Study on the Cerebral Blood Flow Regulatory Features of Acupuncture at Acupoints of the Governor Vessel

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ABSTRACT

Background: Many studies to clarify the influences of acupuncture at different acupoints of various meridians on cerebral blood flow (CBF) were conducted in the past. However, the influences of acupuncture at the points of the Governor Vessel on CBF have not yet been studied tangibly.

Objective: The purpose of this study was to investigate the influences of acupuncture at individual acupoints of the Governor Vessel on cerebral hemodynamic indices.

Materials and Methods: Two hundred and seventy-nine patients with chronic cerebral circulation insufficiency (CCCI) were observed, using a cerebrovascular disease diagnosis system (CVD 3000, KCC, Pyongyang, Democratic People's Republic of Korea). Various hemodynamic indices—such as vascular compliance, hemodynamic resistance, and blood flow quantity—were compared before and after acupuncture at individual acupoints of the Governor Vessel.

Results: The influences of the points of Governor Vessel on CBF were different from each other, and systemic specificity of the Governor Vessel did not emerge. The largest number of indices showed significant changes when GV 16 was punctured, and the effects of GV 16, GV 20, and GV 14 on the head and the neck were relatively better than those of the points on the trunk.

Conclusions: The points on the head and the neck of the Governor Vessel improve CBF biphasic regulation relatively better than the points on the trunk.

Keywords: cerebral blood flow (CBF), Governor Vessel, acupuncture

INTRODUCTION

ACCORDING TO CLASSICAL MERIDIAN THEORY, some meridians are connected, not only to the corresponding *Zang-fu* organs but also to the brain in the body's circulation, so, these meridians might be expected to affect cerebral function.¹ Presently, acupuncture combined with modern biomedical therapy has been applied widely to assist in the management of symptoms related to cerebrovascular insufficiency and vertebrobasilar artery insufficiency on the basis of this meridian theory.^{2–5} There have also been a lot of experimental studies conducted to investigate the effect of

acupuncture on cerebrovascular diseases using various cerebral blood flow (CBF) measurement methods, such as rheoencephalography (REG), transcranial Doppler imaging (TCD), and near-infrared spectroscopy.^{2,6,7}

REG is a noninvasive CBF measurement method based on measuring the change in electrical resistance in a local brain tissue and REG can reflect the vascular congestion and condition of cerebral blood vessels (i.e., elasticity and tension) but has been rarely used since TCD was introduced. TCD measuring blood-flow velocity still has a shortcoming in that TCD is not able to reveal changes of elasticity fully or the radius of a brain artery. Therefore, some scientists have started to show

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interest again in REG, developing it further by combining modern mathematical theories and information technology.^{8,9}

The cerebrovascular disease diagnosis system (CVD 3000, KCC, Pyongyang, Democratic People's Republic of Korea) originated from REG—which had been developed lately in the Democratic People's Republic of Korea—and can be used to estimate local CBF better through producing measurements of vascular compliance, hemodynamic resistance, and blood-flow quantity, etc. Compliance of blood vessels reflects elasticity of the walls of blood vessels, and hemodynamic resistance is a hydrodynamic one, opposing blood flow in an artery and is inversely proportional to the radius of the artery. Blood flow quantity indicates the amount of blood that passes through a section of the circulatory system within a definite period of time and is inversely proportional to hemodynamic resistance.

The current authors' previous study using the cerebrovascular disease diagnosis system showed that different points of the Gall Bladder and Bladder meridians have different functions. In particular, it was proven that the effect of head points on CBF regulation was better than that of limb points.¹⁰

In the traditional literature, the Governor Vessel is one of the meridians that has been described to have effects on brain circulation,¹ and points of the Governor Vessel have been utilized to assist in the management of acute cerebrovascular accidents, hemiplegia, and Parkinson's disease, and the clinical efficacies of these points were investigated in the past.^{11–15} However, simultaneous acupuncture at more than two head points was usually applied for the treatments in these studies. There are few reports of investigations into concrete influences of acupuncture at individual acupoints of the Governor Vessel on CBF or on the effects of the points compared with one another. What was not especially verified was whether or not there is meridian specificity in CBF regulatory functions of various acupoints of the Governor Vessel.

However, in 2011, there was an experimental report that was relevant, with an apparent biphasic regulatory effect of acupuncture on vertebrobasilar artery insufficiency of either decreased or increased blood-flow velocity.⁶ Therefore, in this study, the current authors applied statistical analysis according to the different functional states of an individual brain artery before and after acupuncture. The goal was to reveal the influences of acupuncture stimulation on CBF at individual acupoints of the Governor Vessel more concretely. The purpose of this study was to clarify these influences of acupuncture stimulation at some individual acupoints on the head and the trunk of the Governor Vessel on CBF.

MATERIALS AND METHODS

Participants

This study involved patients with CCCI who complained of headache and dizziness. The patients were divided into

individual acupuncture-point groups according to randomized blocks. The subjects were outpatients of the Pyongyang Medical College Hospital of Kim Il Sung University, Pyongyang, Democratic People's Republic of Korea, and volunteers who agreed to participate in the trial examination, from January 2013 to December 2016.

A total of 279 subjects were recruited; there were 116 males and 163 females ranging in age from 45 to 76.

The study was approved by the ethical committee of the Pyongyang Medical College of Kim Il Sung University, in Pyongyang, Democratic People's Republic of Korea (reference number 17–35), and was registered with the Koryo Medicine Review Committee, of the National Medical Association, Democratic People's Republic of Korea. Medications, including aspirin, that could affect the cerebral circulation were prohibited for 48 hours prior to the study.

Inclusion and Exclusion Criteria

Patients were diagnosed clinically according to the CCCI criteria defined by the 16th Japanese Stroke Society in 1991.¹⁶ Similar symptoms occurring in other diseases, severe complications, and patients with a tendency to hemorrhage were excluded.

Acupuncture Stimulation

The following points of the Governor Vessel were chosen: *Shangxing* (GV 23), *Baihui* (GV 20), and *Fengfu* (GV 16) on the head; *Dazhui* (GV 14) on the neck; *Shenzhu* (GV 12), *Shendao* (GV 11), *Zhiyang* (GV 9), *Mingmen* (GV 4), and *Yaoyangguan* (GV 3) on the trunk.

Stainless-steel needles (0.3×40 mm) were inserted into the selected points and retained for 15 minutes without any manipulation after a needling sensation occurred. The needle insertions were as follows: GV 23 and GV 20 horizontally backward ~10 mm in depth; GV 16 perpendicularly ~10 mm in depth; GV 14, GV 12, GV 11, GV 9, GV 4, and GV 3 obliquely upward 10 to ~15 mm in depth.

CBF measurement

The CVD 3000 was used in this study. During the examination, the probes were fitted on the frontal, temporal, and occipital parts of each patient's head. On the day of examination, each subject rested in a bed for 10 minutes prior to the first examination and then acupuncture stimulation was applied at a single acupoint. The second examination was conducted 10 minutes after withdrawing the needle. Compliance (normal range: 0.7 to ~2.0 mL/mm Hg), hemodynamic resistance (normal range: 0.5 to ~1.4 mm Hg/L), and blood flow quantity (normal range: 0.8 to ~2.2 mL/second) were measured. Compliance and hemodynamic resistance were measured in the places corresponding to the bilateral anterior cerebral arteries (ACA), middle cerebral arteries (MCA), posterior cerebral arteries

TABLE 1. COMPARISON OF COMPLIANCES OF BRAIN ARTERIES BEFORE AND AFTER ACUPUNCTURE AT GV 16^a

Cases	Anterior cerebral artery			Middle cerebral artery			Posterior cerebral artery		
	N	Before	After	N	Before	After	N	Before	After
Normal	23	1.19±0.07	1.17±0.06	23	1.11±0.08	1.06±0.05	30	1.14±0.04	1.35±0.06**
Low	30	0.53±0.02	0.64±0.03**	30	0.53±0.02	0.67±0.03**	14	0.81±0.05	1.12±0.11*
High	7	1.84±0.09	1.46±0.10*	7	1.88±0.04	1.46±0.11*	16	2.75±0.14	2.55±0.14

^a $\bar{X} \pm SE$, mL/mm Hg.Compared with the value before acupuncture: * $P < 0.05$; ** $P < 0.01$.

N, number of arteries; SE, standard error.

(PCA); and blood flow quantity was measured in the places corresponding to the bilateral internal carotid arteries (ICA) and vertebral arteries (VA).

Statistical Analysis

The data were expressed as mean $\pm$ standard error of the mean. Paired two-sample *t*-tests were used to compare the values of each parameter before and after acupoint stimulation. In addition, each brain artery was “divided” into normal case (measurement value within normal range), high case (measurement value higher than normal range) and low case (measurement value lower than normal range) according to the measurement value in the same brain artery before acupuncture. This grouping was done in order to investigate the changes of hemodynamic indices in individual blood vessels with different functional states after acupuncture more clearly.⁶

RESULTS

Comparison of the Values of Hemodynamic Indices Before and After Acupuncture Stimulation at GV 16

As shown in Table 1, after acupuncture at GV 16, the compliances of ACA, MCA, and PCA in low-compliance cases and PCA in normal-compliance cases increased significantly, compared with these compliances before acupuncture. However, compliance of ACA, MCA, and PCA in

high-compliance cases decreased significantly. There was no significant difference in comparison before and after acupuncture in normal-compliance cases of ACA and MCA.

As shown in Table 2, after acupuncture at GV 16, resistances of ACA, MCA, and PCA in high-resistance cases and PCA in normal-resistance cases decreased significantly, compared with resistance before acupuncture, but resistance of ACA, MCA and PCA in low-resistance cases increased significantly. There were no significant differences in resistances of ACA and MCA before and after acupuncture in normal-resistance cases.

As shown in Table 3, after acupuncture at GV 16, blood-flow quantities of ICA and VA in low cases increased significantly, compared with resistance before acupuncture, but blood-flow quantity of ICA in high cases decreased significantly. There was no significant difference in comparison before and after acupuncture in normal cases of ACA and MCA, and in high cases of VA.

Comprehensive Comparison of the Influences of Acupuncture Stimulation at the Points of Governor Vessel on CBF

The influences of various points of the Governor Vessel on hemodynamic indices were compared with one another, by using the rates of the indices with remarkable changes among the total number of observation indices after needling at the points.

As shown in Table 4, the largest number of indices (70.8%) changed remarkably after needling at GV 16. Next, GV 20 and GV 14 showed a rate of 58.3%. Meanwhile, the needling

TABLE 2. COMPARISON OF HEMODYNAMIC RESISTANCE OF BRAIN ARTERIES BEFORE AND AFTER ACUPUNCTURE AT GV 16^a

Cases	Anterior cerebral artery			Middle cerebral artery			Posterior cerebral artery		
	N	Before	After	N	Before	After	N	Before	After
Normal	24	1.01±0.03	0.99±0.03	24	1.01±0.03	1.00±0.03	29	0.74±0.03	0.64±0.03**
High	29	1.82±0.07	1.60±0.07**	29	1.78±0.07	1.57±0.07**	12	2.32±0.14	1.67±0.08*
Low	7	0.42±0.01	0.50±0.03*	7	0.42±0.01	0.51±0.03*	13	0.38±0.01	0.43±0.01*

^a $\bar{X} \pm SE$, mm Hg/L.Compared with the value before acupuncture: * $P < 0.05$; ** $P < 0.01$.

N, number of arteries; SE, standard error.

TABLE 3. COMPARISON OF BLOOD FLOW QUANTITY OF BRAIN ARTERIES BEFORE AND AFTER ACUPUNCTURE AT GV 16^a

Cases	Internal carotid artery			Vertebral artery		
	N	Before	After	N	Before	After
Normal	24	1.09±0.05	1.15±0.05	32	1.23±0.08	1.36±0.11
Low	28	0.67±0.04	0.78±0.03*	13	0.58±0.09	0.81±0.08**
High	8	2.69±0.04	2.38±0.02*	15	2.80±0.13	2.66±0.27

^a $\bar{X} \pm SE$, mL/s.Compared with the value before acupuncture: * $P < 0.05$; ** $P < 0.01$.

N, number of arteries; SE: standard error; s, second.

at GV 12, GV 11, GV 9, GV 4, and GV 3 caused remarkable changes in a considerable number of indices with rates of 45.8%, 45.8%, 45.8%, 41.7%, and 41.7%, respectively. The effect of acupuncture at GV 23 on CBF was the slightest.

To sum up, every point of Governor Vessel influenced CBF, but the regulatory effects and characteristics of every point differed from each other. In particular, the CBF regulatory effects of GV 16, GV 20, and GV 14 located on the head and neck were better than the points on the trunk.

DISCUSSION

In this study, the current authors investigated the influences of acupuncture at GV 23, GV 20, GV 16, GV 14, GV 12, GV 11, GV 9, GV 4, and GV 3—which are the points of the Governor Vessel—on various hemodynamic indices, including vascular compliance, hemodynamic resistance, blood flow quantity, and these parameters compared with one another. Acupuncture at GV 23 caused significant changes in PCA and VA, and acupuncture at GV 20 and GV 16 had significant effects on every hemodynamic index. Acupuncture at GV 14 had significant effects on compliances and resistances of ACA and MCA, compliance of PCA, and blood flow quantities of ICA and VA. Acupuncture at GV 12,

GV 11, GV 9, GV 4, and GV 3 influenced these respective cerebral hemodynamic indices to a remarkable extent. To sum up, the influences of the points of the Governor Vessel on CBF were different from each other, and there was no systemic specificity of the Governor Vessel.

A clinical study on the treatment of acute cerebral infarction by applying electroacupuncture (EA) at points of the Governor Vessel, such as GV 26, GV 23 and GV 20, and the other additional body acupoints for addressing various symptoms, showed an apparent neuroprotective effect of EA at the points of the Governor Vessel with more efficiency in the earlier stage of cerebral infarction.² This was a result of simultaneous stimulation at various acupoints but not of stimulation at a single acupoint.

Another study result obtained from 16 healthy volunteers indicated that delivery of EA on both sides at the inner edge of the eyebrows (BL 2) and 1 cm from the front hairline midpoint (GV 24) might increase blood flow in the prefrontal cortex, reduce heart rate, and increase parasympathetic nervous activity through the trigeminovagal reflex.⁷

GV 23 is located in the prefrontal area, but there were more remarkable changes in PCA and VA after GV 23 stimulation in the current study. Of course, there was a significant change only in compliance of MCA with normal flow, but no change in hemodynamic resistance of ACA and

TABLE 4. COMPREHENSIVE COMPARISON OF THE INFLUENCES OF ACUPUNCTURE AT THE POINTS OF GOVERNOR VESSEL ON CBF

Points	Anterior cerebral artery		Middle cerebral artery		Posterior cerebral artery		Internal carotid artery	Vertebral artery	# of indices with marked change	Rate (%) ^a	Rank
	C	R	C	R	C	R	Q	Q			
GV 23			O		▽	△		O▽	5	20.8	5
GV 20	△▽	O▽	△▽	O▽	△	▽	▽△	▽△	14	58.3	2
GV 16	△▽	△▽	△▽	△▽	O▽	O△▽	▽△	▽	16	66.7	1
GV 14	△▽	△▽	△▽	△▽	O▽		▽△	▽△	14	58.3	2
GV 12	△▽	△▽	△▽	△▽	▽		▽△		11	45.8	3
GV 11	△▽	△▽	△▽	△▽	▽		▽△		11	45.8	3
GV 9	△▽		△▽		△▽	△▽	▽△	△	11	45.8	3
GV 4	△	▽	△	▽	△	▽△	△	△▽	10	41.7	4
GV 3	▽	△	▽	△	▽	▽	▽△	▽△	10	41.7	4

^aRate is a ratio of the number of indices with marked change to the total number of indices.

CBF, cerebral blood flow; C, compliance; R, resistance; Q, quantity; △, high cases, ▽, low cases; O, normal cases.

MCA, and blood flow quantity of ICA, indicating that GV 23 acupuncture might not have an effect on normal blood flow of ACA, MCA, and ICA. The underlying mechanism of CBF regulation by needling at GV 23 should be studied in more detail in the future. The current authors presume that a difference between acupoint stimulation methods might bring about a difference in the effects as well.

The points GV 20 and GV 16 have been described in ancient texts¹⁷—for the management of various conditions, including Wind-stroke syndrome, dysphasia, paralysis of one side, headache, dizziness, and psychosis—as representative acupoints with the function of restoring consciousness.

A study showed the effect of GV 20, GV 26, *Sishencong* (EX-HN 1), and LR 3 on depression in patients with post-stroke.¹⁸

The CBF regulatory effect of GV 20 and of GV 16 offers a reason that could prove the therapeutic effect of these acupoints on cerebral vascular diseases. Particularly, some significant changes occurred in ACA and MCA of normal cases after needling at GV 20 and in PCA of normal cases after needling at GV 16, indicating that needling at GV 20 can affect ACA and MCA more significantly, and needling at GV 16 can affect PCA more significantly.

Previous studies reported that acupuncture can regulate CBF via noradrenergic postganglionic fibers from the superior cervical ganglia and cholinergic postganglionic fibers from the sphenopalatine ganglion.^{19,20} Therefore, the current authors hypothesized that the points on the frontal head, such as GV 20, might influence CBF mainly through the trigeminovagal reflex and the points on the back head, such as GV 16, influence CBF mainly through the spinal-sympathetic reflex. In this current study, needling at the points on the trunk also provoked some changes in CBF, and the mechanism could be through the spinal-sympathetic reflex.

However, the influence of the points of the Governor Vessel on CBF regulation were compared with one another by including the rates of the indices with remarkable changes among the total number of observation indices after acupuncture. This revealed that there were significant changes in the largest number of indices after needling at GV 16, and that the effects of the points on the head and the neck were relatively better than effects of the points on the trunk. This is similar to previous research results showing that the effects of the head points of the Gall Bladder and Bladder meridians were better than those of the points on the legs.^{10,15} The above research results suggest that the nearer a point is anatomically to the brain, the greater its influence on CBF will be.

The current study also showed that, in every point group, a parameter value of any brain artery in the cases that were in the lower-than-normal range increased apparently after acupuncture, but, conversely, in the cases that were in the higher-than-normal range a parameter value decreased significantly (i.e., acupuncture at the points of the Governor Vessel improve blood supply in different brain arteries in the mode of biphasic regulation).

Mechanisms of acupuncture-induced protection against cerebral ischemia might involve various factors, including an acupuncture-induced increase in CBF as well as the roles of the delta opioid receptors, nitric oxide synthase, and neurotropic factors, etc.² However, irrespective of the mechanisms, an increase in the blood flow is obviously a beneficial factor for the ischemic brain. The difference between the influences of the acupoints of the Governor Vessel on CBF in this study may be related to the difference in neural innervation and distribution at each point of Governor Vessel.

In the current study, only 3 acupoints were chosen among the head points of the Governor Vessel. Therefore, it is yet unclear whether or not the observed differences between effects of acupuncture at head points are specific. Studies on the effects of acupoint stimulation according to acupuncture doses are also necessary to clarify the current study's results. In addition, the current author might need to prove the reproducibility of these research results more concretely by using other CBF measurement methods.

In the future, the current authors are going to investigate the influences of the points of the Stomach and Liver meridians, which are described as being connected to the brain, and the influences of the points of the Pericardium and Heart meridians, which are related to mental activities—all based on traditional medical theory descriptions of visceral functions. These study results probably have provided important fundamental data for more scientific understanding of the action principle of acupuncture as well as being significant for clinical practice by supporting a scientific principle that can improve the therapeutic efficacy of acupuncture for cerebrovascular disorders.

CONCLUSIONS

The influences of the individual acupoints of the Governor Vessel on cerebral blood flow in patients with chronic cerebral circulation insufficiency are different from each other. Three other results of the study showed that:

- (1) Acupuncture at the points of the Governor Vessel increases cerebral blood flow in patients with low flow and decreases in patients with elevated flow.
- (2) The points on the head and the neck of the Governor Vessel improve cerebral blood flow better than the points on the trunk.
- (3) Among the points of the Governor Vessel, GV 16, GV 20, and GV 14 have the best cerebral blood flow regulatory effect, and the effect of GV 23 is not apparent.

AUTHOR DISCLOSURE STATEMENT

No competing financial interests exist.

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