

The Physiological Effect of DE QI during Acupuncture

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Acupoints tend to show higher electric conductivity and have a higher concentration of neural and vascular elements as well as mast cells. According to one model, the meridian is an extravascular fluid (interstitial fluid) pathway and circulation of this fluid is driven by skeletal muscle contraction. Our result derived from laser Doppler flowmetry shows that Yanglao (SI6) and Xiaohai (SI8) have larger amplitude of heartbeat and vasomotion than non-acupuncture points. The amplitude of blood flow on the SI8 shows a more significant increase (4.3 ± 0.7 PU) than that of non-acupuncture points (1.1 ± 0.2 PU). Our results indicate that acupuncture increases blood flow when the De-Qi sensation takes place. In the experiment, the needle was only entered into the subject by 2 mm for about 15 sec during a SI6 acupuncture session, and the blood flow increased immediately. The blood flow of SI8 began to rise 5 sec after implementation and increased by 11.1 ± 0.9 PU. However, when the arm was tied up, the blood flow at the SI8 point slowed down quickly. Even though insertion with a twirling needle was followed after the drop in blood flow, the blood flow at the SI8 point did not accelerate again (0.7 ± 0.2 PU). The present study seems to show that acupuncture is effective in regulating the autonomic nervous system. Implementation of acupuncture causes the sphincter of microvessel to relax, and the tissue fluid to flow out, and the propagated sensation along the meridian is caused by this large amount of tissue fluid that flows along the loosen body stalk. The interstitial fluid increases during the needling and blood capillary expansion, which may be one of the mechanisms of acupuncture regulation.

Key words — acupuncture, blood flow, meridian, laser Doppler flowmetry, autonomic nervous system

INTRODUCTION

Acupuncture can increase general circulation and the increase in blood flow in specific organs changes the treatment of diseases.¹⁾ However, the De-Qi effects of acupuncture still remain unclear at the level of microcirculation.

Acupuncture is a rooted treatment in the history of Chinese medicine that dates back at least 3000 years and has been widely used to treatment of disease. Researches have demonstrated the physiological and neurobiological basis for many of the

effects of acupuncture, which has made it more acceptable to many Western physicians. In this past year, we have seen researches using single-photon-emission computerized tomography and functional magnetic resonance imaging technology to examine the effect of body acupuncture on brain physiology.²⁾ Meridians have been described as networks of invisible channels throughout the body and through which vital energy flows.³⁾

The present study can further explore the role of skin blood flow in the De-Qi physiological mechanism of acupuncture stimulation using SI6 acupoint.

MATERIALS AND METHODS

Subjects — The study was performed on fifty-eight healthy volunteers, 20 males and 38 females,

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aged 18 to 24 years. Our experimentation was done on healthy upper limbs. Data of blood flow on SI8 and SI6 of the right arms and a non-acupuncture point, chosen freely near SI8 and SI6, were recorded with the subjects in a sitting position.

SI6 point is known to receive strong De-Qi sensation; therefore, it is chosen for this study. The SI6 is located inside of the suture of flexed metacarpal radial side superior to the styloid process of the ulna, and the SI8 is located inside of the neural groove between the olecranon of the ulna and epicondyle of the humerus. A pair of stainless steel needles of 0.2 mm in diameter and 30 mm in length were inserted vertically into the SI6 point. Following the gradual insertion of the needle to a desired depth (2–3 mm), the needle was then moved up and down (sparrow-pecking needling) or twisted (twisting needling). These types of needling are practical for successful inductions of the De-Qi sensation. The needles were stimulated manually once in every 2–10 min until the De-Qi sensation was achieved. In acupuncture, a De-Qi sensation is a special feeling described by the subject; that is, the subject experiences a sensation of soreness, numbness, heaviness or distension around the region of the acupuncture needle point, and, sometimes, it is a sensation radiating along its meridian from a considerable distance away from the activated acupuncture point (propagated sensation along meridians, PSM).⁴⁾

Physiological Recordings — Skin blood flow was recorded with the use of a laser Doppler flowmeter (Periflux 4001 Master, Perimed Ltd. Stockholm, Sweden).⁵⁾ The device contains a solid-state, low-power diode laser (1 mW at the probe tip, wavelength 780 nm) that delivers a laser beam to a cutaneous surface of [almost equal to] 1 mm in depth through flexible graded-index and fiberoptic light guides.

Skin temperature was assessed continuously under resting conditions by using an electronic thermometer (78214C, Hewlett-Packard, Palo Alto, Calif) and a circular metal thermocouple (0.8 cm²).⁶⁾

Statistical Analysis — Results are given as the mean \pm S.E. in perfusion units for each point measured. Student's *t*-test and analysis of variance (ANOVA) were used to calculate the differences between time points as indicated by the results. Probabilities of ≤ 0.05 were considered statistically significant.

RESULTS

The Blood Flow of Acupuncture Point

In resting condition we detected the following profiles of blood flow. The SI8 has a notable amplitude of the singular value decomposition (SVD).⁵⁾ The SVD-based method utilizes the exponential shape of different ranges of spectrum frequencies. The vasomotion and heartbeat are the main influences on SVD.⁵⁾ The amplitude of SVD on the SI8 is significantly larger (4.3 ± 0.7 PU) ($p = 0.017$) than that of the non-acupoint (1.1 ± 0.2 PU) (Figs. 1A and 1B), and the amplitude of SI6 is also significantly larger (2.2 ± 0.3 PU) ($p = 0.024$) than that of the non-acupoint (0.9 ± 0.2 PU) (Figs. 1C and 1D).

Effects of Acupuncture on the Changes of Blood Flow

Acupuncture stimulation on the SI6 point incurs a sudden rise in the blood flow in SI8 (Fig. 2A), whereas the blood flow of the non-acupuncture point was only changed slightly by the same acupuncture stimulation (Fig. 2B). Figure 2A shows a typical example of augmentative effect of acupuncture with relations to the changes in blood flow. The SI8 blood flow was around 9.8 ± 3.1 PU before acupuncture stimulation. The data was acquired from the average of base line. The SI6 stimulation was implemented for about 15 sec, till the “De-Qi” sensation was achieved. The blood flow increased immediately after the “De-Qi” sensation occurred. The blood flow began to rise after the onset of the “De-Qi” sensation and significantly increased to the level of 11.1 ± 0.9 PU ($p = 0.0009$) within 10 sec (Fig. 2C). The data was acquired from the difference between the peak and the base line. After acupuncture, the SI8 did not show continuous elevation of blood flow as SI6 (Figs. 2A and 3). When the SI6 was stimulated till the “De-Qi” sensation was achieved, the blood flow of SI6 continued increase (54.1 ± 3.8) (Fig. 3) whereas the blood flow of non-acupuncture point only changed slightly by the same acupuncture stimulation (0.9 ± 0.1 PU) (Fig. 3). When the SI6 was stimulated repeatedly by acupuncture, the blood flow increased again after the De-Qi sensation occurred, even without subsequent needle twirling, and as long as the subject is getting a strong De-Qi sensation (numbness, soreness and heat sensations in his hands) or feeling a flow of numbness and heat traveling towards SI8, there will be a visible peak of upward SI8 blood flow (Fig. 4).

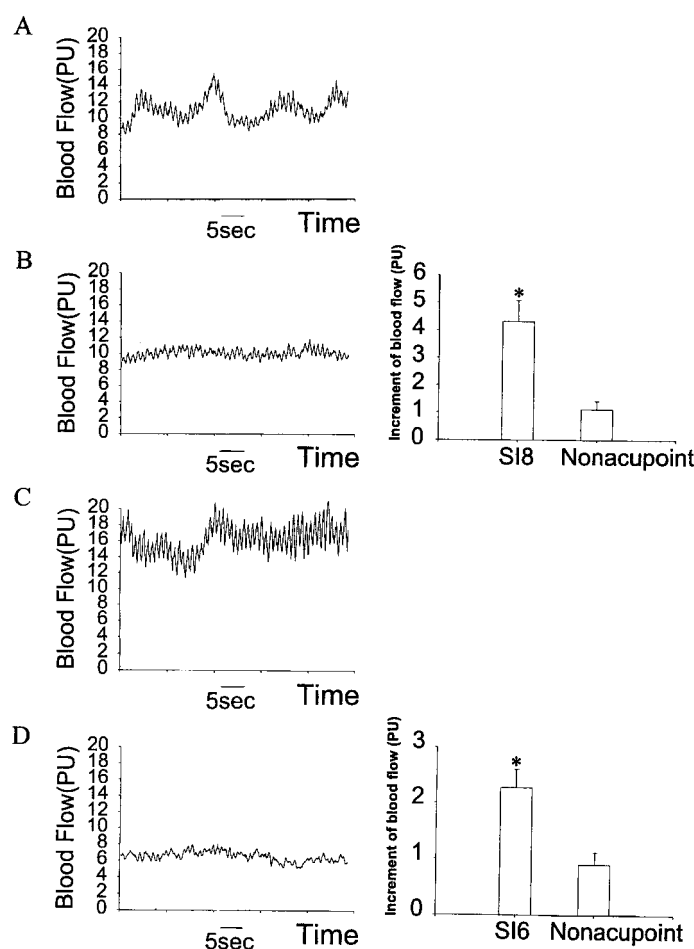


Fig. 1. Laser Doppler Flow Values (under Resting Conditions) Measured in the Skin of SI8 and Non-Acupoint

(A) Record illustrates a typical large-amplitude of heartbeat fluctuations on the SI8 under resting conditions. (B) Control, non-acupoint besides the SI8. (C) Record illustrates a typical large-amplitude of heartbeat fluctuations on the SI6 under resting conditions. (D) Control, non-acupoint besides the SI6. A representative curve of forty-nine experiments is shown. Peak-to-peak amplitudes of blood flow changes are presented as the mean \pm S.E. of forty-nine separate experiments. * $p < 0.05$ as compared with control.

Effect of Mechanical Force Applied on the Skin above the Meridian

In order to find out whether the PSM incurred during acupuncture actions is caused by the flow of tissue fluid along meridian channels, we tied up the upper arm of the subject with a rubber tube (at a location 5 cm above the SI8 point). The result of the above test shows that before the arms were tied up with rubber tubes, the De-Qi feeling (soreness and numbness) occurred due to acupuncture (SI6) brings about an acceleration in the blood flow at the SI8 point (11.1 ± 0.5 PU) (Fig. 5). Once the arm was tied up, the blood flow at the SI8 point slowed down quickly, and although it was still possible to get a minor sore De-Qi feeling with twirling needle insertion, the blood flow at the SI8 point no longer accelerated (0.7 ± 0.2 PU) (Fig. 5), nor did the PSM feeling appear afterward. It proves that obstruction

of blood flow can effectively prevent the PSM phenomenon from happening, and thus indicates that the PSM derived from acupuncture implementation is very likely to be a phenomenon of a flowing sensation created by the motion of a large amount of tissue fluid entering meridian.

Effects of Acupuncture on the Changes of Skin Temperature

When the SI6 was stimulated by acupuncture, the skin temperature of the palms of the test subjects was significantly increased by $0.71 \pm 0.20^{\circ}\text{C}$, compared to the temperature of the control group ($0.18 \pm 0.09^{\circ}\text{C}$) (Fig. 6). The data was acquired from the difference between the maximum temperature taken before and after acupuncture. There was an initial phase of increase in skin temperature of the palms when the subjects are in a resting condition,

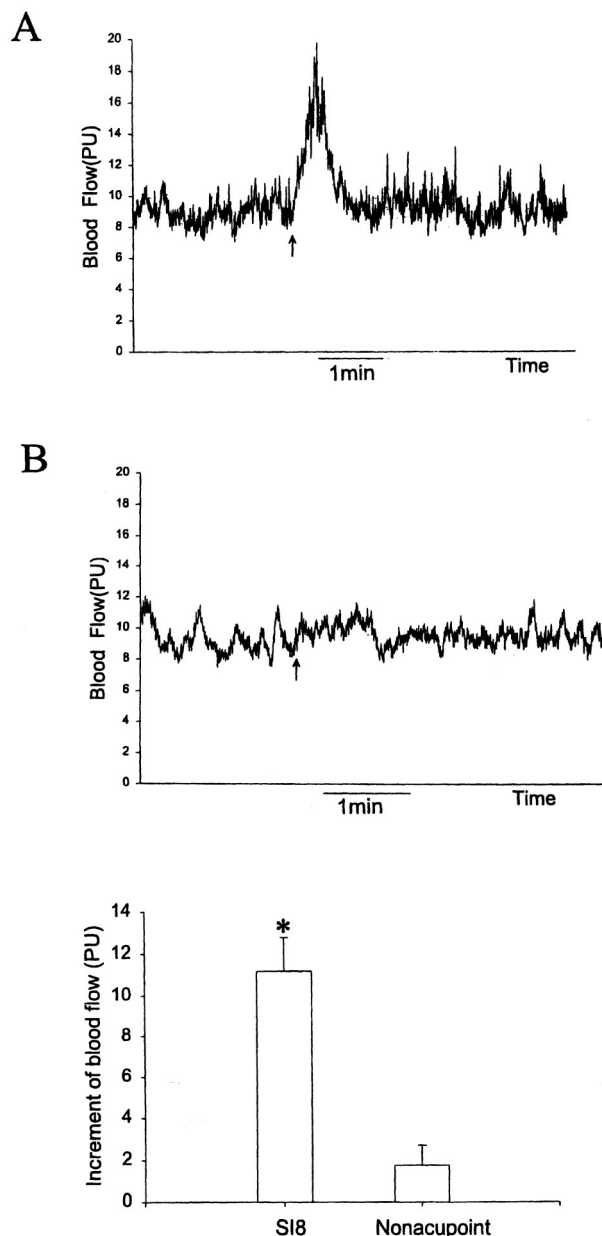


Fig. 2. Representative Time Course of Acupuncture Induced the Changes of Blood Flow in the SI8

(A) Acupuncture stimulation of the SI6 point incur a sudden rise in the blood flow in the SI8 (the De-Qi sensation being achieved, as indicated by the arrows). (B) Control and non-acupuncture point besides the SI8. Data of the results are presented as the mean \pm S.E. of forty-one separate experiments. * $p < 0.01$ as compared with the control group.

which was followed by a secondary phase of rapid increase after acupuncture.

DISCUSSION

In this study, intradermal stimulation by acupuncture caused a significant increase in blood flow.

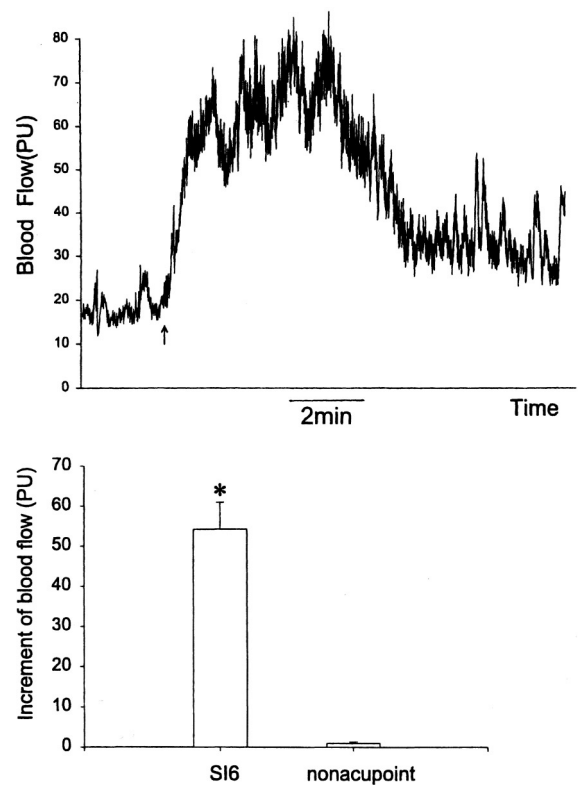


Fig. 3. Effects of Acupuncture on the Changes of Blood Flow

When the SI6 was stimulated till the "De-Qi" sensation was achieved, the blood flow of SI6 continued to increase (the De-Qi sensation being achieved, as indicated by the arrows). A representative curve of twenty-six experiments are shown. Data of the results are presented as the mean \pm S.E. of twenty-six separate experiments. * $p < 0.01$ as compared with the control group.

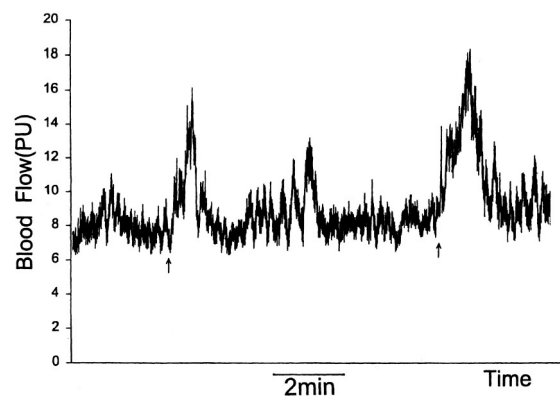


Fig. 4. Effect of Repeated Stimulation on the SI6

In the SI8, the first and second De-Qi sensation can induce two successive responses (the De-Qi sensation being achieved, as indicated by the arrows). A representative curve of thirty-three experiments is shown.

This may suggest that intradermal stimulation by acupuncture plays a significant role in the autonomic nervous system. Press-needle applied to the poste-

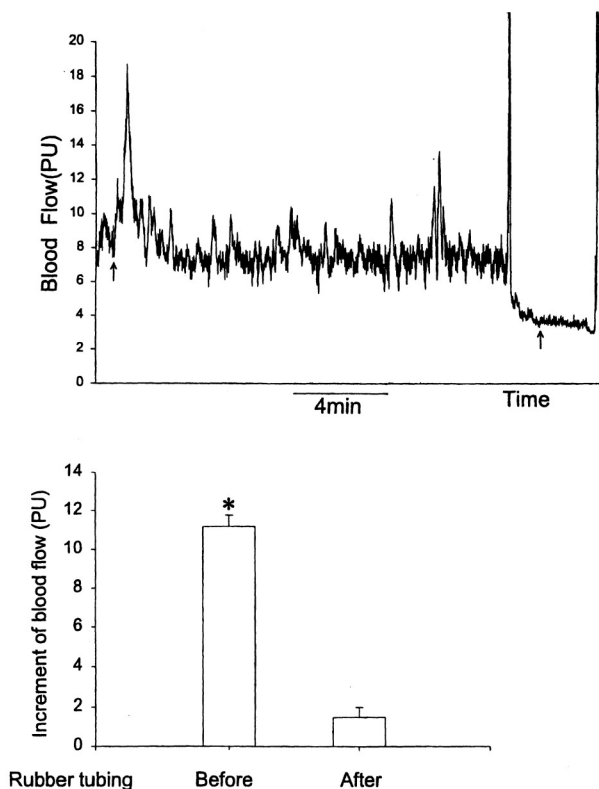


Fig. 5. The Effect of Mechanical Force Applied on the Skin above the Meridian

Before the arm was tied up with a rubber tube, the De-Qi feeling derived from acupuncture (SI6) brought about an acceleration of blood flow at the SI8 point (as indicated by arrow one). After the arm was tied up, the blood flow at the SI8 point slowed down quickly and did not increase even after insertion of a twirling needle was implemented (indicated by arrow two). Data of the results are presented as the mean \pm S.E. of forty-seven separate experiments. $*p < 0.01$ as compared with control.

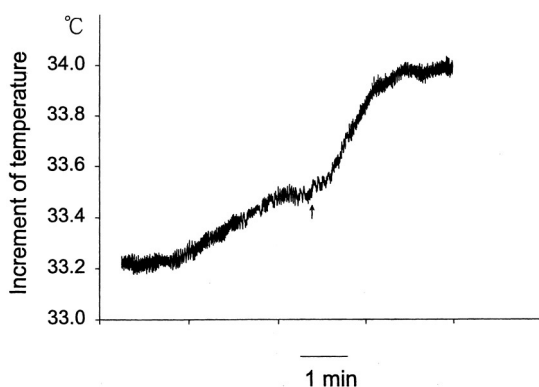


Fig. 6. Effects of Acupuncture on the Changes of Skin Temperature

When the SI6 was stimulated by acupuncture (indicated by the arrows) the skin temperature of the palm increased. A representative curve of forty-five experiments is shown.

rior region of the upper arm has been reported as an effective mean to facilitate recovery by reducing the height of twitches of the biceps brachii after isometric contraction exercise, which supports the significance of the role of intradermal stimulation.⁷⁾

When we implement acupuncture in SI6, the subject felt the soreness and numbness of De-Qi sensation immediately. This kind of De-Qi sensation happening right after insertion of the needle causes an acceleration of blood flow at the SI8 point. After a few minutes, the same acceleration occurred again when we twirl the needle (must have De-Qi feeling). Furthermore, when the needle was not twirled, but the subject has sensations of soreness, numbness and heat within a few minutes after insertion of the needle, the same kind of blood flow acceleration happened as well. Acupuncture points have both afferent and efferent nervous impulses. The present study shows that acupuncture increases skin temperature, which suggests that the increase in skin temperature resulted from cutaneous vasodilatation after acupuncture induces parasympathetic stress response. This suggestion is supported by previous studies, which suggest that the central command is generated by a potent stimulus and plays an important role in cutaneous parasympathetic vasodilation.⁸⁾ Our results suggest that the autonomic nervous system participates in acupuncture stimulation.⁹⁾ Hsieh performed a positron emission tomography study, using regional cerebral blood flow as the index of brain activity, to address the specificity of brain activation patterns incurred by acupuncture stimulation of acupoint.¹⁰⁾ Regions activated by acupuncture stimulation at SI6 includes the hypothalamus with an extension to midbrain, the insula, the anterior cingulate cortex, and the cerebellum. Of note, it was the stimulation at SI6 that activated the hypothalamus under the similar psychophysical ratings of acupuncture sensation (De-Qi).¹⁰⁾ The data suggests that the hypothalamus may characterize the central expression of acupuncture stimulation at the SI6, and serves as a key element in mediating efficacy of acupuncture stimulation.¹⁰⁾ Considering the fact that the afferent and efferent sympathetic C-fibers are involved in the regulation of microcirculation, the skin blood flow regulation is investigated.¹¹⁾ Hypothalamus can regulate the autonomic nervous system.¹²⁾ The skin blood flow is controlled by autonomic nervous system.¹³⁾ The perivascular nerves and vascular endothelial cells regulate blood flow. Recent positron emission tomography studies have

demonstrated areas of pain processing in the thalamus.¹⁴⁾ Blood flow and temperature are also regulatory in the thalamus. Stimulation of human thalamus for pain by acupuncture may change the skin blood flow and temperature.^{8,15)}

According to one model, the meridian is an extravascular fluid (interstitial fluid) pathway and circulation of this fluid is driven by skeletal muscle contraction.¹⁶⁾ The present studies seem to show that acupuncture can regulate the autonomic nervous system, which causes the sphincter of microvessel to relax and the tissue fluid to flow out, and the propagated sensation along the meridian is caused by this large amount of tissue fluid that flows along the loosen body stalk. The interstitial fluid increases during the needling and blood capillary expansion which may be one of the mechanisms of acupuncture regulation.¹⁷⁾

Our result derived from laser Doppler flowmetry shows that SI8 and SI6 have larger amplitudes of heartbeat and vasomotion than the non-acupuncture point. The acupoints have a higher temperature.¹⁸⁾ The formation of high thermal acupoints may have some relationships with the compact microcirculation. Lazorthes (1990)¹⁹⁾ has presented several models to account for the electrical properties of acupoints, based on charge movements and selective permeability of ions through different layers of the skin. The meridian in Chinese traditional medical science is in fact a pipeline of tissue fluid circulation. PSM is an obvious characteristic of meridian research. PSM can be produced by needle puncturing,²⁰⁾ electric-acupuncture,²¹⁾ electric-stimulation or padding on the skin surface.²²⁾ The phenomenon of PSM is the feeling of liquid flowing in a certain path on the skin. Recent studies indicate that it can be detected that radioactive elements flow in the path after injection of a radiotracer (*e.g.*, Na₂HP³²O₄, NaI¹²⁵ and NaTc⁹⁹O₄) at acupuncture points of humans and animals. It was found that the appearance of radiotracer paths can be visualized in the corresponding meridian lines, which indirectly proves the existence of meridian lines in human body and animals.¹⁹⁾ The fact that RBC with a horseradish peroxidase (HRP) tag injected at one point of the meridian could be found at another point of the meridian shows that the meridian can carry physical materials to flow along a specific path.²³⁾ When acupuncture is implemented on the SI6 acupoint, the subject immediately feels the soreness and numbness of De-Qi sensation. This kind of De-Qi sensa-

tion happening right after insertion of the needle causes an acceleration of blood flow at the SI8 point. It is most remarkable that the heat sensation in particular causes the acceleration of blood flow. This hot and numb feeling developed within a few minutes after acupuncture or the propagated sensation along the meridian is most likely caused by the circulation of tissue fluid inside the meridian that is induced by means such as acupuncture stimulation, which creates a flow of Qi along the meridian system.

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