

DIFFERENT EFFECTS OF ACUPUNCTURE AT SHENMEN (HT7)-TONGLI (HT5) AND SHENMEN-NEIGUAN (PC6) POINTS ON HEART RATE VARIABILITY IN HEALTHY SUBJECTS

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Point combinations are commonly used in acupuncture to produce synergistic effects to enhance therapeutic benefits. *Shenmen* (HT 7) and *Tongli* (HT 5) are located on the heart meridian, while *Neiguan* (PC 6) lies on the pericardium meridian. These acupoints lie close together and are all closely related to heart function. Heart rate variability (HRV) analysis is a simple noninvasive technique used to evaluate the function of the autonomic nervous system. The present study sought to investigate the differences in HRV among patients stimulated at HT 7 alone; HT 7 and HT 5; and HT 7 and PC 6. We designed a crossover clinical study and recruited a total of 20 healthy volunteers. All subjects received 4 experimental sessions that included sham acupuncture (SA); verum acupuncture at HT 7; verum acupuncture at HT 7 + HT 5; and verum acupuncture at HT 7 + PC 6. HRV analysis was recorded before, during, and after each acupuncture session. Results indicated that the lnLF and lnVariance components of HRV were lower at 20 min post acupuncture in the HT 7 and HT 7 + HT 5 sessions than in the SA session; no similar results were noted in the HT 7 + PC 6 session. Both acupuncture at HT 7 alone and at HT 7+ HT 5 produce similar effects on the lnLF and lnVariance components of HRV. The effects of acupuncture at HT 7 may be counteracted by adding PC 6, suggesting that HT 7 and PC 6 may have antagonistic effects on sympathovagal balance. In order to enhance the efficacy of point combinations, the points selected should not lie close together along the same meridian and also should not lie close along neighboring meridians.

Key words: Heart rate variability, acupuncture, *Shenmen* (HT 7), *Tongli* (HT 5), *Neiguan* (PC 6), point combinations

Introduction

Acupuncture has been used to treat diseases in China for many centuries. According to practitioners of Traditional Chinese Medicine (TCM) and a number of modern meridian researchers, the meridian system in humans connects the various parts of the body, including the viscera, body surface, extremities, joints, and muscles. This system helps to maintain the physiological and functional balance between the internal organs and other parts of the body¹. Many researchers suggest that acupuncture produces analgesic or therapeutic effects via the autonomic nervous system, the humoral system, or the immun-endocrine system, which transmit acupuncture signals to the brain^{2,3,4,5}.

Heart rate variability (HRV) analysis is a simple, noninvasive, quantifiable, and widely accepted method for investigating autonomic nervous function, including sympathetic and parasympathetic activity. HRV analysis may be used to monitor patients with myocardial infarction or diabetes mellitus to prevent sudden death⁶. Frequency domain analysis of HRV primarily includes high-frequency (HF) and low-frequency (LF) components. Many studies regard the HF component as closely related to vagal activity, whereas the LF component reflects both sympathetic and vagal activity^{7,8,9}. HF % is an indicator of parasympathetic activity, and the LF/HF ratio reflects the balance of sympathovagal or sympathetic activity and parasympathetic activity¹⁰. In terms of the dynamic balance between yin and yang in the human body in TCM, yang may correspond to sympathetic activity

and yin may reflect parasympathetic activity¹¹. Some researchers have reported that acupuncture may serve to regulate autonomic nervous function, including sympathetic and parasympathetic activity^{12,13,14,15,16,17}.

Point combination is a technique commonly used in acupuncture for the treatment of diseases. It involves the use of two or more acupuncture points located either on the same meridian or on different meridians to induce a synergistic therapeutic effect^{18,19,20,21}. *Shenmen* (HT 7) is an acupoint located on the palmar side of the wrist at the ulnar end of the transverse crease of the wrist. It is the source point of the heart meridian and acts to calm the mind. *Tongli* (HT 5) is located 1 cun proximal to the transverse crease of the wrist; it is the connecting point of the heart meridian and acts to quiet the spirit and stabilize the mind²². *Neiguan* (PC 6) is located 2 cun above the transverse crease of the wrist; this acupoint is the connecting point of the pericardium meridian and may play an important role in the treatment of visceral disorders²³. All three points are closely related to heart function; it has been suggested that they have synergistic effects on the heart²². The difference in physiological function between point combinations along the same meridian and point combinations using different meridians has, however, been unclear until now. The purpose of the present study was to compare the differences between a point combination using the same meridian and a combination using different meridians. Verum acupuncture was applied to HT 7 alone, HT 7 and HT 5 simultaneously, and HT 7 and PC 6 simultaneously. HRV was recorded before, during, and after the acupuncture sessions,

and the HRV components were analyzed.

Materials and Methods

Subjects

A total of 20 healthy adult volunteers between the ages of 20 and 40 years were recruited and studied. Exclusion criteria included cardiac ischemia, heart failure, severe arrhythmia, renal failure, chronic obstructive pulmonary disease, neurological abnormalities, pregnancy, and cardiac pacemaker implantation. Subjects who had received acupuncture treatment in the week prior to the test were also excluded. In addition, the use of coffee, tea, and drugs that affect heart rate, such as atenolol (Tenormin) and propranolol (Inderal) was prohibited during the 24 hours prior to the experiment. The study was approved by the institutional review board of the China Medical University Hospital (Taichung City, Taiwan), and informed consent regarding the experimental procedures and purpose was obtained prior to the study.

The location of the acupoints was confirmed and needle insertion performed by a qualified and experienced practitioner of Chinese Medicine. The experiment was performed in a quiet room with a consistent temperature of $25 \pm 1^\circ\text{C}$ between the hours of 8:00 a.m. and 12:30 p.m.

Experimental Procedure

This experiment was designed as a crossover study according to the order of number and session. Each subject was required to complete four acupuncture sessions as follows: sham acupuncture (SA); verum acupuncture at HT 7 alone (HT 7); verum acupuncture at HT 7 and HT 5 simultaneously

(HT 7 + HT 5); and acupuncture at HT 7 and PC 6 simultaneously (HT 7 + PC 6). A period of at least 7 days was allowed to elapse between acupuncture sessions to prevent residual effects from the needling. Each session was divided into a pre-acupuncture period, i.e., a baseline period (BP); an acupuncture period (AP); and a post-acupuncture period (PP). Each period was 25 min in duration.

HRV Analysis Recordings

HRV was recorded using a HRV analyzer (WGMD-ANSA01 HRV analyzer, WeGene Technologies Inc., Jonghe City, Taiwan). Subjects were asked to lie on a bed in the supine position. The electrodes were placed on the subjects' right and left forearms and right lower leg. The signal was processed and stored by fast Fourier transform (FFT), in which the HRV analyzer converted time domain signals into frequency domain signals. The HRV analysis in the present study used frequency domain analysis with 5 min of short-term recording. Frequencies of 0.15 ~ 0.40 Hz were defined as high frequency (HF); 0.04 to 0.15 Hz as low frequency (LF); and 0.003 ~ 0.04 Hz as very low frequency (VLF). The area under the curve of the power spectrum analysis was regarded as the absolute power of the frequency response; the total area under the curve was defined as the total power (TP). The variance of R-R intervals over temporal segments and normalized unit and natural logarithms were also investigated.

During the SA sessions, the baseline HRV was recorded 20 min after the subjects had rested in a relaxed state in the supine position. These were considered baseline recordings (BP). The electrode tape was subsequently placed on the skin surface of the HT 7 acupoints on the right and left hands; however,

no electronic or acupuncture stimulation was performed. HRV analysis was recorded 10 min and 20 min respectively after the electrode tape was placed for acupuncture period 1 and 2 recordings (AP1 and AP2). The electrode tapes were removed immediately after the AP2 recordings, followed by HRV recordings 10 min and 20 min after the electrodes had been removed. These were defined as post-acupuncture period 1 and 2 recordings (PP1 and PP2) (Figure 1).

During the HT 7 sessions, the baseline HRV (BP) was recorded 20 min after the subjects had rested in a relaxed state on the bed in a supine position. The baseline recordings were followed by the insertion of stainless steel acupuncture needles (5.0 cm, 32-gauge, Yu Kuang, Taiwan) into the HT 7 acupoints on the right and left hands. The needles were twisted manually in order to elicit *de qi*, the sensation felt when the acupuncturist reaches the level of *qi* in the body. The subjects experienced soreness, numbness, swelling, and heaviness, while the acupuncturist experienced a sensation of needle resistance. HRV was recorded 10 min and 20 min respectively after *de qi* had been obtained. These were defined as acupuncture period

1 and 2 recordings (AP1 and AP2). The acupuncture needles were removed immediately after the AP2 recordings. Removal was followed by HRV recordings taken 10 min and 20 min later; these were defined as post-acupuncture period 1 and 2 recordings (PP1 and PP2) (Figure 1).

During the HT 7 + HT 5 sessions, the baseline HRVs (BP) were recorded 20 min after the subjects had rested in a relaxed state on the bed in the supine position. The baseline recordings were followed by the insertion of stainless steel acupuncture needles (5.0 cm, 32-gauge, Yu Kuang, Taiwan) into the HT 7 and HT 5 acupoints on the right and left hands. The needles were twisted manually until *de qi* was obtained. HRV was recorded 10 min and 20 min after obtaining *de qi*; these were defined as acupuncture period 1 and 2 recordings (AP1 and AP2). The acupuncture needles were removed immediately after the AP2 recordings and followed by HRV recordings 10 min and 20 min respectively after needle removal. These were defined as post-acupuncture period 1 and 2 recordings (PP1 and PP2) (Figure 1).

During the HT 7 + PC 6 sessions, the baseline HRVs (BP) were recorded after the subjects had rested

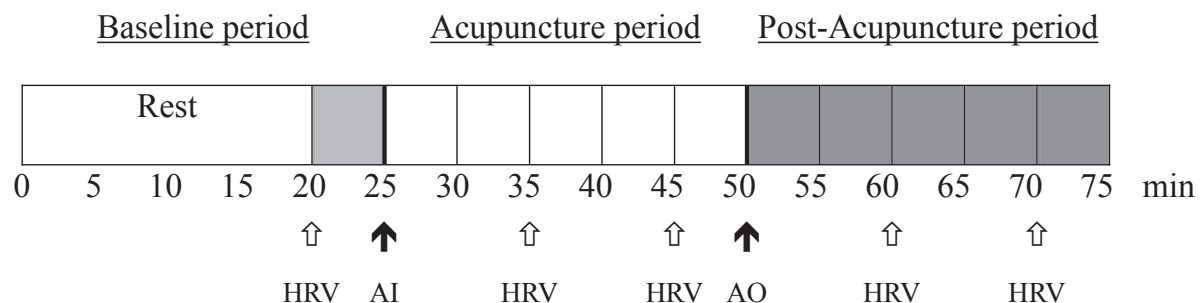


Fig. 1. Experimental procedure. The experiment divided into baseline period (before acupuncture stimulation), acupuncture period and post-acupuncture period (acupuncture needles were taken away). Each period is 25 min. Rest: the subject placed in relaxed state on the bed with supine position; HRV: heart rate variability analysis recordings; AI: acupuncture needles insertion; AO: acupuncture needles were taken away.

for 20 min in a relaxed state on the bed in the supine position. These recordings were followed by the insertion of stainless steel acupuncture needles (5.0 cm, 32-gauge, Yu Kuang, Taiwan) into the HT 7 and PC 6 acupoints on the right and left hands. The needles were twisted manually until *de qi* was obtained. HRV was recorded 10 min and 20 min after *de qi* had been obtained. These were defined as acupuncture period 1 and 2 recordings (AP1 and AP2). The acupuncture needles were removed immediately after the AP2 recordings and followed by HRV recordings taken 10 min and 20 min respectively after needle removal. These were identified as post-acupuncture period 1 and 2 recordings (PP1 and PP2) (Figure 1).

Statistical Analysis

The results in this study included absolute and relative values. The absolute values included the mean R-R interval (RRI), variance, TP, LF, and HF. The relative values comprised LF%, HF%, and the LF/HF ratio. According to previous studies, the distribution of the original values of TP, LF, HF, LF/HF ratio, and variance were seriously skewed. If the original detective values were converted and modified into natural logarithms (Ln), they were no longer skewed. The values of TP, LF, HF, LF/HF ratio and variance were therefore converted into natural logarithmic forms for analysis in this study to correct possible skew. They were expressed as lnTP, lnLF, lnHF, lnLF/HF, and lnVariance. The distribution of LF% and HF% was similar to normal distribution, so the original relative values were used. All values of the detective index were represented by the mean \pm SE. Repeated-measures analysis of variance (ANOVA) using the GLM procedure was used to assess the differences among the different tests, and Duncan's

new multiple range test (MRT) was used to compare the significance of the differences in each test. A two-sided P value, $P < 0.05$, was considered the basis of significant differences.

Results

Demographic data of the subjects

A total of 22 healthy subjects volunteered for the study; two were excluded due to suspected cardiac arrhythmias. Twenty (14 female and 6 male) subjects completed the present study. Their ages ranged from 22 to 33 (mean \pm standard deviation; 26 ± 0.9); average body height was 165.2 ± 1.9 cm and average body weight was 57.7 ± 2.2 kg. The average body mass index (BMI) was 21.0 ± 0.5 .

The effects of SA, acupuncture at HT 7 alone, acupuncture at HT 7 + HT 5, and acupuncture at HT 7 + PC 6 on HRV analysis

In the mean RRI component of HRV, the changes of the RRI component in the BP, AP1, AP2, PP1, and PP2 recordings were similar among the SA, acupuncture at HT 7, acupuncture at HT 7 + HT 5, and acupuncture at HT 7 + PC 6 sessions (all $P > 0.05$, Table 1).

In the lnLF and lnVariance components of HRV, the changes in the lnLF and lnVariance components in the PP2 were greater in the SA session than in the HT 7 and HT 7 + HT 5 sessions ($P < 0.05$, Table 1). The lnLF and lnVariance components in the BP, AP1, AP2, and PP1 were similar among the SA, HT 7, HT 7 + HT 5, and HT 7 + PC 6 sessions (all $P > 0.05$, Table 1).

In the lnHF, lnLF/HF, LF%, HF%, and lnTP components, the changes in lnHF, lnLF/HF, LF%, HF%, and lnTP components in the BP, AP1, AP2,

Table 1. Effect of sham acupuncture, Acupuncture at HT7, Acupuncture at HT7+HT5, Acupuncture at HT7+PC6 on heart rate variability (n=20)

C	Time	SA	HT7	HT7+HT5	HT7+PC6
RRI	BP	859.20±28.93	847.35±18.16	853.35±25.09	843.35±25.44
	AP1	887.35±28.09	878.75±19.56	891.15±27.76	882.10±29.98
	AP2	900.75±27.06	888.40±20.66	903.95±26.40	904.25±31.27
	PP1	904.75±26.00	896.60±20.47	904.45±28.35	892.90±30.34
	PP2	907.45±28.41	876.40±21.58	914.50±28.43	888.20±28.15
lnLF (ms)	BP	5.83±0.25	5.92±0.25	5.80±0.21	6.04±0.28
	AP1	6.27±0.18	6.06±0.20	6.23±0.25	6.25±0.19
	AP2	6.40±0.22	6.28±0.20	6.46±0.22	6.26±0.21
	PP1	6.34±0.21	6.17±0.25	6.35±0.20	6.27±0.20
	PP2	6.64±0.20	6.15±0.23*	6.16±0.16*	6.33±0.19
lnHF (ms)	BP	5.67±0.28	5.58±0.26	5.57±0.25	5.55±0.28
	AP1	5.86±0.22	5.82±0.22	5.89±0.26	5.87±0.25
	AP2	5.93±0.23	5.81±0.23	6.22±0.24	5.83±0.24
	PP1	6.02±0.26	6.00±0.22	6.02±0.20	5.86±0.28
	PP2	5.98±0.23	5.76±0.24	5.86±0.17	5.87±0.26
lnLF/HF (ratio)	BP	0.21±0.21	0.34±0.12	0.23±0.18	0.49±0.18
	AP1	0.41±0.20	0.24±0.14	0.34±0.14	0.38±0.19
	AP2	0.47±0.18	0.47±0.14	0.24±0.14	0.43±0.15
	PP1	0.33±0.21	0.17±0.16	0.32±0.15	0.42±0.19
	PP2	0.66±0.22	0.39±0.18	0.30±0.15	0.46±0.21
LF %	BP	46.09±4.56	49.95±2.80	47.01±3.74	52.82±3.76
	AP1	51.74±4.19	48.13±3.09	49.89±3.06	51.21±4.09
	AP2	53.86±3.89	53.03±3.00	48.72±3.24	52.09±3.46
	PP1	48.73±3.74	46.36±3.58	50.38±3.27	51.77±4.06
	PP2	56.85±4.17	50.26±3.86	49.55±3.52	52.66±4.35
HF %	BP	40.80±3.65	36.22±2.18	38.46±2.95	33.90±2.87
	AP1	35.81±3.29	39.29±2.80	36.08±2.47	35.40±3.22
	AP2	34.2±2.94	34.91±2.16	38.31±2.59	33.91±2.54
	PP1	37.82±2.87	37.32±2.50	37.19±2.63	34.84±3.19
	PP2	31.57±3.22	34.45±2.78	36.88±2.63	34.125±3.42
lnVar	BP	7.57±0.20	7.43±0.20	7.46±0.17	7.48±0.19
	AP1	7.63±0.18	7.53±0.20	7.65±0.16	7.81±0.15
	AP2	7.74±0.19	7.66±0.18	7.88±0.19	7.78±0.15
	PP1	7.81±0.18	7.67±0.17	7.97±0.17	7.68±0.18
	PP2	8.04±0.18	7.58±0.18*	7.69±0.16*	7.87±0.18
lnTP	BP	7.34±0.22	7.32±0.21	7.23±0.17	7.36±0.21
	AP1	7.54±0.19	7.47±0.20	7.62±0.18	7.76±0.15
	AP2	7.64±0.20	7.57±0.18	7.87±0.18	7.69±0.19
	PP1	7.69±0.20	7.63±0.18	7.78±0.18	7.59±0.18
	PP2	7.97±0.20	7.56±0.20	7.64±0.17	7.77±0.20

Data represent as mean ± standard error. SA: Sham acupuncture; BP: HRV analysis recordings of baseline period; AP1: HRV analysis recordings at 10 min of acupuncturing period; AP2: HRV analysis recordings at 20 min of acupuncture period; PP1: HRV analysis recordings at 10 min of post-acupuncture period; PP2: HRV analysis recordings analysis 20 min of post-acupuncture period

ln: natural logarithm; RRI: mean R-R interval; LF: low-frequency; HF: high-frequency; Var: Variance of RRI; TP: total power. Repeated measures ANOVA of GLM procedure was used to assess the differences of different tests, and Duncan's multiple range tests was used to compare the significance of the differences in each test. Two-sided, * $P < 0.05$ compared to SA.

PP1, and PP2 recordings were similar among the SA, HT 7, HT 7 + HT 5, and HT 7 + PC 6 sessions (all $P > 0.05$, Table 1).

Discussion

Our results indicate that acupuncture at HT 7 alone and acupuncture at HT 7 + HT 5 reduced the lnLF and lnVariance components of HRV analysis at 20 min in the post-acupuncture period; that is, 20 min after the acupuncture needles had been removed, whereas acupuncture at HT 7 + PC 6 did not produce this effect. These results suggest that acupuncture at HT 7 alone and acupuncture at HT 7 + HT 5 may affect the sympathovagal balance, because the lnLF component of HRV analysis is the best predictor of sympathovagal balance²⁴. The lnLF component of HRV analysis is generated from the feedback mechanism of the baroreceptor reflex loop and may predict mortality and aging²⁵. lnVariance represents the natural logarithms of variance of the R-R intervals²⁵. Both HT 7 (*Shenmen*) and HT 5 (*Tongli*) are located on the same heart meridian and the distance between them is only 1 cun; we therefore suggest that the physiological functions of HT 7 and HT 5 are similar, resulting in a point combination that did not have a prominent enhancing effect.

Our results leave one question requiring clarification, namely why the point combination of HT 7 and PC 6 (*Neiguan*) did not reduce the lnLF component of HRV analysis in the same manner as acupuncture at HT 7 alone. PC 6 belongs to the pericardium meridian, whereas HT 7 belongs to the heart meridian. Both points have a close relationship to the heart. The results of the present study indicate that acupuncture at HT 7 + PC 6 opposes the action

of acupuncture at HT 7 alone, in terms of the lnLF component of HRV analysis. These results suggest that antagonistic actions are generated on the heart when HT 7 and PC 6 are stimulated simultaneously. We infer that acupuncture at HT 7 alone reduces the modulation of sympathovagal tone, whereas acupuncture at PC 6 just happens to oppose the action of acupuncture at HT 7. Acupuncture at PC6 increases the modulation of parasympathetic activity¹². Li *et al.* (2002) found that acupuncture at PC 6, at HT 7, or at BL 15 alone may shorten the duration of arrhythmia in aconitine-induced ventricular arrhythmia in the rabbit, but this action disappears when acupuncture is applied to PC 6, HT 7 and BL 15 simultaneously²⁶. Together with previous findings, this report suggests that point combinations may act via the central nervous system, autonomic system, neurotransmitters, endocrine hormones, or immune system activity to produce complex physiological results⁴. In this study, HRV analysis was used as an assessment tool to investigate the effectiveness of acupuncture at HT 7 alone, acupuncture at HT 7 + HT 5, and acupuncture at HT 7 + PC 6. These combinations could not fully reflect all physiological phenomena in humans. HT 7 is the source point of the heart meridian; it may be effective in treating diseases of the viscera because it lies at a position on the body surface that accepts the vital energy (*qi*) of the internal organs, according to TCM theory. Therefore, acupuncture at HT 7 possibly produces a maximal effect, with the result that no prominent synergistic action of HT5 was observed. Our results also indicate that acupuncture at HT 7 alone and acupuncture at HT 7 + HT 5 reduced the lnLF component of HRV analysis 20 min after the acupuncture needles were removed, possibly because discomfort on insertion or emotional tension

in the subjects caused a temporary increase in sympathetic activity. This effect may delay the effects of acupuncture but requires further study. The point combination of HT 7 and PC 6 had no significant effect on HRV components during and after the trial which is the same as the sham group might be due to the magnitude of changes are under detectable limit of HRV instrument. Furthermore, either HT 7 alone or other point combination groups had no significant effect on HRV components during the trial enhance out impression about the sensitivity of this doubtful tool or poor quality of assessment. Although the aging on gender difference had been reported in HRV study²⁵, we consider that cannot affect our results because the present study is a cross over design, therefore, the number of female and male is identical in each session.

In conclusion, both acupuncture at HT 7 alone and acupuncture at HT 7 + HT 5 produce similar reductions in the lnLF component of HRV. This action of acupuncture at HT7 may be counteracted by the addition of PC 6, suggesting that HT 7 and PC 6 possibly generate an antagonistic action between them on sympathovagal balance. In order to enhance the physiological effects of point combinations, the points selected should not lie close together along the same meridian and also should not lie close along neighboring meridians.

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針刺神門（HT7）-通里（HT5）和神門-內關（PC6）對正常人心率變異度有不同的效應

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針灸常用配穴來產生協同作用促進療效。神門（HT7）和通里（HT5）屬於心經，而內關（PC6）屬於心包絡經。這些穴位之間都非常的靠近而且都與心臟功能有關。心率變異度（heart rate variability, HRV）分析是一種簡單無侵犯性的技術被使用於自律神經系統的功能評估。本研究的目的是觀察單獨針刺神門，神門加通里，以及神門加內關對HRV作用之區別。我們對20名健康自願者設計一個交叉性（crossover）的研究，所有的受試都接受假針刺（sham acupuncture）、針刺神門、針刺神門加通里、針刺神門加內關等四種試驗。針刺前、針刺中以及針刺取針後分別做HRV分析紀錄。結果顯示針刺神門和針刺神門加通里試驗之HRV的lnLF（low frequency）和lnVariance成分在針刺取針後20分鐘時比假針刺試驗低；神門加內關試驗則沒有相似的結果。單獨針刺神門和針刺神門加通里兩者對HRV的lnLF和lnVariance成分產生相似的作用，針刺神門的作用可以被附加針刺內關抵銷，如此推測神門和內關對交感迷走神經之平衡產生互相拮抗的作用。因此為了增進配穴的效用建議不要選擇相同以及相鄰經絡互相接近的穴位。

關鍵字：心率變異度、針刺、神門（HT7）、通里（HT5）、內關（PC6）、配穴