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A needle temperature microsensor for in vivo and real-time measurement of the temperature in acupoints

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Abstracts

A novel needle temperature microsensor measurement system was established to study the temperature characteristics in acupoints. Before used in vivo, the needle temperature microsensor was tested in vitro and proved stable, accurate and sensitive. Its measurement error was no more than ±0.1 °C by calibration. Its resolution was 0.1 °C and response time was less than 1 s. The measurement ranged from 20 to 40 °C. The in vivo experiments showed that the temperature of the acupoints ascended significantly higher than that of the left and right non-acupoints (parallel to the detected acupoints and 1.0 cm apart from them) after electroacupuncture (EA) at other acupoints, which were located on the same meridian line with the detected acupoints but 6–10 cm away from them. The results indicated that the needle temperature microsensor had a good performance in vivo. Furthermore, it supplied a reliable tool for the study of the mechanism of acupuncture and meridians.

Keywords: Microsensor; Needle temperature sensor; Thermistor; Acupoints; Meridians; In vivo

1. Introduction

Temperature is an important index of life activity. Many creatures including human, whose body temperature is about 37.0 °C, have a relatively constant body temperature. If the body temperature is higher or lower than that, animals might be suffering from some diseases. Temperature is an important parameter associated with substance metabolism, energy transformation and signal transmission, which are the essence of life. Therefore, the measurement of temperature in vivo is considered as an important way to reveal some biophysical and physiological properties of life.

Generally, the temperature in the tissue below the skin is more stable than that on the surface of the skin. The temperature in the tissues can act as a parameter to reflect the situations in them. Therefore it is more significant and meaningful to measure the temperature below the skin instead of on the skin.

There are all kinds of techniques and instruments for temperature measurement, such as thermistors, platinum resistors, thermocouples, bimetals, infrared-ray temperature sensors, quartz thermometers, optical fiber temperature sensors, etc. [1]. Each has its own advantages and disadvantages. The needle temperature microsensor prepared by us for the measurement of temperature in acupoints is based on the principle of thermistors for its high temperature coefficient, high sensitiveness, short response time and minimizability.

Acupuncture is an important part of traditional Chinese medicine (TCM). It is a therapy of stimulating special points called acupoints over the human body and has been widely applied in the clinic to treat various diseases for its simple manipulation, low costs, no side effects and good curative effects [2]. According to the theory of the TCM, there are 14 main meridians running through the human body and joining the acupoints and the corresponding organs together [3]. The anatomical structure and substance basis of the acupoints and meridians remain largely unknown. Thus the in situ measurement of the physical and chemical properties of these loca-

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tions will benefit to clarify the mechanism of acupuncture and meridians in some extent.

The needle temperature microsensor, whose shape is similar to that of an acupuncture needle, was established in the present study. Its sensitivity, accuracy and stability were evaluated in vitro. Afterwards the needle temperature microsensor was applied in vivo for the temperature measurement in acupoints and non-acupoints.

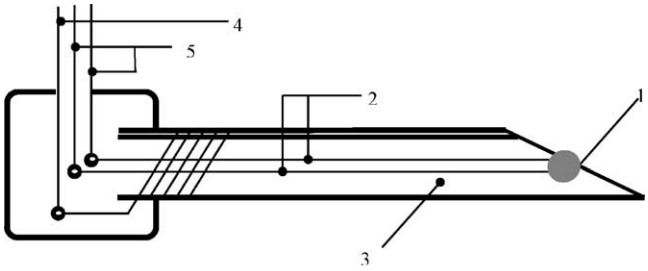
2. Experiments

Twenty healthy rabbits weighting from 2.0 to 3.0 kg were chosen as experimental animals. The multi-purpose electroacupuncture apparatus (Model G6805-2, Shanghai Medical Instrumental High-TECK Co., China) were used for stimulating.

The chosen acupoints included Zusanli (ST36), Shangjuxu (ST37), Xiajuxu (ST38), and Jiexi (ST39) points. The locating of the acupoints was based on the comparative anatomy. The locations of them were as follows: Zusanli (ST36) points, located about 1.2 cm below the capitulum of the fibular and 1.0 cm away from the anterior crista of the tibia; Dubi (ST35) points, located at the lower border of the patella and in the depression lateral to the patellar ligament when the knee is flexed; Shangjuxu (ST37) and Xiajuxu (ST38) points, located at about the 6/16, 9/16 of the distance from the Dubi (ST35) points to the highest point of the ankle, respectively; Jiexi points located at the crease of the instep and between the extensor hallucis longus of the first toe and second toe. The locating of the left and right non-acupoints were as follows: they were parallel to the detected acupoints and 1.0 cm apart from them.

2.1. The fabrication of the needle temperature microsensor and the experimental setup

The fabrication of the needle temperature microsensor (Fig. 1) was divided into four stages. First, the two Pt–Ir silks (20 μm diameter) of a thermistor were coated carefully with insulating materials in order to insulate themselves with each other and with the inner wall of the syringe needle. Then it was dried at a proper temperature. Secondly, the dried thermistor (200 μm diameter) was drawn carefully through a syringe needle (500 μm outer diameter, 250 μm inner diameter) with the small thermistor just at the tip. Thirdly, the two Pt–Ir silks (20 μm diameter) of the thermistor were connected with two copper silks, respectively. Finally, the leaving space of the hollow syringe needle was filled with insulating materials to immobilize the thermistor at the tip and the Pt–Ir silks in it.



1. Thermistor; 2. Pt-Ir silk; 3.Epoxy resin glue;
4. Shielding wire; 5. Copper silk

Fig. 1. The sketch map of the fabrication of needle-tip temperature microsensor.

The experimental setup, which was composed of several parts, was shown in Fig. 2. The temperature analyzer was a three-channel potentiometric amplifier. The potentiometric signals were obtained by a computer equipped with PCL-711B Multi-function Data Acquisition Card (Evoc Technology Co. Ltd.).

2.2. In vitro experiments

The needle temperature microsensors were calibrated and evaluated in a thermostat bath at different temperatures. Three needle temperature microsensors and a standard thermometer were put together in a thermostat bath and were recorded simultaneously when the temperature were raised and dropped between 20 and 40 °C.

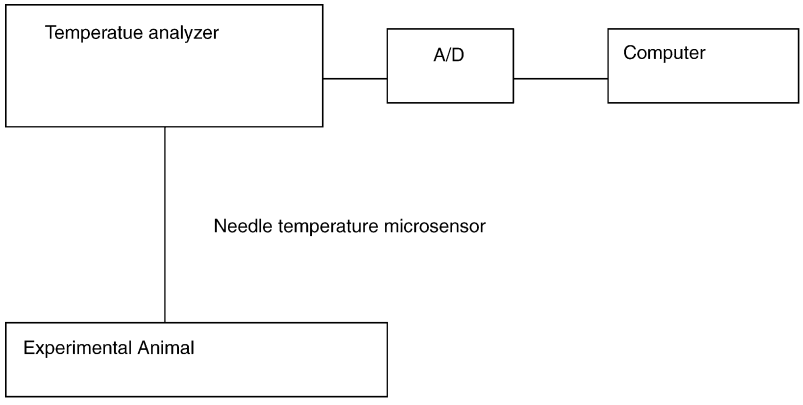


Fig. 2. The setup of the temperature measurement system.