005;26:1612–1617.
18. Singh RB, Kartik C, Otsuka K, Pella , Pella J. Brain-heart connection and the risk of heart attack. *Biomed Pharmacother*. 2002;56(suppl 2):257s–265s.
19. Cashion AK, Holmes SL, Arheart KL, Acchiardo SR, Hathaway DK. Heart rate variability and mortality in patients with end stage renal disease. *Nephrol Nurs J*. 2005;32:173–184.
20. Chambers AS, Allen JJ. Vagal tone as an indicator of treatment repsonse in major depression. *Psychophysiology*. 2002;39:861–864.

Address correspondence and reprint requests to:
Kristen Sparrow, MD
2000 Van Ness Avenue
Suite 506
San Francisco, CA 94109

E-mail: collinssparrow@cs.com

SPARROW

QU1
Since paragraph was replaced, cite for Table 1 was deleted? Please advise.