

Effect of the Hypotension Groove Point in the Indices of the Second Derivative of the Finger Photoplethysmogram Waveform in Healthy Subjects

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Published Date: June 27, 2017

ABSTRACT

Background: Few clinical and experimental studies have suggested cardiovascular changes following auricular acupoint stimulation. Hypotension *Groove* (**HG**) has been used in ear acupuncture to treat hypertension and other cardiovascular diseases. However, its cardiovascular action of has not yet been evaluated through experimental studies. To determine the effect of HG in cardiovascular physiology, we assessed the effects elicited by acupuncture in auricular HG located either in the left or right ear by examining the indices of the second derivative of the digital volume pulse (**SDDVP**). The aim of this study was to investigate the acute effects of manual needling in Hypotensive Groove (**HG**) on SDDVP indices in healthy subjects.

Methods: The DVP was obtained by photoplethysmography. Then the indices derived of SDDVP, i.e., aging index (**AGI**), B:A, and D:A were calculated. The SDDVP indices of thirty healthy subjects healthy subjects aged 26.4 ± 4.9 years (mean \pm SD) divided in two groups receiving auricular acupuncture either in the right or left ear lobe were calculated. HG was stimulated unilaterally by manual needling during 10 s (60-70 s). A registration of DVP 900 s long was obtained. SDDVP indices were compared in each subject at pre- vs. post- acupuncture periods (30 s and 840 s, respectively). HG auricular acupoint was stimulated by manual acupuncture.

Results: Compared with the basal period, B/A ratio and AGI did not change significantly after acupuncture in either right or left HG. While the D/A increased significantly after auriculopuncture in both auricular HG points left or right ($P < 0.01$ and $P < 0.01$, respectively).

Conclusion: In conclusion, the results of the present study in healthy normotensive subjects indicate that the D:A index could be acutely modified by acupuncture in Hypotensive Groove point. The SDDVP indices may be useful as noninvasive measures of vascular pathophysiology to evaluate the effect of acupoints.

Keywords: Digital volume pulse; Hypotensive Groove auricular acupoint; Photoplethysmography; Second derivative of digital volume pulse indices; Hypertension

INTRODUCTION

Auricular acupuncture is based on the premise that the external ear has a representation of each part of the human body, including the internal organs, and provides acupuncture points corresponding to these parts [1,2]. Several articles have evaluated the effect of auricular acupuncture on controlling BP [3,4]. Some studies also reported that treatment with auricular acupoints decreased BP in patients with hypertension [5,6].

The autonomic hypotensive groove or sulcus spot is located in the posterior and superior fold of the ear. In traditional books it is reported that this point lowers blood pressure. Although there is little information about this point, it is traditionally said to calm and eliminate wind, cool blood, lower blood pressure and decrease pruritus. The indications described for this point are hypertension, headache, inflammation of the facial nerve and pruritus in the skin [7,8].

Photoplethysmography (**PPG**) is an optical measurement technique that can be used to detect blood volume changes in the microvascular bed of tissue [9]. Finger photoplethysmography detects the changes in the amount of light absorbed by hemoglobin which reflects changes in blood volume. It has been shown pulsatile that pressure changes in vessel down to meta-arteriole size corresponded to pulse tracing [10]. PTG has been used to evaluate arterial compliance in relation to changes in the amplitude of wave.

Digital volume pulse (**DVP**) has been used to evaluate arterial compliance in relation to changes in the amplitude of wave, but the wave contour itself is not usually used. The developing of SDDVP allow more accurate recognition of the inflection points on the original plethysmographic wave [11]. The SDDVP upgrades accurate recognition of the circulation phase, and it is easier to interpret than the original DVP. Epidemiological studies have shown that the information extracted from the SDDVP waveform reflects both the elasticity of the aorta and peripheral vessels and that it is associated closely with age and other risk factors for atherosclerotic vascular disease [12-14]. The aim of this study was to investigate the acute effects of manual needling in Hypotension Groove on SDDVP indices in healthy subjects.

MATERIALS AND METHODS

Healthy volunteers were recruited from the local community around our institution by advertisement. Thirty-six volunteers were randomly assigned to either of two groups to receive acupuncture in either left or right HG. Group A comprised 18 (9 female), and group B (10 female) healthy subjects (refer to Table 1 for the mean age and standard deviation). All were normotensive (office blood pressure < 120/80mmHg) at the time of the study and none had total serum cholesterol values > 200 mg/dL or fasting glucose values > 95mg/dl. None had cardiac disease, or were taking any medications. The subjects were studied fasting, having abstained from caffeine, alcohol or smoking for 24 hours. The study was approved by the institutional Research Ethics Committee, and all subjects gave written, informed consent.

The measurements were performed in the morning with each subject in supine position. All recordings were made in a laboratory with a temperature of $24^{\circ}\text{C} \pm 1^{\circ}\text{C}$. All subjects were allowed to rest and to acclimatize for at least 30 minutes before recordings commenced. A photoplethysmograph (TSD 200; BIOPAC Systems, Goleta, CA, USA) transmitting infrared light at $860 \pm 90\text{nm}$ placed on the index finger of the right hand was used to obtain the DVP (Figure 1). Frequency response of the photoplethysmograph was flat to 10Hz. Digital output from the photoplethysmograph was recorded through a 12-bit analog-to-digital converter with a sampling frequency of 200 points per second (MP100; BIOPAC Systems, Goleta, CA, USA) using the analysis platform provided by Acknowledge version 3.8.1 software (MP100; BIOPAC Systems, Goleta, CA, USA).

Of each subject, a DVP registration 15 minutes long was obtained. HG was stimulated unilaterally by manual needling during 10 s (60-70 s). SDDVP indices were compared in each subject at pre- vs. post- acupuncture periods (30 seconds and 840 s, respectively). Fifteen minutes was chosen, because at this time, the analyzed indices attained steady values.

The second derivative of the DVP wave contour was obtained using the Origin, Scientific Graphing and Analysis Software version 7.5 (Microcal Software, Inc., Northampton, MA, USA). Typically, the $d^2\text{DVP}/dt^2$ waveform comprises five distinct waves: a to e. For the calculation of the SDDVP indices we measured the height of each wave from the baseline, with the values above the baseline being positive and those under it negative. The B: A and D: A indices, defined as the ratio of the height of b-wave to that of the a-wave (%), height of d-wave to that of the a-wave (%), respectively, were calculated automatically. The aging index (**AGI**), defined as $(b-c-d-e)/a$ according to Takazawa et al [11] was calculated manually (Figure 2).

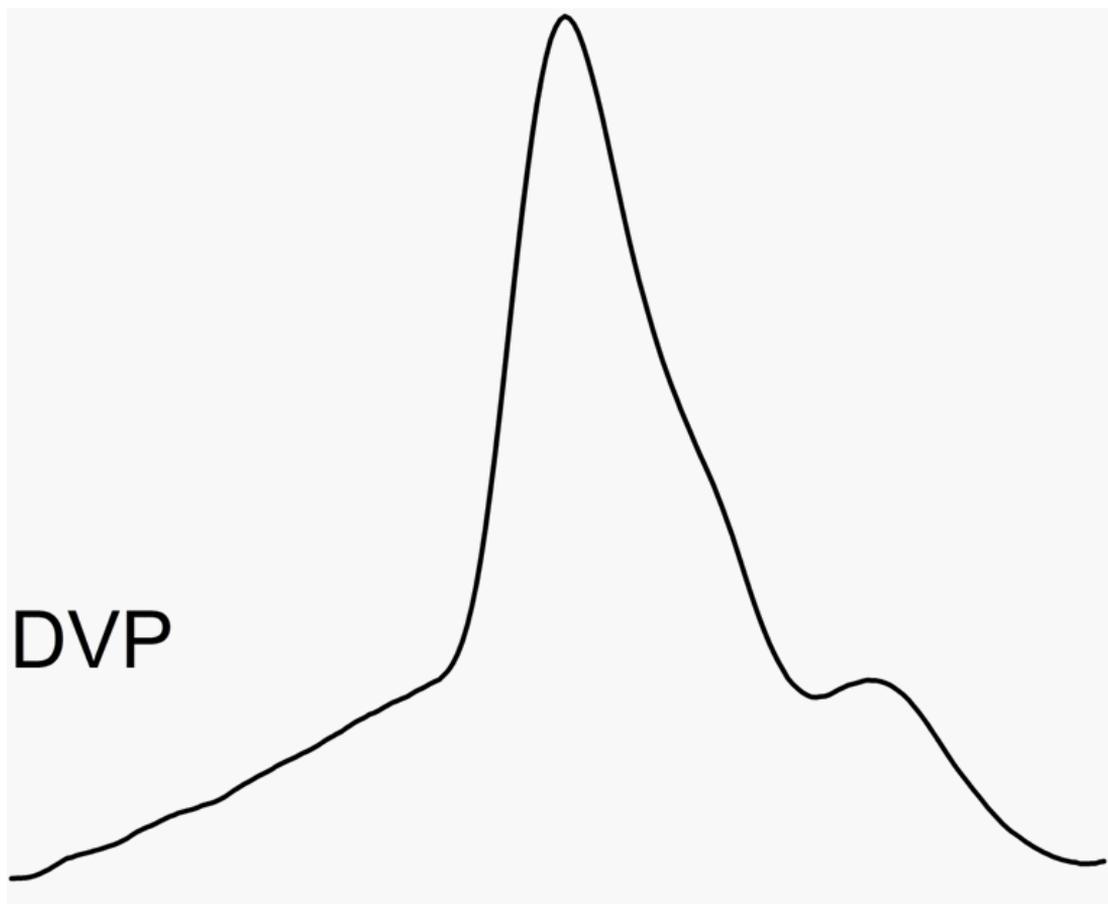


Figure 1: Representative trace of digital volume pulse (**DVP**) or finger photoplethysmogram.

Acupuncture treatment. For the treatment with acupuncture, disposable stainless steel needles of 13 mm in length and 0.22 mm in diameter with silver handle were used (Hawto, China). All subjects underwent the same procedure stimulated manually with acupuncture unilaterally, without additional electrical or laser stimulation; prior registration of your clinical information. The Hypotensive Groove was located in groove on underside of ear lobe opposite to antihelix. The needle was inserted to a depth of 0.2 cm approximately, and remained inserted for 10 seconds (60-70 seconds). And the registration of the PVD continued until completing 900 s. Concerning the primary objective of the study, the trial was blinded for a technician assistant for the calculation of the SDDVP indices.

Statistical analysis. Data were expressed as mean \pm standard deviation. The Student's t test was used for comparison of normally distributed continuous variables. A p value of < 0.05 was considered significant. All statistical analyses were performed with SPSS version 20.0 (SPSS Inc., Chicago, IL, USA) software.

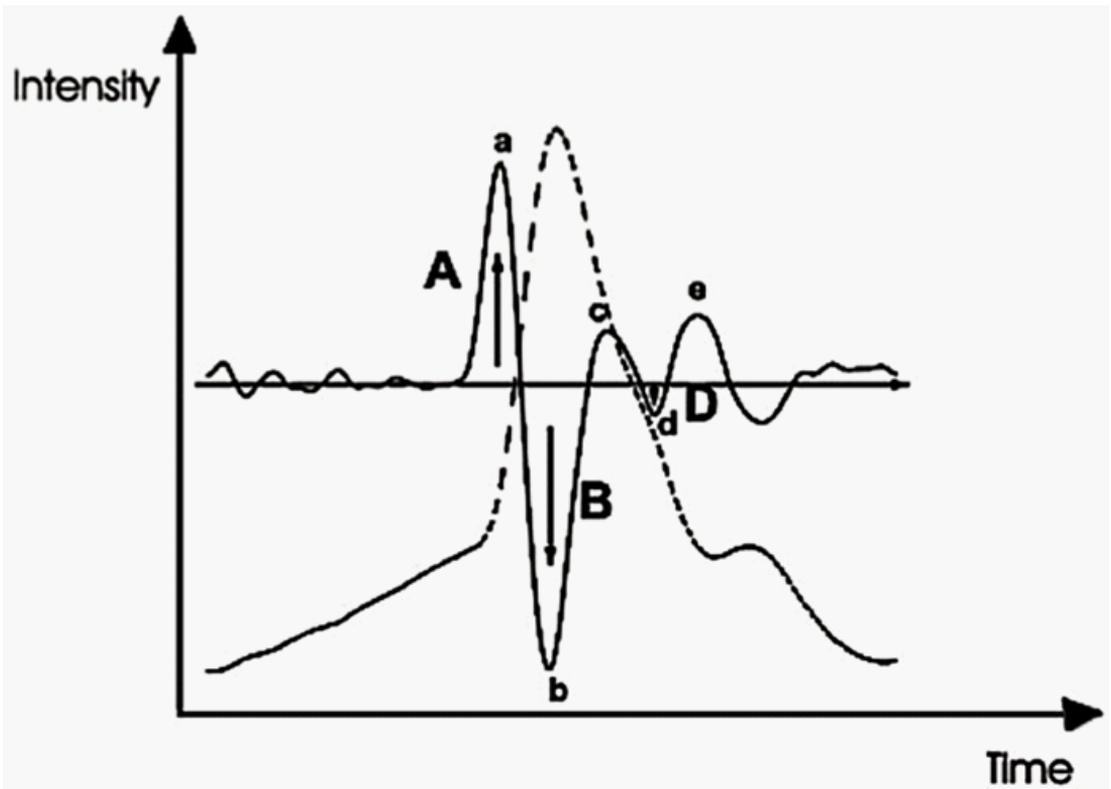


Figure 2: Representative trace of digital volume pulse and second derivative of digital volume pulse (**SDDVP**) waves. The SDDVP wave is comprised of five wave components a to e: positive (a), negative (b), positive (c), negative (d), and positive (e) waves. The B/A ratio was calculated as the ratio of the absolute value for the height of the b wave (B) to that of the a wave (A), and the D/A ratio was calculated as the ratio of the absolute value for the height of the d wave (D) to A. The aging index (**AGI**) was defined as $(b-c-d-e)/a$.

RESULTS AND DISCUSSION

Characteristics of the groups are shown in Table 1. Demographic and cardiovascular data were not significantly different between the two subject groups.

The SDDVP indices before and its changes after acupuncture in the group receiving acupuncture in left HG or right HG are shown in Table 2 and 3, respectively. Compared with the control period, B/A ratio and AGI did not change significantly after acupuncture in either right or left HG. While the D/A increased significantly after auriculopuncture in both auricular HG points left or right ($P < 0.001$ and $P < 0.001$, respectively). At baseline, there was no significant difference in any SDDVP indices between both groups.

Table 1: Demographic and clinical data for study groups.

Demographic and clinical parameter*	Group A (n=18) Acupuncture treatment in left HG	Group B (n=18) Acupuncture treatment in right HG
Female, n	9	11
Age (yr)	22.3 ± 1.8	22.5 ± 1.9
Height (cm)	167.2 ± 4.6	169.1 ± 5.2
Brachial systolic blood pressure	116 ± 8.4	114 ± 9.0
Brachial diastolic blood pressure	67 ± 8.9	68 ± 8.1
Heart rate (beats/min)	67 ± 8	69 ± 7

*Data are presented as mean±standard deviation.

HG: auricular acupoint Hypotensive Groove

The salient finding of this study was that, in healthy subjects, D: A index was improved with manual acupuncture in either left or right HG of ear lobe. The D:A decrease with ascending aortic pressure wave, which indicates that the D:A ratio should be a useful index for the evaluation of vasoactive agents and acupoints with cardiovascular effects [11]. The *d* wave corresponds to the late systolic component of the DVP, which is related to the reflected pulse wave traveling backward from peripheral sites [15]. Therefore D: A ratio is closely related to the late systolic pressure augmentation in the ascending aorta [11], and therefore it is regarded as a marker of the intensity of wave reflection. The D: A ratio reflects the phase of a falling pulse wave rising again due to the action of the reflex wave. The reflex wave increases because of functional vascular wall tension arising from the elevated intravascular pressure and organic vascular wall sclerosis due to arteriosclerosis. In adults, the D: A ratio became lower with aging as the reflex wave increased in older people [11,16].

Table 2: Comparison of indices of second derivative of digital volume (**SDDVP**) in the pre- vs. post-acupuncture period in healthy subjects: Hypotensive Groove in left ear lobe.

SDDVP index	Pre-acupuncture	Post-acupuncture
AI	-0.72± 0.18	- 0.74± 0.12
B:A	-0.56 ± 0.18	- 0.63 ± 0.20
D:A	0.16 ± 0.09	0.36± 0.19†

*Data are presented as mean±standard deviation; †significantly different from pre-acupuncture values, $p < 0.05$. AI = aging index, defined as $(b-c-d-e) / a$; B: A = the ratio of the absolute value for the height of the b wave (B) to that of the a wave (A); D: A = the ratio of the absolute value for the height of the d wave (D) to a wave (A).

Table 3: Comparison of indices of second derivative of digital volume (**SDDVP**) in the pre- vs. post-acupuncture period in healthy subjects: Hypotensive Groove in right ear lobe.

SDDVP index	Pre-acupuncture	Post-acupuncture
AI	- 0.73 ± 0.21	- 0.75 ± 0.23
B:A	- 0.53 ± 0.19	- 0.61 ± 0.23
D:A	0.18 ± 0.10	0.38 ± 0.17†

* Data are presented as mean±standard deviation; †significantly different from pre-acupuncture values, p<0.05. AI = aging index, defined as (b-c-d- e) /a; B: A = the ratio of the absolute value for the height of the b wave (B) to that of the a wave (A); D: A = the ratio of the absolute value for the height of the d wave (D) to a wave (A).

Otherwise the AGI is proposed specifically as a marker and evaluation of vascular aging [13]. Takazawa et al. [11] reported that the second derivative AGI is higher in subjects with any history of diabetes mellitus, hypertension, hypercholesterolemia and ischemic heart disease than in age-matched subjects without such a history. It has been shown that acupuncture in PC6 can positively modified AGI, B: A indices in smokers and nonsmokers [17]. Imanaga et al. [16] reported the relationship between the B: A ratio and the distensibility of the carotid artery, suggesting that the B:A ratio reflects the stiffness of large arteries.

In conclusion, the results of the present study in population including healthy normotensive an subjects indicate that the D: A index can be acutely modify by acupuncture in Hypotensive Groove point. The SDDVP indices may be useful noninvasive measure to evaluate the experimental and clinical effects of acupoints in vascular pathophysiology.

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