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ORIGINAL ARTICLE

Electrodermal mapping: A new technology

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Abstract

AIM: To provide the first objective data to show that the electrical conditions of an acupuncture point and a non acupuncture point are different.

METHODS: A newly developed multi-channel skin resistance measuring system is used to characterize the variability in electrical resistance measurements in and around an acupoint, a non-acupoint and a scar. The system measures the electrical skin resistance at 48 points, both absolutely and continuously. The study was performed at the Medical University of Graz in 10 male volunteers, aged between 20 and 30 years and of euro-caucasian descent. With software developed along with the hardware, both a high-resolution measurement and a graphical presentation of possible changes in electrical resistance in the region of interest are possible.

RESULTS: Using the new electrodermal mapping system, differences in skin resistance of an acupoint, a non-acupoint and around a scar could be observed. The values varied within a range of up to 100-500 kOhm. Thermography measurements for control reasons in the same spot did not show these changes.

CONCLUSION: Electrodermal mapping is an innovative method for highly precise skin resistance measurements.

Key words: Electrodermal mapping; Acupuncture point; Scar; Complementary medicine; Electrical skin resistance

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INTRODUCTION

The discipline of biomedical engineering has emerged as an integrating medium for two dynamic professions, medicine and engineering. In this process, biomedical engineers have become actively involved in the design, development and utilization of devices and new techniques[1].

The Research Unit of Biomedical Engineering in Anesthesia and Intensive Care Medicine at the Medical University of Graz (http://litscher.info) has been dealing with the development and implementation of new instruments, especially in the field of high-tech acupuncture research for more than 14 years[2-12].

Acupuncture has been used for medical treatment for thousands of years. A large number of empirical data is available but the technical quantification of effects was

not possible until now. Using electro-acupuncture, needle or laser needle stimulation and modern biomedical techniques, it was possible to quantify changes in biological activities caused by acupuncture[2-12]. In the middle of the 20th century, researchers found lower skin resistance of acupuncture points compared to non acupuncture sites. Impedance measuring devices were developed[13-23] in order to locate the acupuncture points precisely and guarantee the success of the therapy. But a few years later, new measurements were made that disproved this discovery by potential confounders.

In this context, electrical characterization of acupuncture points is a real challenge[13]. The numerous complicating factors, like electrode-tissue interface, electrode material, contact medium, electrode geometry, electrode arrangements, *etc.*, involved in electrodermal readings present a daunting challenge for anyone intent on studying the electrical characteristics ascribed to the acupuncture point[13].

In order to approach the issue of electrical characterization of acupuncture points scientifically, basic research is absolutely necessary because at the moment there are many open questions. It is not clear if the electrical skin resistance at and around an acupuncture point is higher, lower or equal to a non acupuncture point. The same questions arise concerning scars on the human body. In numerous publications acupuncture points are described as having distinct electrical properties[13]. Therefore, comprehensive, high-precision measurement of skin resistance in the area of an acupoint or a scar plays an important role, especially since there is currently no reliable data on the subject. This is also very important because it is a commonly held opinion that acupuncture structures (acupuncture points and meridians) are special conduits for electrical signals. It has to be mentioned here that this opinion has always been viewed sceptically by the scientific community in general.

Within the present editorial, the first measurements of newly developed equipment for electrodermal mapping[14] which allows precise measurements of skin resistance are presented. In a previous manuscript from our research team, a short technical description of the system and two measurement examples during acupuncture needle insertion and needle stimulation as well as during violet laser application can be found[14]. In that publication[14], information concerning other devices in the area of acupuncture research can be found.

MATERIALS AND METHODS

The study was performed at the Medical University of Graz in 10 male volunteers, aged between 20 and 30 years (mean age ± SD: 24.6 ± 2.5 years) and of eurocaucasian descent[15,16]. The aim of this study was to take measurements of the skin resistance of acupuncture points compared to a non acupuncture point.

The basis for the "electrodermal mapping system" was laid with the development and initial testing of a multichannel skin resistance measuring system.

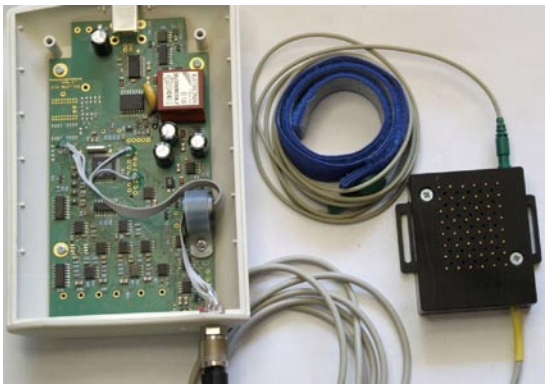

Figure 1 Measurement system for electrodermal mapping (modified from[14,15]).

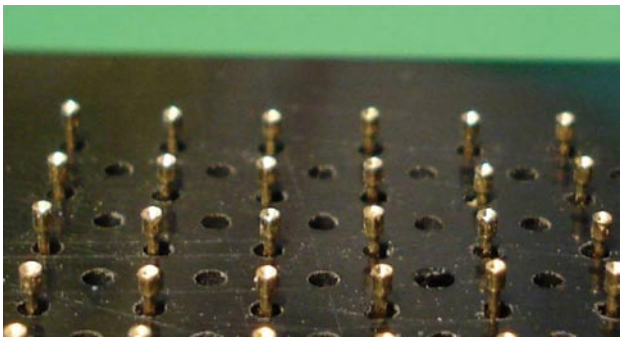

Figure 2 Part of the electrode arrays of the sensor for electrodermal mapping.

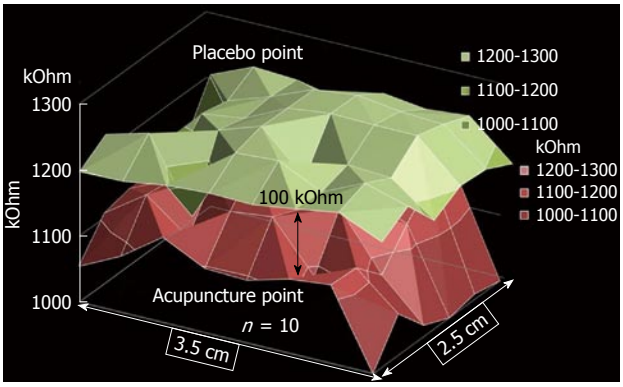

Figure 3 Graphical analysis of 48 channels of electrodermal skin impedance (average values of *n* = 10 persons) at an acupuncture point (below) and a non-acupuncture point (placebo point; above). Note the mean difference between the two surrounding areas is about 100 kOhm. Modified from[16].

The new Grazer ElectroDermal Impedance measurement System (GEDIS)[15,16] has been used. It is an 8 × 6 electrode array with spring-mounted electrodes.

GEDIS, the new system (Figure 1), was developed to register the skin resistance over a period ranging from seconds to hours. The signals of 48 channels are detected simultaneously using a multiplexer. The electrodes have a diameter of 0.9 mm (Figure 2) and consist of a gold-plated beryllium-copper alloy. While it is not possible to measure the constant pressure of the spring-mounted

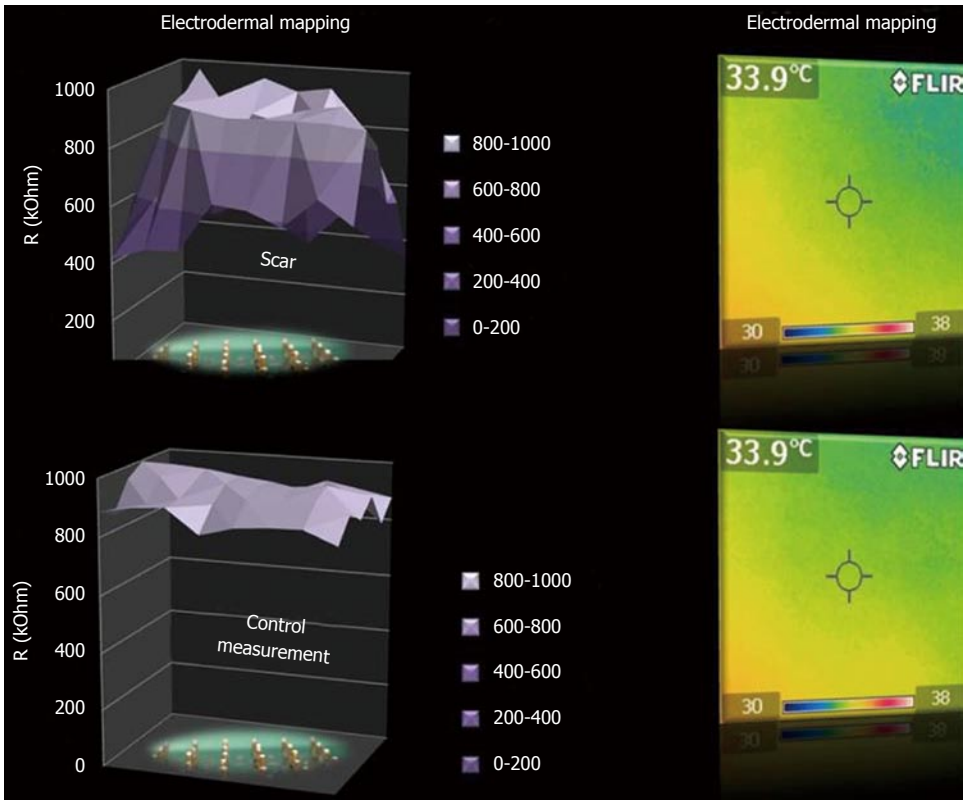

Figure 4 Three-dimensional presentation of the electrodermal activity at and around a scar (top) and a control area (bottom) (left) and corresponding thermal images of the same areas (right). Modified from[17].

electrodes during online monitoring, the contact pressure of an electrode is estimated to be about 0.5 to 1 N[14,15]. The measurement current was 1.46 μA.

The point Kŏngzuì (Lu6) and a placebo-point on the same level of the acupoint but located on the ulnar side of the heart meridian were used. These points were located by an experienced acupuncture practitioner. At these points, the measurement system was easy to apply. The results of acupuncture points and placebo points were then compared.

In addition, thermal imaging was performed of the areas surrounding the scar. These were taken with a Flir i5 (Flir Systems Inc., Portland, USA) infrared camera. These pictures were taken to exclude a difference in the surface of the body temperature at the location of the scar and the surrounding tissue.

RESULTS

Figure 3 shows the results of the first study with the system[16]. The results of the electrical characterization (skin resistance) of the areas surrounding the acupuncture point and the placebo point were compared. The measurements of skin resistance at the acupuncture point showed lower impedance values than those taken from the placebo point on the same arm (Figure 3). A significant ($P < 0.01$; ANOVA on ranks) difference of the values was found. Measured values on the acupuncture point were significantly lower (by 106 kOhm; mean values placebo point: 1218 kOhm, mean values acupuncture point 1112 kOhm)[16].

The changes of skin resistance at the appendectomy scar (20 years old) can be seen in Figure 4 (top left). The three-dimensional presentation clearly shows the increased resistance values around the scar, ranging from 800-1000 kOhm. In comparison, the impedance of the surrounding tissue is markedly lower. A control measurement of intact tissue located lateral to the incision is shown in Figure 4, bottom left. The resistance values within the control measurement area are more uniform than those of the region of interest (skin incision). In addition to the results of the electrodermal mapping, Figure 4 shows thermographic images on the right. In contrast to the impedance measurements, the two thermal images show absolutely no difference[17].

DISCUSSION

Because of the controversially discussed results of existing studies in acupuncture research[14,18-23], a new multichannel skin impedance measurement system was developed at the Research Center for Traditional Chinese Medicine at the Medical University of Graz. This system was designed to supply objective data for the first time, taking into consideration the previously existing technical limitations[14].

Many non-scientific contributions report that scars show altered electrical skin resistance and this difference can be detected with one-channel measurements. It is

concluded that these altered conditions of the electrical activity indicate an interference field, which could then be "erased" using simple injection techniques with a few drops of local anesthetics. It is claimed that this would require only one or two sessions. However, to our knowledge there are no evidence-based publications available on this topic.

We found, for example, that skin resistance within a very small area can differ by up to 500 kOhm. These alterations cannot be detected by any other method currently (e.g. thermography).

Thus, "electrodermal mapping" is a method which allows a highly precise electrical characterization of acupoints, non-acupoints and scars for the first time. Further studies are needed to show whether "electrodermal mapping" may contribute to clarification of important questions concerning the existence and possible structure of the tissue of acupuncture points and/or meridians in complementary medicine.

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COMMENTS

Background

Although acupuncture has been used as a medical treatment for thousands of years, there are still many open questions concerning this ancient method. For example, it is not clear if the electrical skin resistance at and around an acupuncture point is higher, lower or equal to a non acupuncture point. The same questions arise concerning scars on the human body. This is very important because it is a commonly held (though scientifically still controversially discussed) opinion that acupuncture structures (acupuncture points and meridians) are special conduits for electrical signals. In the mid-20th century, researchers found lower skin resistance of acupuncture points compared to non acupuncture sites. Impedance measuring devices were developed in order to locate the acupuncture points precisely and guarantee the success of the therapy. But a few years later, new measurements seemed to disprove this discovery as several potential confounders were found. To date, no scientific consensus on the electrical properties of acupuncture points *vs* non-acupuncture points has been achieved.

Research frontiers

In numerous publications acupuncture points are described as having distinct electrical properties. Therefore, comprehensive, high-precision measurement of skin resistance in the area of an acupoint or a scar plays an important role, especially since there is currently no reliable data on the subject.

Innovations and breakthroughs

Because of the controversially discussed results of existing studies in acupuncture research, a new multichannel skin impedance measurement system ("GEDIS") was developed at the Research Center for Traditional Chinese Medicine at the Medical University of Graz. GEDIS was designed to supply objective data for the first time, taking into consideration the previously existing technical limitations. We found, for example, that skin resistance within a very small area can differ by up to 500 kOhm. These alterations cannot be detected currently by any other method (e.g. thermography).

Applications

"Electrodermal mapping" using the GEDIS system is a method which allows a highly precise electrical characterization of acupoints, non-acupoints and scars for the first time. However, further studies are needed to show whether electrodermal mapping may contribute to a clarification of important questions concerning the existence and possible structure of the tissue of acupuncture points and/or meridians in complementary medicine.

Terminology

Electrodermal mapping: a (mainly) graphical presentation of electrical skin resistance measured simultaneously and continuously in 48 sites, thus covering an area of about 2.5 cm x 3.5 cm. (Electrical) skin resistance/impedance: Human skin has electrical properties; one of them is its electrical resistance/impedance. The electrical resistance of the skin measures its opposition to the passage of an electric current. Electrical impedance extends the concept of resistance to alternating current circuits, describing not only the relative amplitudes of the voltage and current, but also the relative phases. When the circuit is driven with direct current, there is no distinction between impedance and resistance.

Peer review

This paper provided the first objective data to show that the electrical conditions of an acupuncture point and a non acupuncture point are different. This paper may be interesting for the readers.

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