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A Semi-quantitative Method to Study Electrical Properties of Acupuncture Points

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Abstract—**An invasive method has been developed for a measurement of voltage response of acupuncture points themselves at different frequencies from 10 to 80Hz. The input voltage for each frequency varied from 100 mV to 1000 mV or 200 mV to 1000 mV. The output voltage response to input voltage has a linearity property under the same frequency, and the output voltage response to input voltage exhibit non-linearity under different frequencies. A simple model is developed to explain the unique characters of acupuncture points that the acupuncture points are a resistor-and-capacitor combined system.**

Index Terms—**Acupuncture points, voltage response, frequency, non-linearity.**

I. INTRODUCTION

There are more than 2000 acupuncture points, some of them also known as biological active points, nonuniformly distributed on human body. Acupuncture therapy has great effect on many medical disorders. Based on National Institute of Health (NIH) Consensus Panel's consensus statement, acupuncture clearly works to treat a number of conditions, including nausea from chemotherapy, surgery and pregnancy, and pain after surgery (including dental surgery). Acupuncture may also be an effective adjunct therapy for a number of other condition, including stroke rehabilitation, relieving addictions, headaches, menstrual cramps, a variety of muscle pains, carpal tunnel syndrome, tennis elbow, low back pain, osteoarthritis, and asthma. But why do acupuncture needles work when they are inserted to right acupuncture points, and how they work? This is a thousand-year puzzle. Acupuncture points play very important roles in acupuncture therapy. Electrical properties of acupuncture points have been studied since 1950s [1]-[4] and studies show that they have lower electrical resistance that their surrounding tissues and the impedance around them is frequency-dependent [5]-[10]. Most studies about their electrical properties are performed by using direct current measurement or polarized electrodes [11]-[13]. People have developed many methods to measure the physical properties of skin surround acupuncture points [10]-[16]. All of these measurements are non-invasive, and the electrodes used in these studies are 3-8 mm diameter. These results are variable and related to the measurement conditions. But in the acupuncture therapy, the used needles are 0.25-0.13 mm diameters, and are punch into skin about 10mm. Studies have pointed out that the measurement results of physical properties of skin are related to such measurement conditions as the pushing pressure applying on electrodes, tissue displacement, electrodes size, and contact of electrodes on skin [7]-[11]. However, all these studies investigated the skin around acupuncture points, not acupuncture points themselves. The significance and detail of electrical properties of acupuncture points themselves are unknown at present and more research and reliable measurement are needed. Therefore, in order to improve the reliability of measurement and to reveal the electrical properties of acupuncture points and meridian system comprehensively, we use an invasive method, punching the needle into the skin, and developed a new experimental protocol in this work.

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II. METHOD AND RESULTS

Three acupuncture points compose a simplest network. The input and output response of electrical properties of each acupuncture point can be studied. Therefore, three acupuncture points, i.e., Quchi (L11), Hegu (L14), and Shoushanli (L10) are selected. They are located on Shoushaoyang meridian at the right arm, as shown in Fig. 1(a). Three tests (Test #1, Test #2 and Test #3) are designed, as shown in Fig. 1(b), (c), and (d). Three normal steel stainless acupuncture needles with a diameter of 0.15 mm as used by most acupuncturists are inserted into these three points, respectively. The experiments are performed on healthy human subjects (male, age 30-40 years) guided by a clinical doctor and an acupuncturist.

In Test #1 shown in Fig. 1(b), the signal was input from Quchi (L11) and Hegu (L14). The voltage amplitude is set as 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, and 1000 mV, and for each voltage the frequency is set as 10, 20, 30, 40, 50, 60, 70 and 80 Hz. Then the voltage and frequency responses of between Quchi (L11) and Shousanli(L10), and V_2 between Hegu (L14) and Shousanli(L10) acupuncture points are measured. In Test #2 as shown in Fig. 1(c), input voltage V, as set to 200mV, 300mV, 400mV, 500mV, 600mV, 700mV, 800mV, 900mV and 1000mV, is added between Quchi (L11) and Shousanli (L10), and for each voltage the frequency is set as 20Hz, 30Hz, 40Hz, 50Hz, 60Hz, 70Hz and 80Hz. The output voltage response V_3 is measured between Shousanli (L10) and Hegu (L14). In Test #3 as shown in Fig. 1(d), input voltage V is added between Shousanli (L10) and Hegu (L14), and the voltages and frequencies are set the same as Test #2. The output voltage response V_4 under different frequencies is measured between Quchi (L11) and Shousanli (L10).

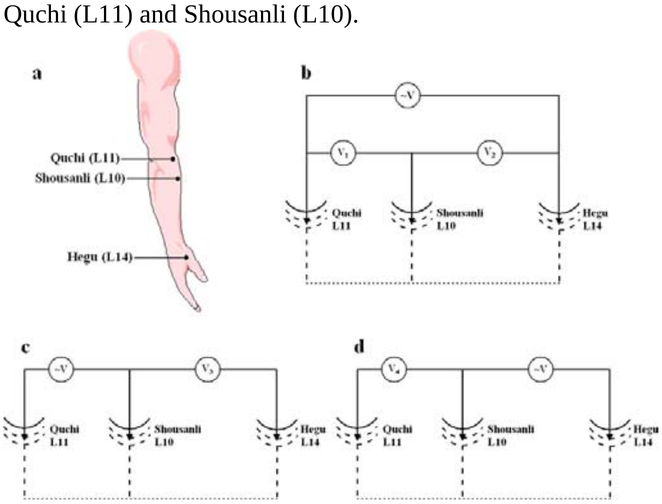

Fig. 1. Three acupuncture points in right arm and three tests schematics. (a) Three acupuncture points, Quchi (L11), Shoushanli (L10) and Hegu (L14) in right arm, showing the positions of them. (b) Schematic of Test #1. V is the input voltage between Quchi (L11) and Hegu (L14). V_1 is the output voltages between Quchi (L11) and Shousanli(L10), V_2 is the output voltage between Shousanli(L10) and Hegu (L14). (c) The schematics of Test #2. V is the input voltage between Quchi (L11) and Shousanli(L10), V_3 is voltage between Hegu (L14) and Shousanli(L10). (d) The schematics of Test #3. V is the input voltage between Hegu (L14) and Shousanli(L10), V_4 is the output voltage between Quchi (L11) and Shousanli(L10)

The output voltages V_2 and V_3 as a function of input voltage V under different frequencies of Test #1 is presented in Fig. 2(a). As shown in Fig. 2(a), the output voltage between Shousanli (L10) and Hegu (L14), V_2, is higher than output voltage between Quchi (L11) and Shousanli (L10), V_1. The output voltage is linear as the input voltage under the same frequency. But the summation of V_1 and V_2 is equal to input voltage V. The results of Test #2 and Test #3 are presented in Fig. 2(b) that the output voltages V_3 and V_4 are linear as input voltage V at same frequency. But the output voltage between Quchi (L11) and Shousanli (L10), V_4, is higher than output voltage between Shousanli (L10) and Hegu (L14), V_3, in all measured frequencies 20Hz-80Hz.

III. Discussion

The results presented in Fig. 2(a) and (b) can be described as an equation $V_m = B(V - V')$, where V_m is output voltage between two acupuncture points as V_1, V_2, V_3 or V_4, V is input voltage, B and V' are two parameters. The parameters B and V' of Test #1, #2 and #3 are listed in Table 1. In Test #1, the biggest B for V_1 is 0.44 at 40 Hz, and the smallest B for V_2 is 0.57 at 40 Hz. The biggest B for V_3 is 0.42 at 60 Hz in Test #2, and the biggest B is 0.543 for V_4 at 60 Hz in Test #3. The averages of B for V_1, V_2, V_3 and V_4 are 0.411, 0.596, 0.406 and 0.526, respectively. The number of V' is scattered. But there are still some orders that V' for V_1 is negative except at 10 Hz, V' for V_2 is positive except at 10 Hz, V' for V_3 and V_4 are all negative.

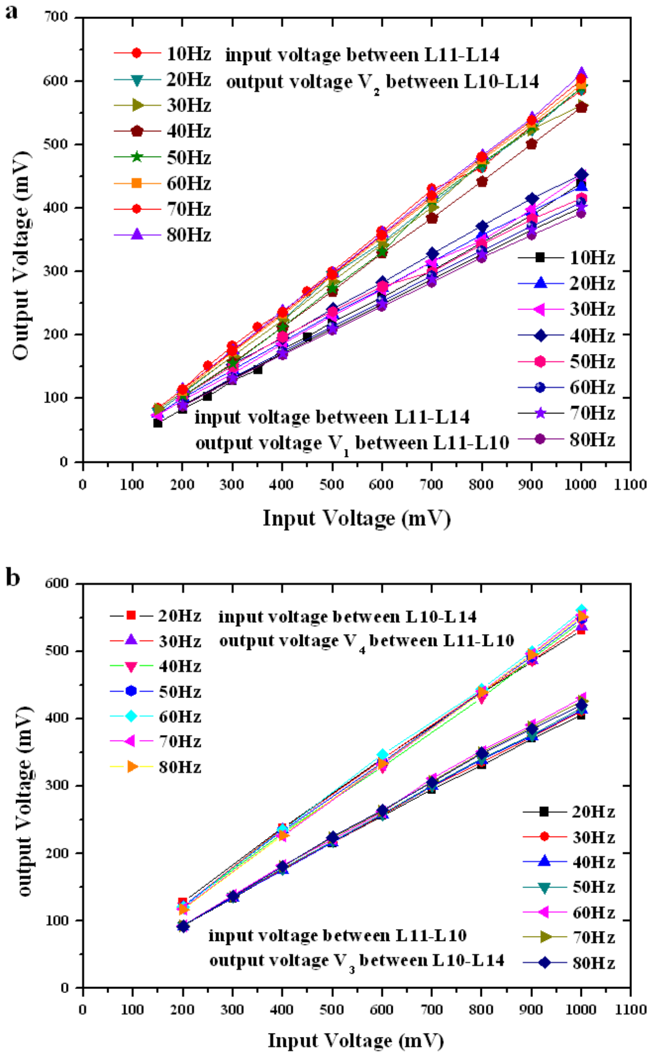

Fig. 2. Output voltages response to different input voltages under different frequency. (a) The output voltage V_1 between Quchi (L11) and Shousanli (L10), and V_2 between Shousanli (L10) and Hegu (L14) as functions of input voltage V between Quchi (L11) and Hegu (L14) under different frequencies. The frequency of V is set as 10Hz, 20Hz, 30Hz, 40Hz, 50Hz, 60Hz, 70Hz and 80Hz. (b) The output voltage V_3 between Shousanli (L10) and Hegu (L14) as a function of input voltage V between Quchi (L11) and Shousanli (L10), and V_4 between Quchi (L11) and Shousanli (L10) as a function of input voltage V between Shousanli (L10) and Hegu (L14) under different frequencies. The frequency of V is set as 20Hz, 30Hz, 40Hz, 50Hz, 60Hz, 70Hz and 80Hz.

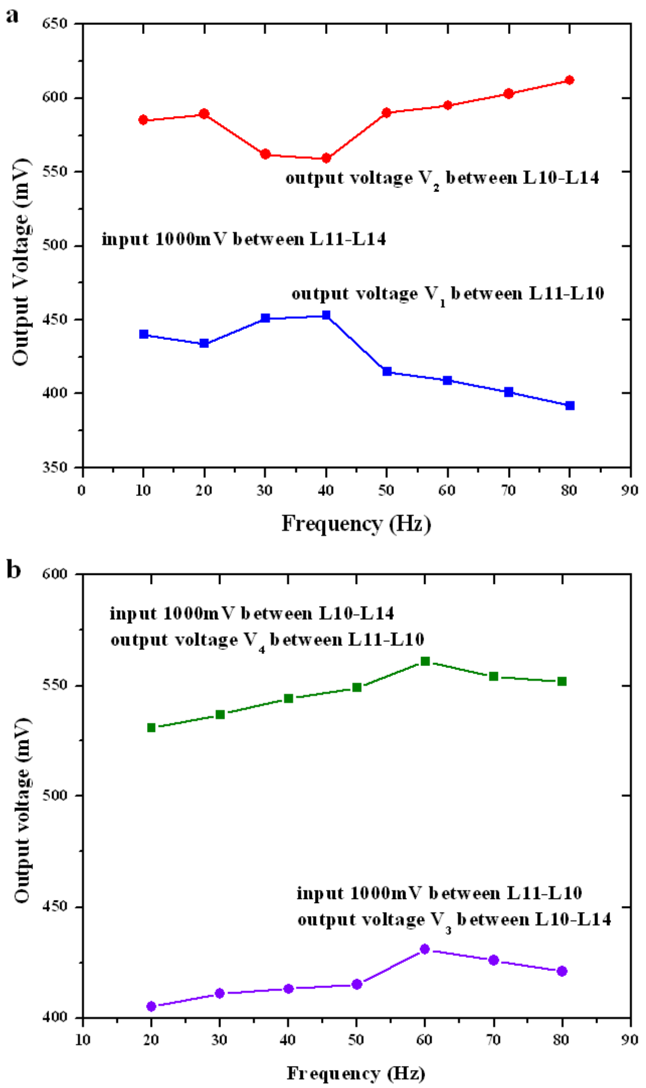

Fig. 3. Output voltages response to different frequencies at 1000mV input voltage. (a) The output voltage V_1 between Quchi (L11) and Shousanli (L10), and V_2 between Shousanli (L10) and Hegu (L14) as functions of frequency at 1000mV input voltage V between Quchi (L11) and Hegu (L14). (b) The output voltage V_3 between Shousanli (L10) and Hegu (L14) as a function of frequency at 1000mV input voltage V between Quchi (L11) and Shousanli (L10), and V_4 between Quchi (L11) and Shousanli (L10) as a function of frequency at 1000mV input voltage V between Shousanli (L10) and Hegu (L14).

The output voltage is not constant as input frequency change at the same input amplitude. In Test #1, the output voltages V_1 and V_2 as a function of frequency at input 1000mV are plotted in Fig. 3(a). When V_1 increases, V_2 decreases. As V_1 gets decrease, V_2 increases. They present a symmetric property at 500 mV output. At 40 Hz, V_1 is the biggest and V_2 is the smallest. The results agree to the results listed in Table I that B for V_1 is the biggest at 40Hz and B for V_2 is the smallest at 40Hz. Fig. 3(b) presents the output voltages V_3 and V_4 as a function of frequency at input 1000 mV in Test #2 and Test #3. V_3 and V_4 reach the maximum at 60 Hz. The results of B shown in Table I also have the maximum value at 60 Hz.

TABLE I
PARAMETERS OF EQUATION DESCRIBING THE RESULTS IN FIG. 2

Frequency (Hz)	10	20	30	40	50	60	70	80
B for V_1	0.44	0.42	0.43	0.45	0.38	0.40	0.39	0.38
B for V_2	0.58	0.60	0.58	0.57	0.62	0.60	0.61	0.61
B for V_3		0.39	0.40	0.40	0.40	0.42	0.418	0.413
B for V_4		0.50	0.51	0.52	0.53	0.543	0.54	0.54
V' for V_1 (mV)	10	-43	-22	-47	-99	-33	-37	-41
V' for V_2 (mV)	-6	20	9	26	48	14	15	15
V' for V_3 (mV)		-44	-40	-36	-37	-25	-29	-35
V' for V_4 (mV)		-67	-49	-32	-33	-28	-15	-17

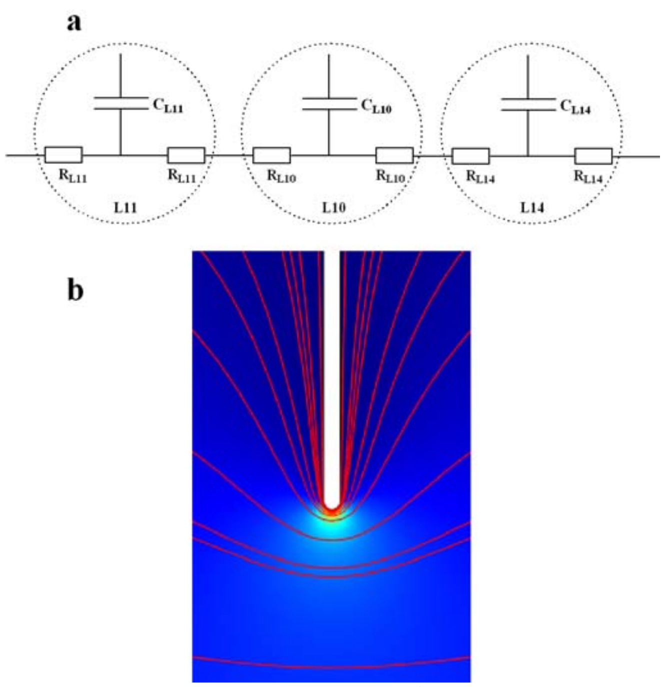

Fig. 4. The electrical equivalent circuit model of acupuncture points and the electric field as a needle is inserted into an acupuncture point. (a) Three acupuncture points, Quchi (L11), Shousanli (L10) and Hegu (L14), compose a simplest network including three capacitors and six resistors. (b) Finite-element-method simulation of electric field as a acupuncture needle is inserted into an acupuncture point. The red colour indicates the strongest electric field position. The red curves show the electric field distribution

The acupuncture points present frequency properties from our test results. One electrical equivalent circuit model is suggested to describe properties of an acupuncture point. In this model two resistors and one capacitor are included. The resistors are used to characterize the voltage linear property, and the capacitor is used to describe the frequency properties. Therefore, based on this model the equivalent circuit of three tested acupuncture points is plotted in Fig. 4(a). Based on the test results, a hypothesis is that an acupuncture point is a good frequency converter, and in electrical equivalent circuit model the capacitor plays a more important role in an acupuncture point than a resistor. Finite-element-method (FEM) was used to simulate the electric field in an acupuncture point as an acupuncture needle is inserted into it. In this simulation, one parallel capacitor is used. The capacitor dimension is 3 mm wide, 6 mm deep. The result is shown in Fig. 4(b). The red color indicates the strongest electric field at the tip of the needle. The red curves show the electric field density, the high curve density showing the high electric field. When considering an acupuncture point, we have to take look at the rearrangement of charge at the molecule level. Most of the molecules in the body are polar molecules. They build up an organized electric field. If the acupuncture point is out of function, the electric filed inside is disordered and the resonant frequency of the acupuncture point is changed. But as the needle is inserted into the point, it changes the electric field, and at the tip of needle, the field is very strong. The strong field can force polar molecules to be in order and help reinstall the organized field gradually, and the acupuncture needle can also increase the conductivity of acupuncture point because it is a metal.

IV. CONCLUSION

In summary, this study presents that acupuncture points have the following three properties. Under the same frequency, the output voltage response to input voltage has a linearity property. Under different frequencies, the output voltage response to input voltage exhibits non-linearity. If inputs cross three acupuncture points, the output from two neighboring acupuncture points (L11 – L10 and L10 – L14) presents the opposite direction frequency response. If input from two neighboring acupuncture points (L11 – L10 or L10 – L14), output from another two neighboring acupuncture points (L10 – L14 or L10 – L11), 60Hz is an inflexion and resonant frequency, at which the output voltage reach the maximum value given the same input value. Future research will focus on the current response of acupuncture points and derive the capacitance and resistance of each acupuncture point.

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