

Effect of electroacupuncture at the Pericardium Meridian on the heart function of volunteers with acute hypoxia

电针心包经对急性缺氧志愿者心功能的影响

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Abstract

Objective: To study the effect of electroacupuncture (EA) at the Pericardium Meridian on the heart function of volunteers with acute hypoxia, and to provide scientific evidence for the acupoints selection along the affected meridian in acupuncture-moxibustion therapy.

Methods: Based on a self-control design, eighteen healthy volunteers were recruited in the study. Points from the Pericardium Meridian [Neiguan (PC 6), Ximen (PC 4), Quze (PC 3) and Tianquan (PC 2)], non-Pericardium Meridian point [Shousanli (LI 10)], non-meridian and non-acupoint points [1.0-1.5 cm lateral to Neiguan (PC 6) and Ximen (PC 4), respectively on both sides], and a blank control (only inhaling low-oxygen gas without EA stimulation) were selected to observe, once every week, 10 sessions in total, and only 1 acupoint was observed once. The volunteers inhaled low-oxygen gas mixture (10.8% O₂ and 89.2% N₂) for 30 min to imitate acute hypoxia. EA was conducted when the gas mixture was inhaled for 10 min and then lasted for 20 min; meanwhile, hemodynamic indexes such as cardiac output (CO), cardiac index (CI), systemic vascular resistance (SVR), systemic vascular resistance index (SVRI), left cardiac work (LCW), left cardiac work index (LCWI) and heart rate (HR) were recorded on a hemodynamic monitor.

Results: EA at the acupoints of Pericardium Meridian significantly down-regulated the increased CO/CI, LCW/LCWI, and HR ($P < 0.05$), and significantly up-regulated the decreased SVR/SVRI in hypoxia ($P < 0.05$); EA at other meridian acupoints or at non-meridian and non-acupoint points didn't produce such effects.

Conclusion: EA at the Pericardium Meridian can obviously improve the cardiac hyper-activation caused by acute hypoxia in healthy volunteers.

Keywords: Acupuncture Therapy; Electroacupuncture; Pericardium Meridian; Hypoxia; Cardiac Function; Healthy Volunteers

【摘要】目的: 观察电针心包经对急性缺氧志愿者心功能的影响,为针灸循经取穴治疗原则提供实验依据。**方法:** 共 18 例健康志愿者,采用自体对照的方法,分别取心包经穴位(内关、郄门、曲泽和天泉),非心包经穴位(手三里),非经非穴点(内关和郄门左右各旁开 1.0~1.5 cm)电针,以及空白对照(只吸低氧不作电针刺激)处理,1 个星期测试 1 次,每次针刺 1 个位点,共进行 10 次测试。志愿者吸入低氧混合气体(10.8% O₂ 和 89.2% N₂) 30 min 造成急性缺氧,并在吸低氧 10 min 后,电针各个位点 20 min。采用血液动力学监护仪记录心输出量(CO)、心脏指数(CI)、外周血管阻力(SVR)、外周血管阻力指数(SVRI)、左心做功(LCW)、左心做功指数(LCWI)和心率(HR)在针刺前后的变化。**结果:** 电针心包经穴位能显著降低急性缺氧所致的 CO/CI、LCW/LCWI 和 HR 升高($P < 0.05$),并显著升高急性缺氧所致的 SVR/SVRI 降低($P < 0.05$),而非经非穴与他经穴位均无此作用。**结论:** 电针心包经能显著改善健康志愿者急性缺氧所致的心功能亢奋状态。

【关键词】 针刺; 电针; 心包经; 缺氧; 心功能; 健康受试者

【中图分类号】 R246.1 **【文献标志码】** A

With a history of thousands of years in China, today, as a complementary and alternative therapy, acupuncture is growing in popularity worldwide. Selecting the right acupoint is the important basis for

the regulation effect, so, how to select acupoints to treat a given disorder is especially worthy of notice.

The acupoints of the Pericardium Meridian has been being increasingly used to treat cardiovascular disorders^[1-2]. Their effects were documented in Chinese ancient literatures and well supported by modern researches. About Neiguan (PC 6), as *Zhen Jiu Jia Yi Jing* (A-B Classic of Acupuncture and Moxibustion)

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documented, 'acupuncture at Neiguan (PC 6) improves both symptoms and underlying cause in cardiodynia due to excessive syndrome and anxiety due to deficiency'. Modern experimental studies indicated that needling Neiguan (PC 6) remarkably improved the symptoms of angina pectoris, premature beat, tachyarrhythmia and adjusted myocardial ischemia, heart rate (HR) and heart rate variability (HRV)^[3-5]. The neurophysiological mechanisms of the action of Neiguan (PC 6) in treating cardiovascular disorders had been studied and reviewed^[6]. *Zhen Jiu Jia Yi Jing (A-B Classic of Acupuncture and Moxibustion)* also recorded, 'cardiodynia and diseases similar to panic disorder and psychosis are under the indications of Ximen (PC 4)'. Modern research showed that acupuncture at Ximen (PC 4) down-regulated HR and enhanced myocardial contractility to adjust cardiac function and recover acute ischemic myocardial injury in coronary heart disease^[7-8]. It's recorded in *Zhen Jiu Da Quan (A Complete Collection of Acupuncture and Moxibustion)* that 'Quze (PC 3) treats cardiodynia'. Experimental study indicated that mild moxibustion at Quze (PC 3) was effective in treating coronary heart disease through improving cardiac function^[9-10]. This classic also stated that 'heart disease such as effusive pericarditis can be treated by Tianquan (PC 2)'. Modern research suggested that this point improved adenosine triphosphate (ATP) depletion in myocardial ischemia^[11-12].

It's been revealed that the Pericardium Meridian is different from the surrounding areas in some physical features: faster light propagation and slower light attenuation^[13-14], skin/tissue impedance along the meridian is lower than that in the surrounding areas^[15-16]. Our previous study also showed that in the normal state, the microcirculatory blood perfusion units (BPU) and transcutaneous oxygen pressure (TCPO₂) along the Pericardium Meridian were significantly higher than those of the control points. Inhaling low-oxygen gas mixture or acupuncturing Neiguan (PC 6) significantly decreased the value of TCPO₂ along the Pericardium Meridian^[17-18]. All the characteristics mentioned above provide a material foundation for the function specificity of the Pericardium Meridian.

Acupuncture is based on meridian and acupoint theories, and selecting acupoints from the affected meridian is one of the basic principles in acupuncture-

moxibustion therapy. Based on the above studies, we compared four acupoints from the Pericardium Meridian, four non-meridian and non-acupoint points, an acupoint from another meridian, and a blank control without any electroacupuncture (EA) stimulation to systematically study the effects of EA at the Pericardium Meridian on heart function of volunteers with acute hypoxia, to elucidate the specificity of acupoints effect of the Pericardium Meridian, and to provide scientific evidence for the treatment principle of selecting acupoints from the affected meridian.

1 Materials and Methods

1.1 Human subjects

The participants ($n=18$, 8 females and 10 males) were volunteers recruited from Fujian University of Traditional Chinese Medicine, aged 18-25 years. All the subjects were healthy nonsmokers without a history of cardiovascular disease. Female participants were not in their menstrual period on the study day. This study was approved by Chinese Medicine Clinical Research Ethics Committee of Fujian Academy of Traditional Chinese Medicine. All detections were finished in the Class III Laboratory of Acupuncture Physiology, Key Unit of the Propagated Sensation along Meridian of State Administration of Traditional Chinese Medicine, Fujian Academy of Traditional Chinese Medicine.

1.2 Detection method

1.2.1 Detection instruments

BZ-4110-121 hemodynamic monitor (Cardiodynamics, San Diego, USA) was used to record 16 cardiac function indexes including cardiac output (CO), cardiac index (CI), systemic vascular resistance (SVR), systemic vascular resistance index (SVRI), left cardiac work (LCW), left cardiac work index (LCWI) and heart rate (HR). It is able to noninvasively calculate the above indexes by detecting and measuring the change in thoracic impedance by injecting a high-frequency (60 kHz minimum) low-amplitude (4.0 mA rms maximum) alternating electrical current through the thorax between a pair of sensors placed on neck and another pair placed on the mid-axillary line at xiphoid process level.



Figure 1. Hemodynamic monitor

1.2.2 Acupoints selection

The acupuncture sites included four acupoints [Neiguan (PC 6), Ximen (PC 4), Quze (PC 3) and Tianquan (PC 2)] along the Pericardium Meridian, one acupoint [Shousanli (LI 10)] along the Large Intestinal Meridian, the bilateral control points of Neiguan (PC 6) (1.0-1.2 cm away, in the middle between two parallel meridians to avoid the risk of 'contamination' by another meridian), the bilateral control points of Ximen (PC 4) (1.2-1.5 cm away). All acupuncture points were determined according to the standards issued by the World Health Organization (WHO)^[19]. To ensure the consistency of assessment, the above-mentioned points of all participants were located and marked on the skin by the same acupuncturist. The 18 healthy volunteers participated in all ten experiments, once a week, one-point EA stimulation each time. Besides, we also observed the subjects when in acute hypoxia state but without EA stimulation (Figure 2).

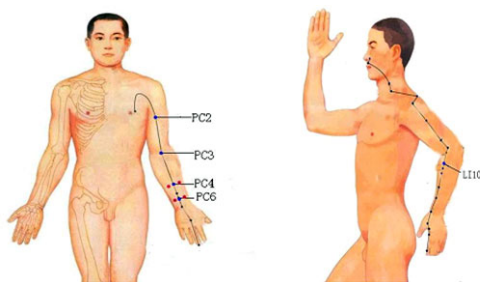


Figure 2. Acupoints used in the study

1.2.3 EA parameter

EA stimulation was applied to each point of every volunteer once a week, conducted initially using a 1 V pulse with duration of 0.2 ms at 0.5 Hz for 20 min. The voltage pulse might be increased depending upon whether the subject experienced a sensation of 'De Qi' (arrival of qi, i.e. the feeling of soreness, numbness, distension or pain). During the course of EA stimulation, the subjects were asked whether they still maintained the sensation. If not, the voltage pulse was increased until they obtained the sensation again.

1.2.4 EA procedure

Before every session, each subject was required to rest in a supine position at room temperature (28 ± 1) °C for 10 min. The sensors of hemodynamic monitor were fixed at the end of neck and xiphoid process level, respectively, to record cardiac function indexes for 10 min as the basic values. The volunteers then inhaled low-oxygen gas mixture (10.8% O₂ and 89.2% N₂) for 30 min to imitate acute hypoxia about 5 000 m above sea level. EA was conducted when the gas mixture was inhaled for 10 min and lasted for 20 min^[20]. The changes of each index before and during EA were recorded separately.

Five measurement periods were compared: one in normal state (a), one during inhaling low-oxygen gas mixture (b), two during EA (c-d), and one after EA (e) (Figure 3).

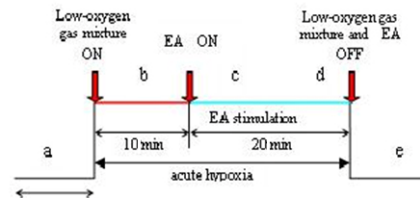


Figure 3. Measurement protocol

1.3 Statistical analysis

To avoid the deviation from individual difference, the data of cardiac function were represented with a ratio, which came from the detection value compared to the basic value. The ratio was expressed as mean \pm standard error ($\bar{x} \pm s$). The SPSS 13.0 version software was used for data processing. One-way ANOVA was used for inter-group comparisons, and the least significant difference (LSD) for intra-group comparisons. $P < 0.05$ was considered as statistically significant.

2 Results

Figure 4-Figure 6 showed the ratio of cardiac function indexes of the 18 volunteers during the four measurement phases (a-d). There was a significant increase in CO/CI, LCW/LCWI and HR ($P < 0.05$), while an insignificant decrease in SVR/SVRI ($P > 0.05$) after inhaling low-oxygen gas mixture for 10 min.

2.1 Effects of EA at the Pericardium Meridian on cardiac dysfunction induced by acute hypoxia

After 10 min and 20 min of EA stimulation to the four acupoints of the Pericardium Meridian, four out of the seven cardiac function items (CO/CI, SVR/SVRI) can be adjusted significantly ($P < 0.05$), indicating that the Pericardium Meridian can adjust cardiac dysfunction.

Although Neiguan (PC 6), Ximen (PC 4), Quze (PC 3), and Tianquan (PC 2) are all from the same meridian, the specificity of acupoints exists. Ten-minute EA stimulation to the four points all induced SVR/SVRI to increase significantly ($P < 0.05$). Except for that, EA at Neiguan (PC 6) caused CO/CI, LCW/LCWI, and HR to decrease significantly ($P < 0.05$). EA at Ximen (PC 4) induced CO/CI and HR to decrease significantly ($P < 0.05$). EA at Quze (PC 3) and Tianquan (PC 2) only caused CO/CI to decrease significantly ($P < 0.05$). Twenty-minute EA stimulation to the four points all made SVR/SVRI increase significantly ($P < 0.05$). Except for that, EA at Neiguan (PC 6) induced CO/CI, LCW/LCWI and HR to decrease significantly ($P < 0.05$). EA at Ximen (PC 4) led CO/CI and LCW/LCWI to decrease significantly ($P < 0.05$). EA at Quze (PC 3) caused CO/CI and HR to decrease significantly ($P < 0.05$). EA at Tianquan (PC 2)

only caused CO/CI to decrease significantly ($P<0.05$). The function of adjustment should be Neiguan (PC 6) > Ximen (PC 4) > Quze (PC 3) > Tianquan (PC 2). That's why Neiguan (PC 6) is more often used in clinic (Figure 4).

2.2 Effects of EA at the control points

Compared with EA at the acupoints of the Pericardium Meridian, the control points elicited no remarkable change in the present study (Figure 5).

2.3 Effects of EA at the Shousanli (LI 10)

Quze (PC 3) and Shousanli (LI 10) are both in the upper limb and supplied by C_{5-6} innervations, but belonging to the Pericardium Meridian and Large Intestinal Meridian, respectively. Their clinical efficacies are totally different. The result indicated that EA at Quze (PC 3) induced CO/CI and HR to decrease significantly, and SVR/SVRI to increase significantly, while EA at Shousanli (LI 10) had no obvious effect on cardiac dysfunction in acute hypoxia (Figure 6).

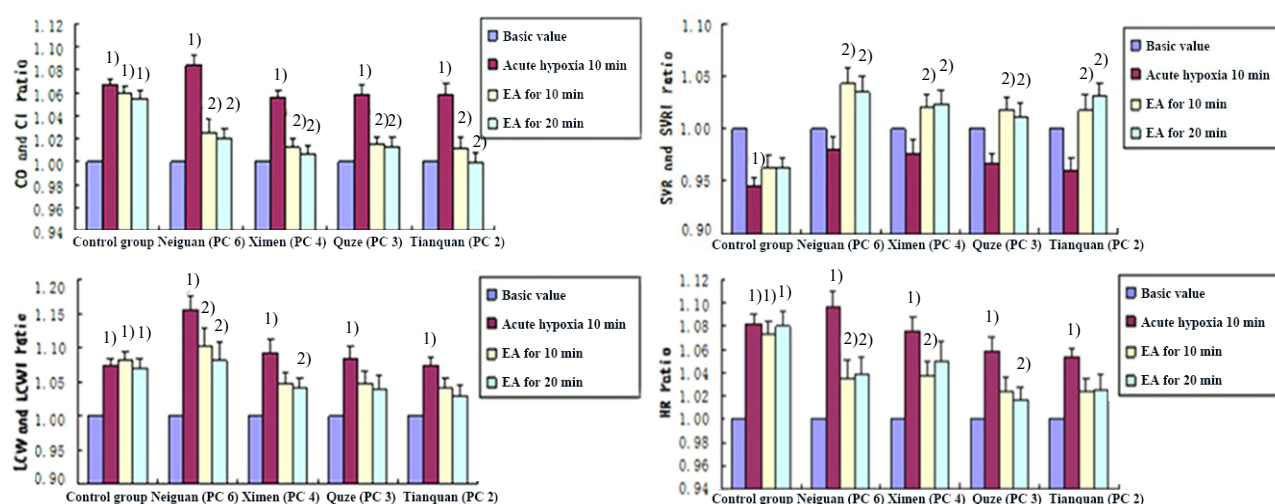


Figure 4. Effects of EA at acupoints of the Pericardium Meridian on cardiac dysfunction

Note: Compared with the baseline, 1) $P<0.05$; compared with acute hypoxia 10 min, 2) $P<0.05$

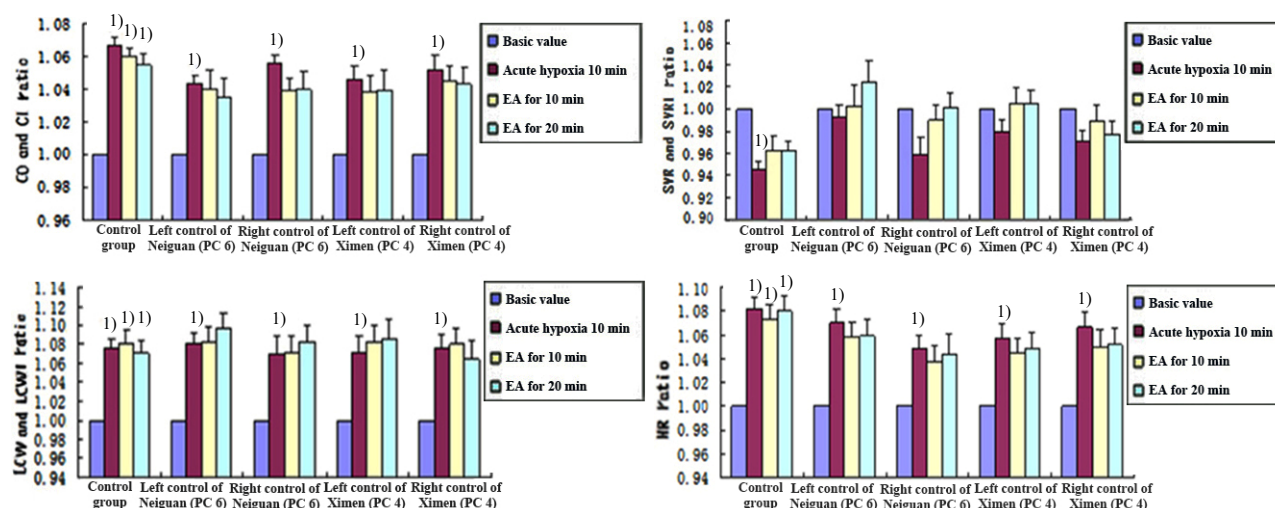


Figure 5. Effects of EA at the control points on cardiac function

Note: Compared with the baseline, 1) $P<0.05$; compared with acute hypoxia 10 min, 2) $P<0.05$

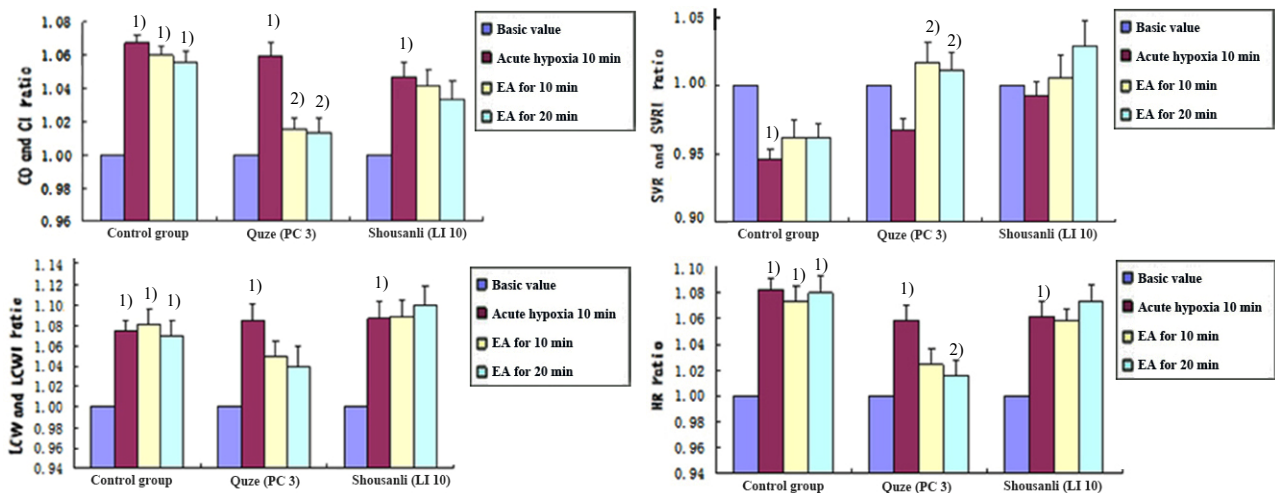


Figure 6. Effects of EA at Shousanli (LI 10) on cardiac function

Note: Compared with the baseline, 1) $P < 0.05$; compared with acute hypoxia 10 min, 2) $P < 0.05$

3 Discussion

Meridian connects with visceral organs internally and links with joints, limbs and other superficial tissues of the body externally. It has a specific running route in the body and is named by its subordinated organs. It is a holistic function entity. Ancient famous doctor, Yang Ji-zhou said, 'rather missing the acupoint than missing the meridian', and Han JS summarized, 'it is more important to identify the right meridian rather than the right point'^[21-22]. Fang ZB, *et al.*^[23-24] found EA at Shenmen (HT 7) and Lingdao (HT 4) was more effective on the regulation of ischemic cardiac function of rabbits than EA at Taiyuan (LU 9) and Lieque (LU 7), which indicated that the Heart Meridian had a close relationship with cardiac functional activity. Liu JL, *et al.*^[25] discovered the effect of EA at bilateral Neiguan (PC 6), Zhongchong (PC 9), Laogong (PC 8), Daling (PC 7) and three non-acupoints on the recovery of ECG ST-segment and arterial mean pressure in myocardial ischemia rabbits, which indicated that the Pericardium Meridian is closely related to cardiac function.

Acupuncture is the achievement through Chinese people's long-term struggle with diseases. Its effects are more obvious in pathological or dysfunctional conditions than in normal physiological conditions. Therefore, we had volunteers inhale low-oxygen gas mixture (10.8% O₂ and 89.2% N₂) to imitate acute hypoxia. As a result, the condition of the volunteers deviated from normal, and the effect of EA was detected more clearly. We found that CO/CI, LCW/LCWI, and HR increased after inhalation, while EA at the Pericardium Meridian decreased them significantly. SVR/SVRI decreased after inhalation and increased significantly during EA at the Pericardium Meridian ($P < 0.05$). No remarkable change was detected during EA at Shousanli (LI 10) and the control points. The results indicated that EA at the Pericardium Meridian

can correct cardiac dysfunction. On the other hand, there was a little difference in the action of the four acupoints from the Pericardium Meridian. According to our observation, regarding the adjustment of cardiac dysfunction induced by acute hypoxia, the effect was Neiguan (PC 6) > Ximen (PC 4) > Quze (PC 3) > Tianquan (PC 2), which suggested that, although the acupoints of the Pericardium Meridian have similar clinical effects, they have their own specificities.

In summary, according to this study, we believe that major functions of the acupoints from the same meridian are similar while specificity does exist. The function of acupoints in four limbs is more closely related to the course of classical meridian than segmental innervations. All these findings will provide more reliable and valid scientific evidence for the principle of selecting acupoints from the affected meridians.

Conflict of Interest

There was no potential conflict of interest in this article.

Acknowledgments

This work was supported by Youth Fund of National Natural Sciences Foundation of China (国家自然科学基金青年科学基金, No. 81403490); Public-funded Project of Fujian Provincial Science & Technology Ministry (福建省科技厅省属公益类项目, No. 2014R1035-6); Scientific Research Project (Type B) for Young Teachers of Fujian Education Department (福建省教育厅中青年教育科研 B 类项目, No. JB14050); Key Unit of the Propagated Sensation along Meridian of Fujian Province (福建省经络感传重点实验室).

Statement of Informed Consent

Informed consent was obtained from all individual participants included in this study.

Received: 28 April 2017/Accepted: 29 May 2017

References

- [1] Litscher G, Liu CZ, Wang L, Wang LP, Li QQ, Shi GX, Gaischek I, Litscher D, Wang XM. Improvement of the dynamic responses of heart rate variability patterns after needle and laser acupuncture treatment in patients with burnout syndrome: a transcontinental comparative study. *Evid Based Complement Alternat Med*, 2013: 128721.
- [2] Middlekauff HR. Acupuncture in the treatment of heart failure. *Cardiol Rev*, 2004, 12(3): 171-173.
- [3] Su LQ, Li WH, Jiao Y. Clinical observation of thread-embedding in Neiguan (PC 6) for stable angina. *Shanghai Zhenjiu Zazhi*, 2014, 33(1): 31-33.
- [4] Yu HJ, Qin ZM. Clinical study of the specificity of Neiguan (PC 6) in treatment for premature beat. *Shanghai Zhenjiu Zazhi*, 2014, 33(1): 121-123.
- [5] Cai RL, Hu L, Wang KM, Wu ZJ, Chen YN, Long DH, Liu J, Zhou YP. Effects of electroacupuncture of Neiguan (PC 6) and Taichong (LR 3) on cardiac function in acute myocardial ischemia rabbits. *Zhen Ci Yan Jiu*, 2010, 35(2): 104-107.
- [6] Li J, Li J, Chen Z, Liang F, Wu S, Wang H. The influence of PC6 on cardiovascular disorders: a review of central neural mechanisms. *Acupunct Med*, 2012, 30(1): 47-50.
- [7] Jiang LY, Huang JR, Zhu JF, Dai JL, Zhang WD. The experimental study on the effect and relative mechanism of acupuncture at Ximen (PC 4) on the cardiodynamics in the myocardial ischemia model of rats. *Zhongguo Zhongyi Jichu Yixue Zazhi*, 2013, 19(4): 439-442.
- [8] Chen CY, Xu B, Yu XC, Wang LL, Chang XJ. Study of the difference in the regulating effect on rat bradycardia between electroacupuncture at meridian points and corresponding non-meridian points. *Shanghai Zhenjiu Zazhi*, 2010, 29(12): 747-751.
- [9] Wang X, Shan QH, Tian XJ, Wang JL. Contrast observation of acupuncture Quze (PC 3) and Daling (PC 7) on the immediate effect of electrocardiogram of coronary heart disease. *Shandong Zhongyi Zazhi*, 2008, 27(12): 821-823.
- [10] Chen DF, He ZM, Li YW, Zhou JH. Relative specificity of Quze (PC 3) in laser acupuncture for acute myocardial ischemia. *Guangzhou Zhongyiyao Daxue Xuebao*, 1997, 14(3): 172-174.
- [11] Zhang JL, Chen SP, Liu JL. Research on the connection pathway between Tianquan (PC 2) of the Pericardium Meridian and the heart in the cat. *Zhen Ci Yan Jiu*, 2002, 27(2): 124-129.
- [12] Cui LL, Liu JL. Comparative study of the effect of acupuncturing Tianquan (PC 2) on the adenosine acid content and electrical stability of ischemic myocardium. *Zhen Ci Yan Jiu*, 1995, 20(4): 8-11.
- [13] Jiang YF, Chen CS, Liu XM, Liu RT, Liu SH. Light propagation along the pericardium meridian at human wrist as evidenced by the optical experiment and Monte Carlo method. *Chin J Integr Med*, 2014, 20(1): 1-5.
- [14] Yang HQ, Xie SS, Liu SH, Li H, Guo ZY. Differences in optical transport properties between human meridian and non-meridian. *Am J Chin Med*, 2007, 35(5): 743-752.
- [15] Rezaei S, Khorsand A, Jamali J. Characterization of human skin impedance at acupuncture point Ximen (PC 4) and pericardium meridian using the four-electrode method. *Acupunct Med*, 2012, 30(2): 127-131.
- [16] Ahn AC, Wu J, Badger GJ, Hammerschlag R, Langevin HM. Electrical impedance along connective tissue planes associated with acupuncture meridians. *BMC Complement Altern Med*, 2005, 5: 10.
- [17] Zheng SX, Pan XH, Xu JS, Xiu CY, Dong YQ, Zhu XX. Variations in energy metabolism along the Pericardium Meridian and its relationship with visceral function adjustments during electroacupuncture. *BMC Complement Altern Med*, 2014, 14: 323.
- [18] Dong YQ, Xiu CY, Zhu XX, XU JS. Effects of acute hypoxia on transcutaneous oxygen pressure along Pericardium Meridian and heart function of healthy volunteers. *Fujian Zhongyiyao Daxue Xuebao*, 2014, 24(1): 6-8.
- [19] WHO Regional Office for the Western Pacific. WHO Standard Acupuncture Point Locations in the Western Pacific Region. Manila: WHO Western Pacific Regional Publications, 2008.
- [20] Han JS. Acupuncture analgesia: areas of consensus and controversy. *Pain*, 2011, 152(3 Suppl): 41-48.
- [21] Dong YQ, Xiu CY, Xu JS, Hu XL. Preliminary observations on the effect of acupuncture at point Ximen (PC 4) on heart function in volunteers with acute mild hypoxia. *Shanghai Zhenjiu Zazhi*, 2011, 30(8): 511-513.
- [22] Zeng XY, Pan MD. Mild acute, severe hypoxia stress effect and heart function in China air medical journal on left ventricular wall. *Zhongguo Hangkong Hangtian Yixue Zazhi*, 1992, 3(2): 65-68.
- [23] Fang ZB, Wang YL, Zhou YP. Effect of electroacupuncture at heart meridian on ventricular pressure of myocardial ischemia rabbits. *Gansu Zhongyi Xueyuan Xuebao*, 1995, 12(2): 42-43.
- [24] Fang ZB, Wang YL, Zhou YP. Effect of electroacupuncture at heart meridian on arterial pressure of myocardial ischemia rabbits. *Zhongguo Zhongxiyi Jiehe Zazhi*, 1997, 17(5): 298-299.
- [25] Liu JL, Chen SP, Cao QS. Effects of electroacupuncture at pericardium meridian acupoints and non-acupoints on myocardial electric activity of myocardial ischemia rabbits. *Zhongguo Zhen Jiu*, 1996, 16(4): 31-34.