The soreness and numbness effect of acupuncture with skin blood flow

Tsun-Cheng Kuo, PhD * ; Chii-Wann Lin, PhD ** and Feng-Ming Ho, MD. PhD ***

*Department of Cosmetic Science, Chia-Nan University of Pharmacy and Science,Taiwan.

**Institute of Biomedical Engineering, Colleges of Engineering and Medicine, National Taiwan University

***Tao Yuan General Hospital Department of Health the Execute Yuan, R.O.C.

Correspondence: Tsun-Cheng Kuo

Department of Cosmetic Science,Chia-Nan University of Pharmacy and Science. 60, Erh-Jen RD., Sec. 1, Jen-Te, Tainan, Taiwan, Phone: 886-6-266-4911 ext 320,Fax: 886-6-266-7324 Email:kuotsung@mail.chna.edu.tw

Abrtract: The purpose of this study was to investigate the effect of De-Qi sensation of acupuncture(needling sensation propagating along channels) stimulation. Fifty two healthy medical student volunteers received acupuncture on Hoku(LI-4) acupoints while resting. Their skin blood flow were measured on the Quchi(LI-11) and skin temperature was taken during the acupuncture stimulation. Each test took 30 minutes. Our results indicate that acupuncture increased blood flow during the De-Qi sensation being took place. A few minutes thereafter, if we twirl the needle (must have De-Qi feeling), the action will cause the same acceleration again. If we don't twirl the needle, but if the test person gets a feeling of soreness, numbness and heat sensation within a few minutes after the insertion of needle, the same kind of blood flow acceleration would happen as well. After acupuncture ,the Quchi did not show continuous elevation of blood flow as Hoku. When the Hoku was stimulated , the blood flow of Hoku was continued increase. Other results showed that acupuncture increases skin temperature, suggesting that the increases of blood flow resulted from cutaneous vasodilation. In concoulse, as the Hoku stimulation was given, the test person would immediately feel the sore and numb De-Qi sensation. This kind of De-Qi sensation happening right after the insertion of needle would cause an acceleration of blood flow at the Quchi point. Therefore,our results suggest that acceleration of tissue fluid may be the mechanism accounting for meridian system and responses during acupuncture.

Introduction

Skin blood flow was measured with the use of laser Doppler flowmetry (LDF), a noninvasive method that registers the sudden changes evoked by acupunture. Changes in skin blood flow and acral skin temperature are used as indicators for sympathetic reflex changes in response to the cold pressure test or to various non-thermal stimuli such as deep,inspiratory gasps,painful stimuli and mental or emotional stressor(Kistler et al., 1998).

In its original form acupuncture was based on the principles of traditional Chinese medicine. According to these,the workings of the human body are controlled by a vital force or energy called "Qi" , which circulates between the organs along channels called meridians. There are 12 main meridians, and these correspond to 12 major functions or "organs" of the body. Qi energy must flow in the correct strength and quality through each of these meridians and organs for health to be maintained. The acupuncture points are located along the meridians and provide one means of altering the flow of Qi (Andrew and Catherine, 1999).

The acupuncture stimulation always acquire "De-Qi" sensation (sourness -distension and distension-numbness). The "De-Qi" sensation is important for acupunture (Li et al., 1993; Hao et al., 1995; Xing and LI, 1998; You et al., 1993; You et al., 1992). Therefore we attempted to study the physiological effect of "De-Qi" sensation.

Materials and Methods

Subject

The study was performed in fifty two healthy volunteers patients, 19 males and 33 females, mean age 19.2 ±5.2., aged 18 to 24 years. Our experimentation was done on the healthy upper limbs.The subjects sit down.During the test day,they were not allowed to have any alcoholic or caffeinated beverages.Every subject was food restricted at least one hour before experiment. One hour rest was routinely required before the test.All examinations were done in a quiet, draught-free laboratory, controlled for temperature and humidity (24°C± 1°C; relative humidity 30-40%), in the morning at about the same time of day .Each subject was asked to sit down.The blood flow on Quchi of right hand or a non-acupuncture point chosen freely near Quchi was recored. Each test took 30 minutes. The initial 1 min were defined as baseline(no acupuncture), the following 29 min as the acupuncture period.

Acupunture

The Hoku point in the Chinese meridian, which has been reported to produce strong analgesic effect in the oral regions, was used for acupuncture stimulation(Kitade and Ohyabu, 2000). A pair of stainless steel needles of 0.2 mm in diameter ,30 mm in long(interpolar distance, 2 mm) were inserted vertically into the Hoku point, which was located on the dorsal surface of the hand inside the angle of the first two metacarpals. Following gradual insertion of the needle to a desired (2-3 mm), the needle was moved up and down (sparrow-pecking needling), or twisted (twisting needling).These type of needling are practical for a successful induction of the De-Qi sensation. The needles on the nonparetic side were stimulated manually, every 2-10 minutes, each time until the De-Qi sensation was achieved. Each treatment was given for 30 minutes.

Laser Doppler Flowmetry

Skin blood flow was recorded with the use of a laser Doppler flowmeter (Periflux 4001 Master, Perimed Ltd) (Tulevski etal., 1999). The device contains a solid-state, low-power diode laser (1 mW at the probe tip, wavelength 780 nm) that delivers a laser light to a cutaneous surface of [almost equal to]1 mm at a depth of [almost equal to]1 mm through flexible, graded-index, fiberoptic light guides. The laser light strikes moving red blood cells and is reflected with a shift in frequency, whereas nonmoving structures cause no shift in frequency. The reflected light is guided from the tissue surface through a second fiberoptic light guide, mixed, and analyzed in real-time by an analogue processor that provides a continuous output of the instantaneous mean Doppler frequency in the photocurrent identified by a square-law detector; the digitized signal was fed into a computer for on-line and off-line analyses. Before each study, the instrument was made null for a condition of no flow by placing the laser probe in the calibration clip on a surface containing no mobile structures and calibrated into a colloidal suspension of latex particles moving by brownian motion. Biological zero (ie, the laser Doppler flux recorded under no-flow conditions) was not subtracted because the precise nature of this measurement is still undetermined. Time-constant and sampling frequency were set at 0.03 seconds and 16 Hz, respectively. Double-sided adhesive disks were attached to the probes, which then were applied to the skin of the arm surface. Results (expressed in perfusion units, PU, were 1 PU equals 10 mV measured on the analogue output) were computer-derived, smoothed averages (Perisoft, Perimed Ltd) of skin blood flow recordings.

Skin temperature

Skin temperature was assessed continuously, under resting conditions at heart level, using an electronic thermometer (78214C, Hewlett-Packard, Palo Alto, Calif) and a circular metal thermocouple (0.8 cm^2) (Kurvers et al., 1996).Skin temperature was digitized by an analogue-to-digital converter and saved on a hard disk. Off-line analysis was performed employing a software program.

Statistics

Results are given as the mean ±SE in perfusion units for each point measured. Student's t-test and ANOVA were used to calculate differences between time points and locations as well as patient subgroups. Probabilities of ≤0.05 were considered statistically significant.

Results

The blood flow of acupoint

In resting condition we detected the profile of blood flow . The Quchi has the markedly amplitude of heartbeat. The amplitude of heartbeat on the Quchi are significantly large (4.7 ± 0.7 PU) than of the nonacupoint (2.1 ± 0.4 PU)(Fig.1A,B) and the Hoku are significant large (4.6 ±0.7 PU) than of the nonacupoint (0.8 ±0.3 PU)(Fig.1C,D).

Effects of Acupuncture on the Changes of Blood Flow

Acupuncture stimulation of a Hoku point sudden raised the blood flow in Quchi (Fig. 2B), whereas nonacupuncture point beside the Quchi slightly changed the blood flow by the same stress stimulation (Fig. 2A). Figure 2B shows a typical example of augmentative effect of acupuncture on the change in blood flow. The Quchi blood flow was shown to be about 10.6 ±2.9 PU before the acupuncture stimulation. The Hoku stimulation was given for about 15 s, until the "De-Qi" sensation was achieved. The blood flow was increased immediately after the "De-Qi" sensation. The blood flow began to rise 5 s after the onset of the "De-Qi" sensation being achieved and increased approximately 10.6 ±1.8 PU within 10-60 s(Fig. 2C). After acupuncture ,the Quchi did not show continuous elevation of blood flow as Hegu (Fig. 2B, 3A). When the Hoku was stimulated until the "De-Qi" sensation was achieved, the blood flow of Hoku was continued increase (75.2 ±4.1 PU)(Fig. 3A) whereas nonacupuncture point beside the Hoku slightly changed the blood flow by the same stress stimulation(1.1 ±0.2 PU) (Fig. 3B).

When the Hoku was stimulated repeatedly by acupunture, the blood flow was increased again after the "De-Qi" sensation, even without subsequent needle twirling, and as long as the test person is getting the emergence of a strong De-Qi feeling (feeling numb, sore and hot sensations in his hands) or feeling a flow of numbness and heat traveling to reach Quchi, there will be a visible peak of upward Quchi blood flow (Fig. 4).

Effect of mechanical force applied on the skin up the meridian

In order to find out that whether the PSM (propagated sensation along meridians) caused by acupuncture action is derived from the flow of tissue fluid along meridian channels, we tied up the upper arm of the test person with a length of rubber tubing (at a location 5 cm above the Quchi point). The result of the above test shows that before having the arm tied up with the rubber tubing, the acupuncture (Hoku) derived De-Qi feeling (soreness and numbness) would bring about an acceleration of blood flow at the Quchi point(11.6 ±0.9 PU) (Fig. 5). Once the arm was tied up, the blood flow at the Quchi point slowed down quickly, and although it was still possible to get that somewhat sore De-Qi feeling with twirling needle insertion, the blood flow at the Quchi point would no longer accelerate as a result(0.9 ±0.3 PU) (Fig. 5), nor the appearance of PSM feeling afterward. It proves that obstruction of blood flow can effectively prevent PSM phenomenon from happening, and thus indicates the acupuncture derived PSM is very likely 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

There was an increase in skin temperature of palm after acupuncture.When the Hoku was stimulated by acupunture, the skin temperature of palm was significantly increased 1.12 ±0.26 ℃ than of the control (0.28 ±0.19 ℃) without acupuncture (Fig.6.).

Discussion

Many physiologists thought that at the acupoints located in abundant muscles spindles and have a higher concentration of neural (Wei et al,1974; Hwang,1992). The afferent fibers acupoints take part in forming and maintaining the needling sensations (Wang et al.1987). The primary afferent C fiber (including the SP containing nerve) may play important roles in the input of the informations of pain, and needling, as well as in the

acupuncture (Zhang et al., 1990). It was suggested that acupuncture of acupoint could excite some C fibers. Most of the neurons in the thalamic nucleus submedius responded to stimulation of the acupoint with afferent C fiber excitation (Yang et al., 1996). 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 pattern by acupuncture stimulation of acupoint (Hsieh et al., 2001). Regions activated by acupuncture stimulation at Hoku included the hypothalamus with an extension to midbrain, the insula, the anterior cingulate cortex, and the cerebellum. Of note, it was only the stimulation at Hoku that activated the hypothalamus under the similar psychophysical ratings of acupuncture sensation (De-Qi) (Hsieh et al., 2001). The data suggested that the hypothalamus might characterize the central expression of acupuncture stimulation at the Hoku, and serve as one key element in mediating efficacy of acupuncture stimulation (Hsieh et al., 2001).

Hypothalamus can regulate the autonomic nervous system (Stratakis and Chrousos, 1995). The skin blood flow is control by autonomic nervous system (Bernardi et al., 1997;Wallin,1990). Considering the fact that the afferent and efferent sympathetic C-fibres are involved in regulation of microcirculation, the skin blood flow regulation is investigated by means of laser Doppler flowmetry (Bonelli and Koltringer, 2000). The perivascular nerves and vascular endothelial cells which regulate blood flow. Perivascular nerves, once considered simply adrenergic or cholinergic, release many types of neurotransmitters, including peptides, purines and nitric oxide (Burnstock and Ralevic, 1994). Recent positron emission tomography studies have demonstrated areas of pain processing in the thalamus (Sellami et al., 1995). Blood flow and temperature are also regulatory in the thalamus. Stimulation of human thalamus for pain of acupunture may change the skin blood flow and temperature (Van Someren, 2000; Mayer, 2000; Gleeson, 1998; Proppe, 1981; Evans, 1980).Our results showed that acupuncture increases skin temperature, suggesting that the increases of skin temperature resulted from cutaneous vasodilation due to acupuncture induced parasympathetic stress response.This suggestion is supported by previous studies that central command is generated by a potent stimulus and it plays an important role in cutaneous parasympathetic vasodilation (Proppe,1981).

Our result showed Quchi and Hoku have the larger amplitude of locomotion and heartbeat than of the nonacupuncture point. Acupoints tend to show higher electric conductivity and have a higher concentration of neural and vascular elements as well as mast cells(Hwang et al., 1992).The acupoints have a higher temperature (Ovechkin et al.,2001; Zhang et al., 1996).The formation high thermal acupoints may have some relationship with the compact microcirculation. As the needle has only entered by 4 mm during Hoku acupuncture, the test person would immediately feel the sore and

numb De-Qi sensation. This kind of De-Qi sensation happening right after the insertion of needle would cause an acceleration of blood flow at the Quchi point. A few minutes thereafter, if we twirl the needle (must have De-Qi feeling), the action will cause the same acceleration again. If we don't twirl the needle, but if the test person gets a feeling of soreness, numbness and heat sensation within a few minutes after the insertion of needle, the same kind of blood flow acceleration would happen as well. It is the most remarkable that the heat sensation in particular will certainly cause the acceleration of blood flow. This hot, numb feeling developed within a few minutes after acupuncture, or the so-called PSM (propagated sensation along meridians) traveling along the meridian, is most likely caused by the circulation of tissue fluid inside meridian.The interstitial fluid increases during the needling by axon reflection and blood capillary expanding which may be one of the mechanisms of acupuncture regulation (Zhang et al., 1999).

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 could be produced by needle puncturing (Xing et al., 1998), electric-acupuncturing (Wu et al., 1993), electric-stimulating (Wu et al., 1993) or padding on the skin surface (Weng et al., 1990). The phenomenon of PSM is the feeling of liquid flowing in a certain path on the skin. Resent studies indicate that it can be detected that radioactive element flows in the path after injecting 100 μl radioactive technetium ^{99m}Tc in that path (Guo et al., 1992). The fact that RBC with HRP tag injected at one point of the meridian could be found at another point of the meridian showed that the meridian could carry physical materials to flow along a specific path (Xu et al., 1996). And the fact that mechanical force applied on the skin up the meridian can stop the initiation of PSM (Xu et al., 1993; Wu et al., 1993; Wu et al., 1993) further proves that the PSM is most probably the phenomenon of tissue fluid flowing along body surface. Other studies in occurring turns of PSM show that when PSM occurs, the electric potential at brain cortex, backbone, root ganglia of back (Guo et al., 1992) and cerebellum changes, the electric potential (Hu et al., 1993; Xu et al., 1993; Wu et al., 1993) and temperature on the skin of arms vary (Liu et al., 1990) and that the changes of the activities of nerves and muscles could also be detected (Hu et al., 1993; Wang et al., 1987). So it should be that when skin receives local stimulations, a instruction to relax is sent by the cerebrum, and when the instruction arrives in the arm, the sphincter at the position stimulated will relax and the tissue fluid flows out, and the PSM is caused by this large amount of tissue fluid which flows along loosen body stalk.

According to one model,the meridian is an extravascular fluid (interstitial fluid) pathway driven by skeletal muscle contraction (Zhang et al., 2000; Takano, 1985). The permeability (hydraulic conductance) and the density of lymphatics are higher

along the meridian than in surrounding tissue (Zhang et al., 2000). A lower interstital fluid pressure than in surrounding tissue show that the pressure gradient would serve to drain tissue fluid into the meridian area (Zhang et al., 2000) and the acupuncture derived PSM is very likely a phenomenon of a flowing sensation created by the motion of a large amount of tissue fluid entering meridian.

Our results showed that acupuncture increases skin temperature, suggesting that the increases of skin temperature resulted from cutaneous vasodilation due to acupuncture induced parasympathetic stress response.This suggestion is supported by previous studies that central command is generated by a potent stimulus and it plays an important role in cutaneous parasympathetic vasodilation (Proppe,1981).

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References

Andrew, V. and Z. Catherine. ABC of complementary medicine: Acupuncture. Brit. Med. J. 319:973-976, 1999.

Bernardi, L., D. Hayoz, R. Wenzel, C. Passino, A. Calciati, R. Weber and G. Noll. Synchronous and baroceptor-sensitive oscillations in skin microcirculation: evidence for central autonomic control. Am. J. Physiol. 273(4 Pt 2):H1867-78, 1997.

Bonelli, R.M. and P. Koltringer. Autonomic nervous function assessment using thermal reactivity of microcirculation. Clin. Neurophysiol. 111(10):1880-8, 2000.

Burnstock, G. and V. Ralevic. New insights into the local regulation of blood flow by perivascular nerves and endothelium. Brit. J. Plast. Surg. 47(8):527-43, 1994.

Evans, M.H. An effect of hypothalamic stimulation on cardiac output in the rabbit. Q. J. Exp. Physiol. 65(3):217-27, 1980.

Gleeson, M. Temperature regulation during exercise. Int. J. Sports Med. 19 Suppl 2:S96-9, 1998.

Guo, Y., C. Chen, C. Zhang, J. Feng, S. Wu, Z. Wang, Y. Cao and L. Zhang. Study on radionuclide migrating along thechannel. Chen. Tzu. Yen. Chiu. 17(2):143-146,1992.

Hao, J., C. Zhao and S. Cao. Yang S. Electric acupuncture treatment of peripheral nerve injury. J. Tradit. Chin. Med. 15(2):114-7, 1995

Hsieh, J.C., C.H. Tu, F.P. Chen, M.C. Chen, T.C. Yeh, H.C. Cheng, Y.T. Wu and R.S. Liu. Activation of the hypothalamus characterizes the acupuncture stimulation at the analgesic point in human: a positron emission tomography study. Neurosci. Lett. 307(2):105-8, 2001.

Hu, J., B. Wu, X. Huang and J. Xu. Evidences for the appearance of peripheral activator during the advance of PSMi. Chen. Tzu. Yen. Chiu. 18(2):115-122,1993.

Hwang, Y.C. Anatomy and classification of acupoints.Probl Vet Med,4,12-15, 1992.

Kistler, A., C. Mariauzouls and K. von Berlepsch. Fingertip temperature as an indicator for sympathetic responses. Int. J. Psychophysiol. 29(1):35-41, 1998.

Kitade, T. and H. Ohyabu. Analgesic effects of acupuncture on pain after mandibular wisdom tooth extraction. Acupuncture Electro. 25(2):109-15, 2000.

Kurvers, H.A., M.J. Jacobs, R.J. Beuk, F.A. van den Wildenberg, P.J. Kitslaar, D.W. Slaaf and R.S. Reneman. The spinal component to skin blood flow abnormalities in reflex sympathetic dystrophy. Arch. Neurol. 53(1):58-65, 1996.

Li, B., L. Li Lng, J.Chen, L. Chen, W. Xu, R. Gao, B. Yang, W. Li and B. Wu. Observation on the relation between propagated sensation along meridians and the therapeutic effect of acupuncture on myopia of youngsters. Chen. Tzu. Yen. Chiu. 18(2):154-8, 1993.

Liu, R., D. Zhuang, X. Yang and Y. Li. Objective observation on phenomena of sensation along channels and QI reaching to affects area-the influence of acupuncture points on infrared thermal image of face.Chen. Tzu. Yen. Chiu. 15(3):245-249, 1990.

Liu, X.A., M.C. Jiang, P.B. Huang and T. Zou. Role of afferent C fibers in electroacupuncture of "zusanli" point in activating nucleus raphe magnus. Sheng Li Hsueh Pao - Acta Phys. Sin. 42(6):523-33, 1990.

Mayer, D.J. Biological mechanisms of acupuncture. Prog. Brain Res. 122:457-77, 2000.

Ovechkin, A., S.M. Lee, K.S. Kim. Thermovisual evaluation of acupuncture points.

Acupuncture Electro. 26(1-2):11-23, 2001.

Proppe DW. Influence of skin temperature on central thermoregulatory control of leg blood flow. J. Appl. Physiol. 50(5):974-8, 1981.

Sellami, S., R and de Beaurepaire. Hypothalamic and thalamic sites of action of interleukin-1 beta on food intake, body temperature and pain sensitivity in the rat. Brain Res. 694(1-2):69-77, 1995.

Stratakis, C.A. and G.P. Chrousos. Neuroendocrinology and pathophysiology of the stress system. Ann. NY. Acad. Sci. 771:1-18, 1995.

Takano S. The contribution of the extravascular body liquid to ryodoraku meridian and the nature of the meridians.1. A theoretical examination.Jpn. Ryodoraku, 30, 7-12, 1985.

Tulevski, II., D.T. Ubbink and M.J. Jacobs. Red and green laser Doppler compared with capillary microscopy to assess skin microcirculation in the feet of healthy subjects. Microvas. Res. 58(2):83-8, 1999.

Van Someren, E.J. More than a marker: interaction between the circadian regulation of temperature and sleep, age-related changes, and treatment possibilities. Chronobiol. Int. 17(3):313-54, 2000.

Wallin, B.G. Neural control of human skin blood flow. J. Autonom. Nerv. Syst. 30 Suppl:S185-90, 1990.

Wang, T., W. Wang and J.Q. Zheng. Astudy of transmission of impulses between peripheral nerves-research on the mechanism of propagated sensation along the channels. Chen. Tzu. Yen. Chiu. 12(3):219-221,1987.

Weng, T., M. Lu, X. Lu and W. Lu. Studies on the phenomenon of latent propagated sensation along channel by combining applied knocks measurement of resistance and record electric current. Chen. Tzu. Yen. Chiu. 15(1):82-84,1990.

Wu, B., J. Xu, X. Hu, B. Yang and B. Li. Obervation on the functional characteristics of cortical somatosensory area during the advance of the propagated sensation along meridiansd. Chen. Tzu. Yen. Chiu. 18(2):123-127, 1993.

Wu, B., X. Hu, B. Yang, J. Xu, W. Li, B. Li, J. Chen and L. Chen. The influence of pressing the meridian course on electroretinogram during acupuncture. Chen. Tzu. Yen. Chiu. 18(2):132-6, 1993.

Wu, B., X. Hu, J. Xu, B. Yang, W. Li and B. Li. Localization of the meridian track over body surface by the method of blocking the acupuncture effect with mechanical pressure. Chen. Tzu. Yen. Chiu. 18(2):128-31, 114, 1993.

Xing, W. and Q. Li. Effect of different manipulations of acupuncture on electrical activity of stomach in humans. J. Tradit. Chin. Med. 18(1):39-42, 1998.

Xu, J., X. Huang, B.Wu and X. Hu. Influence of mechanical pressure applied on the stomach meridian upon the effectiveness of acupuncture of zusanli. Chen. Tzu. Yen. Chiu. 18(2):137-42, 1993.

Xu, R., D. Guo, H. Qin and X. Guan. Electroacupuncture along meridians activating subcutaneous primary afferents in acupoints-CB-HRP tracing study. Chen. Tzu. Yen. Chiu. 21(4):45-58, 1996.

Yang, J., J. Tang, B. Yuan and H. Jia. Responses of neurons in thalamic nucleus submedius to electrical stimulation of peroneal nerve and "zusanli" point in rats. Chen. Tzu. Yen. Chiu. 21(4):28-33, 1996.

You, Z. Preliminary observation on the relation among needling sensation, propagated sensation along meridian (PSM), and acupuncture effect when acupuncture neiguan. Chen. Tzu. Yen. Chiu. 17(1):75-8, 1992.

You, Z., X. Hu, B. Wu, W. Zhang and D. Liang. The difference in the time for the appearance of acupuncture effects between the subjects with and without PSM during acupuncture of neiguan. Chen. Tzu. Yen. Chiu. 18(2):149-53, 148, 1993.

Zhang, D., W.Fu, S. Wang, Z. Wei and F. Wang. Displaying of infrared thermogram of temperature character on meridians. Chen. Tzu. Yen. Chiu. 21(3):63-7, 1996.

Zhang, W., R. Xu and Z. Zhu. The influence of acupuncture on the impedance measured by four electrodes on meridians. Acupuncture Electro. 24(3-4):181-8, 1999.

Zhang, W.B., K. Aukland, T. Lund and H. Wiig. Distribution of interstitial fluid pressure and fluid volumes in hind-limb skin of rats: relation to meridians?. Clin. Physiol. 20(3):242-9, 2000.

Zhang, Y., Z. Zhang, X. Liang, X. Guan and M. Ai. The effect of extradural injection of capsaicin on pain threshold and electroacupuncture analgesia of rat. Chen. Tzu. Yen. Chiu. 15(2):130-5, 1990.

Legends to figures

Figure 1. Laser Doppler flow values(under resting conditions) measured in the skin of Quchi and nonacupoint. (A) Record illustrates the typical large-amplitude of heartbeat on the Quchi under resting conditions. (B) Control,nonacupoint beside the Quchi. (C) Record illustrates the typical large-amplitude of heartbeat on the Hoku under resting conditions. (D) Control,nonacupoint beside the Hoku. A representative curve of thirty-seven experiments are shown. The result of Data are presented as the mean ± S.E. of thirty-seven separate experiments. $^{*}P<0.01$ as compared with control.

Figure 2. Representative time course of acupuncture induced the changes of blood flow in the Quchi. (A) Control, nonacupunture point beside the Quchi. (B) Acupuncture stimulation of a Hoku point sudden raised the blood flow in the Quchi (the De-Qi sensation being achieved, as indicated by arrow). (C) The result of Data are presented as the mean ±S.E. of fifty-two separate experiments. $^{*}P<0.01$ as compared with control.

Figure 3. Effects of acupuncture on the changes of blood flow of the Hoku. (A) When the Hoku was stimulated until the "De-Qi" sensation was achieved, the blood flow of Hoku was continued increase (the De-Qi sensation being achieved, as indicated by

arrow). (B) Control, nonacupunture point beside the Hoku. A representative curve of twenty-one experiments are shown. (C) The result of Data are presented as the mean ±S.E. of twenty-one separate experiments. $^{*}P<0.01$ as compared with control.

Figure 4. Effect of repeated stimulation on the Hoku .In the Quchi, the first and second De-Qi sensation can induce two successive response (the De-Qi sensation being achieved, as indicated by arrows). A representative curve of twenty-six experiments are shown.

Figure 5. Effect of mechanical force applied on the skin up the meridian . Before having the arm tied up with the rubber tubing, the acupuncture (Hoku) derived De-Qi feeling would bring about an acceleration of blood flow at the Quchi point (indicated by arrows one). Once the arm was tied up, the blood flow at the Quchi point slowed down quickly and would not increase blood flow even twirling needle insertion (as indicated by arrows two). The result of Data are presented as the mean ±S.E. of forty-two separate experiments. $^{*}P<0.01$ as compared with control.

Figure 6. Effects of Acupuncture on the Changes of skin temperature. When the Hoku was stimulated by acupunture (indicated by arrow), the skin temperature of palm was

increased. A representative curve of thirty-three experiments are shown.