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Electroacupuncture-induced pressor and chronotropic effects in anesthetized rats

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Abstract

The effects of electroacupuncture (Ea) on circulatory dynamics were investigated in anesthetized rats. The arterial blood pressure (BP) and the heart rate (HR) in response to Ea stimulations at the Tsusanli point (St-36) and the Hoku point (Li-4) were tested by a low frequency Ea (2 Hz; LFEa) and a high frequency Ea (20 Hz; HFEa) with stimulation intensities 20 times the motor threshold. Neither the HR nor the BP was affected when the Tsusanli point was stimulated. Whereas, Ea stimulations at the Hoku point elicit chronotropic and pressor effects. The patterns of pressor responses caused by the LFEa were different from that of an HFEa, i.e., the LFEa elicited a tonic effect, while an HFEa had a phasic one. The HFEa-induced pressor and chronotropic effects were attenuated, while the LFEa induced effects were completely blocked by an intravenous infusion of an alpha-adrenergic blocker (moxisylyte 0.2 mg/min/kg, *i.v.,* for 20 min). A co-infusion with alpha-and beta-adrenergic blockers (propanolol 0.2 mg/min/kg, *i.v.,* for 20 min) completely blocked the HFEa-induced pressor and chronotropic effects. We concluded that Ea stimulations, at the Hoku acupoint, with appropriate stimulation parameters can increase and maintain BP. Furthermore, the LFEa stimulation activates sympathetic vasomotor tone, whereas the HFEa stimulation causes an additional potentiation on the sympathetic drive to the heart.

Keywords: Heart rate; Blood pressure; Tsusanli; Hoku; Stimulation; Rat

1. Introduction

In China, acupuncture has been used to treat various diseases for more than two thousand years. Researchers exploring the physiological mechanism underlying acupuncture suggest that acupuncture might modulate nerve activities influencing visceral functions via somato–visceral reflexes (Tsuchiya et al., 1991; Sato et al., 1993; Kimura et al., 1995; Langevin et al., 2002). Electroacupuncture (Ea), where stimulation parameters can be clearly quantified, is not only used in clinical practice (Lewis et al., 1990; Lu and Lu, 1993), but is also widely used in animal (Sato et al., 1992, 1993) and human (Tsuchiya et al., 1991; Sugiyama et al., 1995; Averill et al., 2000) studies.

Many studies exploring therapeutic effects elicited by Ea stimulations have concentrated on the cardiovascular system. Ea-induced pressor responses have been reported in normal subjects (Sugiyama et al., 1995; Tanaka et al., 2002) and anesthetized rats (Lin et al., 1998; Stener-Victorin

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et al., 2003). Sato and coworkers investigated the neural mechanism underlying Ea-induced pressor responses and suggested that the segmental sympathetic outflow is activated by the Ea stimulations to induce pressor effects (Sato et al., 1992, 1993; Kimura et al., 1995; Loaiza et al., 2002). An investigation done by Lin and Fu (2000) discovered that a potentiation in the sympathetic tone mediates Ea-induced pressor responses in anesthetized rats. In addition, Ea-induced pressor effects were almost abolished by an alpha-adrenergic blocker, suggesting that a vasoconstriction induced by the sympathetic outflow was one of the major routes for the Ea stimulation to elicit a pressor effect. However, since the circulatory system is composed of both the heart and peripheral vasculature, the role of the heart in an Ea-induced pressor response is an interesting topic that needs to be further elucidated. Therefore, in the present study, we test whether or not a beta-adrenergic blocker can abolish the Ea-induced pressor effect under an alpha-blocker infusion to further investigate the role of the heart in Ea-induced pressor responses.

2. Materials and methods

Twenty adult female SD rats weighing 220–350 g were used throughout this study. Initially the rats were anesthetized with penthrane (methoxyflurane, Abbott Lab.) for surgical preparation, and then they were maintained under alpha-chloralose anesthesia (50 mg/kg, *i.v.*). The right femoral vein and the trachea were cannulated for drug infusions and for artificial respiration if necessary, respectively. Systemic blood pressure (BP) was continuously recorded on a computer recording system (Biopac MP30) through a transducer (Statham P23D) with a catheter inserted in the right femoral artery. Systolic blood pressure (SBP), diastolic pressure (DBP), and heart rate (HR) were also recorded on the computer system. The rat was placed in a supine position and the rectal temperature was maintained at around 37 °C using an infra-red lamp. The depth of anesthesia was routinely judged during the experiment by observing the animal's respiration and BP. Whenever these conditions became unstable, additional doses of anesthetics were given.

Acupoints were determined by anatomically transposing the points using traditional Chinese human acupuncture charts (Fig. 1). Two acupoints: the Tsusanli point (St-36), which is located at the lateral upper tibia and the Hoku point (Li-4), which is located at the junction of the first and the second metacarpal bones were tested. An interdermal needle (32 gauge, 1/2 inches long, Trueline Instruments), soldered to a flexible electrical wire, was inserted vertically into the selected acupoints. A second identical needle, used as a positive pole, was inserted into the other point approximately 5 to 10 mm from the first one. An electric current of square wave pulses, with pulse durations of 0.05 ms, was applied from a stimulator (Grass S88) through a stimulus

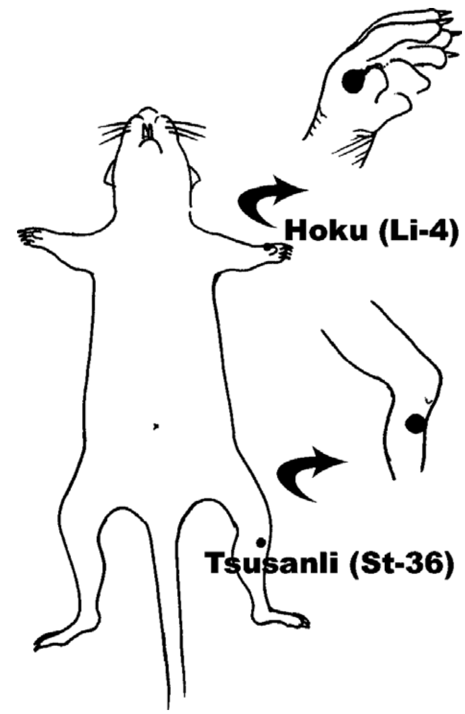

Fig. 1. The location of the acupoints used in this study. The Tsusanli point (St-36), is located on the lateral upper tibia and the Hoku point (Li-4), is located at the junction of the first and the second metacarpal bones.

isolation unit (Grass SIU5B) and a constant current unit (Grass CCU1A). Two stimulation frequencies: 2 Hz (low frequency Ea; LFEa) and 20 Hz (high frequency Ea; HFEa) were tested in this experiment. A frequency of 2 Hz is widely employed in manual and electric acupuncture studies, while 20 Hz is 10 times higher to serve as the high frequency stimulation. The stimulation intensities (Lin and Fu, 2000) were 20 times the threshold (the minimal stimulation intensity to induce a muscle twitch). The total stimulation time in this study was set for 10 min because the effects of the Ea stimulations on BP and HR became stable within 5 min.

Drugs including the alpha-(moxisylyte, Sigma) and the beta-(Propanolol, Sigma) adrenergic blockers were tested by using an intravenous infusion at a constant infusion rate of 0.2 mg/min/kg for 20 min (i.e., a total dose of 4 mg/kg).

All the data in the text and figures are mean ± S.E.M. Statistical differences between groups were determined using two-way ANOVA followed by a Student's t test, where a $P < 0.05$ was accepted as a minimal level of significance.

3. Results

3.1. Effects of electroacupuncture at Hoku

Ea stimulations at the Hoku point can raise BP and HR in anesthetized rats. Neither a unilateral nor a bilateral adrenalectomy affected the pressor and chronotropic effects