Communications

Electrical Correlates of Acupuncture Points

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Abstract—Employing a Wheatstone bridge, skin conductance was measured over those putative acupuncture points on the large intestine and pericardium meridians lying between the metacarpophalangeal joints and the elbow. Results were compared to those from anatomically similar locations devoid of acupuncture points. At most acupuncture points on most subjects, there were greater electrical conductance maxima than at control sites.

INTRODUCTION

It has been asserted that acupuncture points exhibit locally decreased DC electrical skin resistance [1]–[3]. Commercial devices intended for clinical application seek to exploit this property [1]–[4]. If true, this would give the technique of acupuncture some physical basis other than hypnosis or suggestion [5].

This assertion has recently been challenged by Noodergraaf and Silage, who reported that no resistance minima could be located on the fingers when care was taken to avoid electrode pressure artifacts [6]. They concluded that they could find no evidence for the objective existence of any acupuncture points.

This study might be considered conclusive as regards the existence of electrical resistance minima at acupuncture points, except for two factors. To establish the existence of acupuncture points, it would be sufficient to establish that they are electrical resistance minima *with respect to the surrounding tissue*. It is not necessary to show that these points are absolute minima in resistance. Noodergraaf and Silage reached their conclusion on the basis of the second and needlessly stronger criterion of existence. Furthermore, their study was confined to acupuncture points on the fingers and their results possibly do not apply to other anatomical areas.

In view of both its importance and the scarcity of available information, we decided to re-examine the question. Our object was to determine whether the DC resistance of acupuncture points differs from that of surrounding tissue.

METHOD AND PROCEDURE

We limited our inquiry to easily accessible parts of two meridians, the large intestine (Li) and pericardium (P) [7], [8], located between the metacarpophalangeal joints and the elbow (see Fig. 1).

Skin resistance measurements were made employing a Wheatstone bridge with the subjects connected in parallel with one leg of the bridge (Fig. 2). The bridge was designed so that its imbalance current was directly proportional to the subject conductance (the reciprocal of resistance). Our data are therefore presented in terms of increased conductance, rather than decreased resistance. Two kinds of electrodes were used during the course of the measurements. One measuring electrode was a rod 1.5 mm in diameter; the other was a specially designed wheel electrode which is illustrated and described in Fig. 3. The reference electrode for both was a hand-held cylinder, 10 cm long and 3 cm in diameter. All electrodes were made of stainless steel.

The standard charts are in agreement as to the anatomical locations of the acupuncture points shown in Fig. 1(a). However, we quickly found that they are insufficient to allow their precise location on the subjects. Invariably, there was an area of about 1 cm^2, anywhere in which the point might exist and

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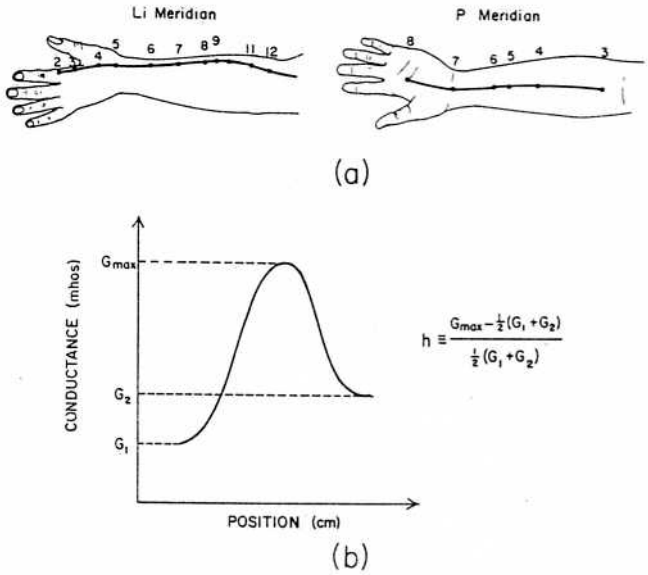

Fig. 1. (a) Approximate locations of acupuncture points on the large intestine (Li) and pericardium (P) meridians [6], [7]. (b) Idealization of conductance peaks seen at acupuncture points and the computational method employed to characterize the peaks. The fractional increase in conductance, h, implies a correction for individual differences in skin conductance level similar to that advocated by Lykken [9].

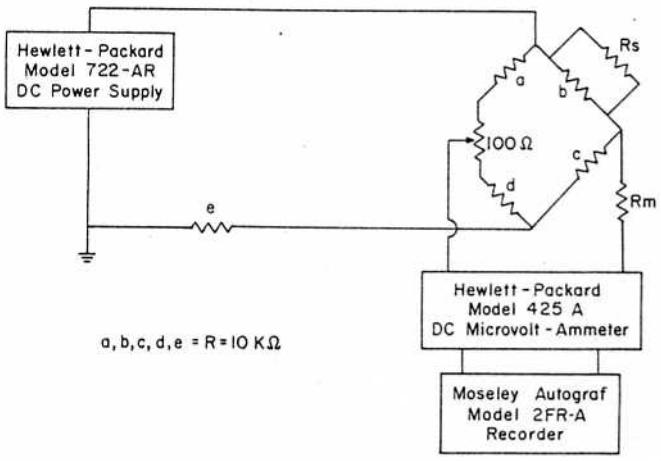

Fig. 2. The current across the unbalanced Wheatstone bridge is $I = V/[8R_s(1 + R_m/R) + 3R + 5R_m]$ [10]. As long as R_m (meter resistance) $\ll R \ll R_s$ (subject resistance), $I = V/8R_s = VG_s/8$ and the voltage across the subject if $V/4$ (V = input voltage). We set $V = 8$ V throughout the experiment, and found I to be on the order of 1 μamp, with a current density through the probe on the order of 10 μamp/cm^2.

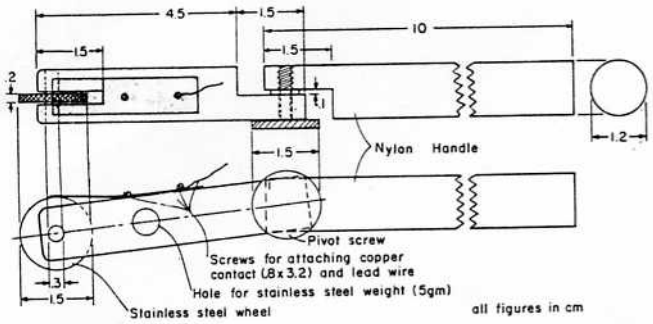

Fig. 3. The probe operator rolled the stainless steel wheel along a line through the acupuncture point while maintaining an angle between the hinged sections of about 135°. Electrical continuity was maintained by the copper contact and connecting lead wire. Variations in the internal angle of 10° (well within operator capability) resulted in a variation in force exerted on the skin of 8%. Independent measurements showed that concomitant changes in probe surface contact area were negligible. Thus the probe exerted constant pressure to within about 8%.

still conform to the charts. It therefore became necessary to determine the location of the points with more precision; this in turn necessitated a redefinition of the problem formulated above.

A boot-strap method for locating the points within the 1 cm^2 was adopted. Employing the rod measuring electrode, the location within the delimited area with the highest electrical conductance was found excluding any visible abrasions, contusions, pigmented moles, or superficial veins or arteries. This location was assumed to be the acupuncture point. Then, employing the wheel measuring electrode, a curve of conductance vs. position was generated by rolling proximally along an arbitrary line through the acupuncture point. For each acupuncture point, a curve resembling a typical absorption curve was generated. The experimental quantities h_E were then calculated as shown in Fig. 1(b).

Since the boot-strap method was necessary to locate acupuncture points, the absolute conductance values at the point could not validly be compared to those of the immediate area. Therefore, control points were chosen and measured. For every acupuncture point, a nearby anatomically similar location of 1 cm^2 was chosen and the point within it which exhibited the highest conductance was found. A curve of conductance vs. position was then generated in the same fashion as was done for the acupuncture points. These measurements yielded the control values h_C. Neither the subject nor the probe operator was informed of which area contained the acupuncture point. Statistical tests of significance were made between h_E and h_C on the theory that, if the h_E were greater, that would establish that the corresponding points were objectively different because they exhibited more pronounced electrical conductance maxima than did non-acupuncture points. This is precisely the condition necessary to justify the boot-strap procedure.

The procedure described above was performed on each subject at every acupuncture point listed in Fig. 1(a). It was then repeated ten times. A total of seven subjects, both male and female, were measured.

RESULTS

Table I gives the mean fractional increase in conductance at each acupuncture point (h_E) and at the corresponding control point (h_C) for all subjects. Fig. 4 shows the number of subjects for which h_E at the indicated acupuncture point differed significantly from h_C (2-tailed t-test, $p < 0.05$).

Fig. 4 shows that three out of eleven acupuncture points on the large intestine meridian and two out of six points on the pericardium meridian were found to exist on all seven subjects. A total of thirteen points out of seventeen were found on at least five subjects. Thus the results establish that most of the acupuncture points studied objectively exist on most of the subjects measured.

It is presently not possible to determine why all acupuncture points are not found on all subjects. Certainly further refinements in the measuring technique such as diminished contact area of the measuring probe will tend to enhance both the finding and measuring of acupuncture points. But beyond problems of technique, it is possible that not every classical acupuncture point exists on every subject at all times. Such a possibility would be consistent with the origin of the acupuncture system as the summation of countless individual observations made over many centuries. Lastly, and again in view of its origin, it is possible that some spurious acupuncture points have been grafted onto an otherwise valid system. Possible candidates for points in that group are Li-9 and P-5, each of which was found on only one subject.

In conclusion, it was found that most points on the pericar-

TABLE I
FRACTIONAL INCREASE IN CONDUCTANCE AT THE INDICATED ACUPUNCTURE POINT (h_C)

Point	h_E	h_C
Li-2	2.12 ± 0.23	1.15 ± 0.02
Li-3	1.40 ± 0.12	1.13 ± 0.00
Li-4	2.78 ± 0.96	1.16 ± 0.01
Li-5	1.61 ± 0.16	1.14 ± 0.02
Li-6	1.45 ± 0.18	1.12 ± 0.01
Li-7	1.25 ± 0.03	1.13 ± 0.00
Li-8	1.23 ± 0.02	1.13 ± 0.02
Li-9	1.16 ± 0.02	1.14 ± 0.02
Li-10	1.31 ± 0.06	1.12 ± 0.01
Li-11	1.30 ± 0.02	1.13 ± 0.01
Li-12	1.34 ± 0.05	1.15 ± 0.01
P-3	1.35 ± 0.08	1.13 ± 0.01
P-4	1.43 ± 0.13	1.13 ± 0.02
P-5	1.18 ± 0.03	1.14 ± 0.01
P-6	1.48 ± 0.18	1.12 ± 0.01
P-7	2.13 ± 0.25	1.14 ± 0.02
P-8	1.89 ± 0.21	1.13 ± 0.02

Note: Each value is the mean and standard error of the seven individual subject means for each point.

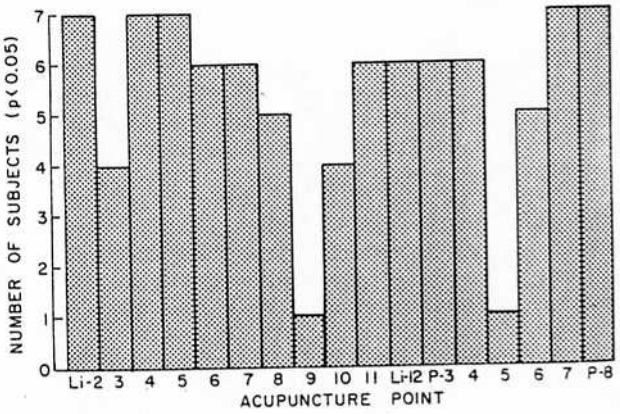

Fig. 4. Number of subjects (of a possible seven) for whom the indicated acupuncture point was a significant (t-tailed t-test, $p < 0.05$) local DC conductance maximum.

d large intestine meridians, as defined and described by dard charts, are points of local electrical conductance on most subjects. These points, therefore, have an e existence in most subjects.

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nformed consent was obtained from all of the volunteers in- uded in this study after the nature of the procedure had been xplained.