

BEFORE POLARIZATION CURRENT AND THE ACUPUNCTURE MERIDIANS

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ABSTRACT: Current-response waveforms resulting from the application of square-voltage pulses to the skin were recorded and analyzed by a new electrodermal instrumentation system. It was found that the before polarization (BP) current flows in the water-rich phase of the dermal connective tissue and that the level of this current is always higher in a Yin meridian than its corresponding Yang meridian partner. These findings suggest that the BP current level is a parameter reflecting meridian functioning and thus that the physical location of the meridians is in the dermal connective tissue.

INTRODUCTION

Although the meridians of acupuncture have been reported subjectively in considerable detail by acupuncturists and their patients for these past several thousands of years, objective investigation into their possible histological and anatomical basis is still in the early stages.¹⁻⁵ Recent electrodermal findings at our Institute, however, have led us to propose that the meridians do in fact have a physical reality and that this resides in the water-rich phase of the dermal and other connective tissues.⁶⁻⁸ These findings will now be presented.

INSTRUMENTATION AND THE PARAMETERS MONITORED

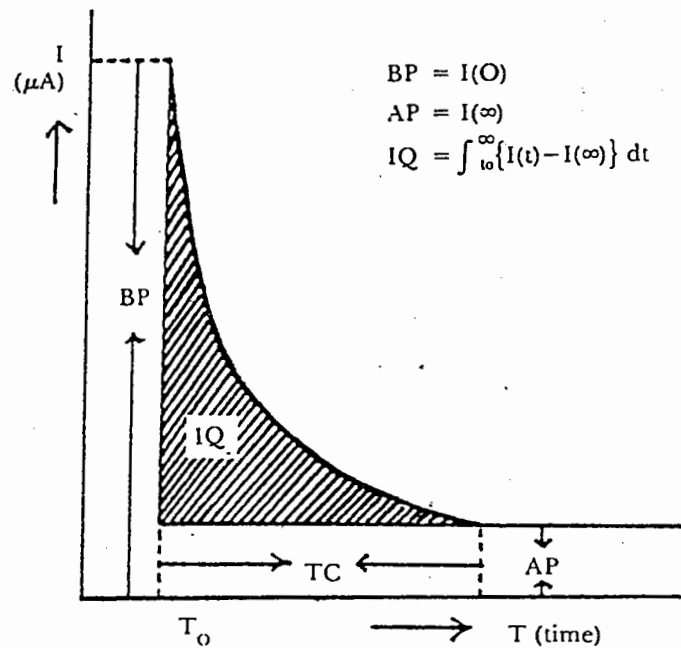
The microcomputer-based instrumentation system used in our investigations records and analyzes current waveforms produced by applying square-voltage pulses of 0.5V to 5.0V to the skin via surface or intracutaneous electrodes and is referred to by the acronym AMI (Apparatus for measuring the functioning of the Meridians and their corresponding Internal organs). Details of the instrumentation system can be found elsewhere.⁹⁻¹² Referring to Figure 1, it can be seen that four parameters are used to define the current-response waveform:

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FIGURE 1

Definition of Parameters



(i) *BP (Before Polarization or Peak Current)*—the peak current which flows immediately after the application of the external potential to the skin; it can be thought of as corresponding to a frequency nearing the infinite. Previous researchers in this field envisioned the current at infinite frequency as penetrating through all the cells and intercellular spaces, including those layers possessing dielectric membranes such as the stratum corneum and basal membranes of the epidermis (see Figure 2).¹³

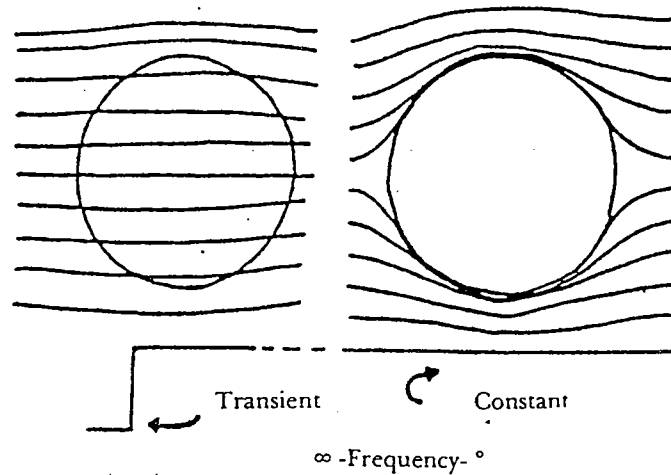
(ii) *AP (After Polarization Current)*—the steady-state current which flows after completion of all polarization (charging of capacitive elements); it can be thought of as corresponding to zero frequency (Figure 2). This level is normally reached within about 400 μ sec.

(iii) *IQ (Integrated Polarization Charge)*—the total electrical charge which is mobilized during the polarization process.

(iv) *TC (Time Constant)*—the initial time constant of the polarization process; it is a measure of the rate at which polarization proceeds.

FIGURE 2

Schematic of Instantaneous and Constant Direct Current
(By permission of the authors and publisher)¹³



*MAJOR FINDINGS RELATING TO THE FUNDAMENTAL
ELECTRICAL NATURE OF THE SKIN*

The Dermis Implicated as the Major Pathway of the BP Current within the Skin

In one experiment, nonpolarizing electrodes (with electrode paste) were attached to the dorsal aspect of each foot (L & R acupoints LV3) and the current responses to applied 3V square-voltage pulses were recorded at various stages of adhesive-tape stripping of the skin at those electrode sites (Figures 3 & 4). (It should be noted that these and other chart recordings read from right to left.)

Prior to stripping, the before polarization (BP) current level was 1322 μA (L -ve, R +ve) and the corresponding after polarization current (AP) level was 35.1 μA . After stripping each side 20 times the BP level was 1586 μA and the AP level 270 μA , and after 40 times stripping of each side the current waveform was almost square-like with a BP level of 1762 μA and an AP level of 1467 μA . At this time, blood began to appear on the surface of the skin, indicating that the dermal layer had been reached (in part at least) and stripping was discontinued. Current levels at each stage were found to be relatively independent of the polarity of the electrodes (i.e. whether L +ve, R -ve or L -ve, R +ve) and so only one set of values (L -ve, R +ve) is mentioned here.

FIGURE 3

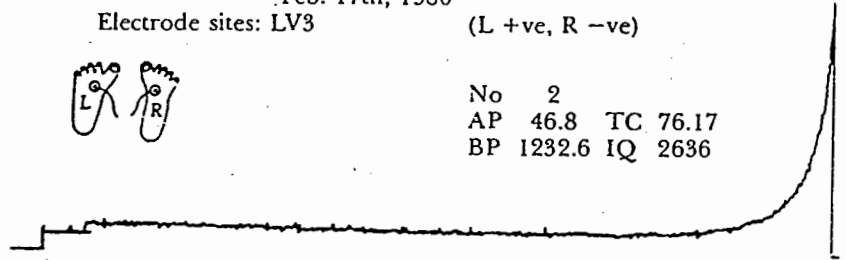
Stratum Corneum Removal Experiment
—before tape stripping

Subject: T.H.
V = 3 Volt; 2-msec
Feb. 17th, 1980

Electrode sites: LV3 (L +ve, R -ve)

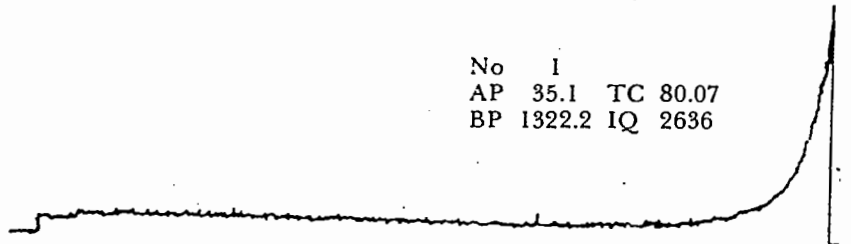


No 2
AP 46.8 TC 76.17
BP 1232.6 IQ 2636



(L -ve, R +ve)

No 1
AP 35.1 TC 80.07
BP 1322.2 IQ 2636



200 μsec
Time(t)

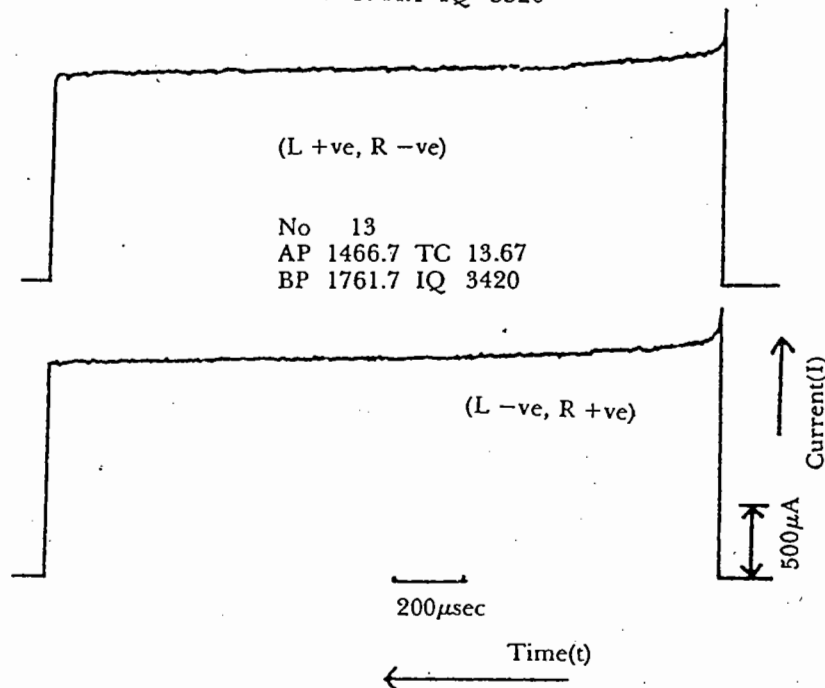
Thus, the difference in the peak or before polarization (BP) current level between the states of intact and almost totally-removed epidermis is 440μ ($1762-1322 \mu A$) which represents an increase of 33% over the original epidermis-intact state. Since this increase, which can be attributed to the removal of the epidermal resistance contribution from the total skin resistance, is only about 30%, it can be concluded that in the intact state the before polarization (BP) current flows mainly through the sub-epidermal layers, presumably the derm regardless of the existence of the epidermis.

FIGURE 4

Stratum Corneum Removal Experiment
—after stripping 40 times

No 14
AP 1431.6 TC 15.62
BP 1744.1 IQ 3320

No 13
AP 1466.7 TC 13.67
BP 1761.7 IQ 3420



*The Water-Rich Phase as the Probable Pathway
of the BP Current within the Dermis*

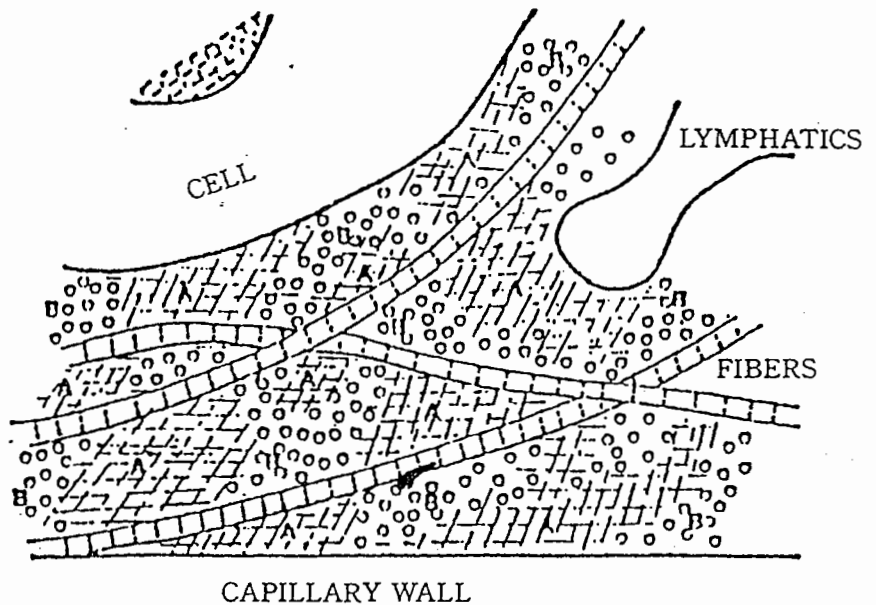
The dermis, which can be divided structurally into three layers—the stratum papillare, the stratum sub-papillare, and the stratum reticulare—contains fibrillar elements (esp. white collagenous fibers), ground substance (nonfibrillar intercellular material), and cellular elements (fibroblasts, mast cells, and others) as its main structural components. Of these, the fibrillar elements (insoluble proteins) amount to more than 90% of the bulk of the dermis with the extracellular, extrafibrillar ground substance filling in the space between the fibers and the cells. The ground substance itself is amorphous (formless) material comprising nonfibrillar colloidal matter, soluble proteins, electrolytes, and water. Because of this predominance of intercellular (interstitial) matter, the dermis is classified as a connective tissue.

Recent histological and physiological evidence suggests that the interstitial (extracellular) space is a highly organized and functional structure and that two separate phases may be distinguished within it.¹⁴ One is a colloid-rich, water-poor phase and the other is a water-rich, colloid-poor phase containing mobile, water-soluble components. This "two phase" organization of the interstitial space is illustrated in Figure 5.

FIGURE 5

A Schematic Drawing of the Hypothesized, Submicroscopic Organization of Interstitium of Connective Tissue

Letter A represents fixed, colloid-rich, water-poor phase; Letter B represents movable, colloid-poor, water-rich phase (By permission of the authors and publisher.¹⁴)



Now, because electric current tends to flow along the path(s) of least resistance and because this is expected to be through the electrolyte and water-rich phase of the interstitium rather than through the fibrillar and cellular elements, it is surmised that the peak or before polarization (BP) current will flow mainly through the water-rich phase of the dermal connective tissue.

Polarization Occurs at the Epidermal Membranes

Referring back to Figure 3, it can be seen that the initial peak current level (1322 μA) fell sharply to an almost constant level (35.1 μA) within about 50 μsec

of the application of the external potential. This rapid decrease of the initial current is due to the generation of a polarization potential within the skin opposite in direction to the externally-applied potential. When, however, most of the epidermis was removed (Figure 4), polarization hardly occurred at all. It is therefore apparent that polarization occurs in the epidermis, but in which layer(s)? In an attempt to answer this question the following experiments were undertaken.

Two insulated needle electrodes (size No.3, length 5mm, exposed metal tip 1mm) were inserted angularly 2cm apart into the palmar epidermis of a subject to a depth of 0.5mm. A 1.0V, 2-msec duration square-voltage pulse was then applied between the points and the current-response recorded (Figure 6A). The low BP value (78.1 μ A) of this recording suggests that the intrinsic resistance of the epidermis is high and, moreover, the occurrence of polarization suggests that there is a barrier membrane within the epidermis, presumably the stratum lucidum, that is responsible for this.

In the next set of experiments, current-response recordings were made with the needle electrodes inserted into two acupuncture points on the back (UB12 and UB11), first with one needle in the dermis and the other in the epidermis (Figure 6B), then with both needles in the dermis (Figure 6C), and finally with both needles in the subcutaneous tissue (Figure 6D). Since polarization was particularly apparent in the epidermis-dermis needle arrangement but not as evident in either the dermis-dermis or subcutaneous-subcutaneous needle arrangements, therefore, it can be concluded that when surface electrodes are used on the intact epidermis (Figure 3) the major barrier causing the rapid polarization resides at the boundary between the epidermis and the dermis, that is, at the epidermal basal membrane.

Generalized Picture of Polarization at the Epidermal Membranes

Figure 7 sums up in simple diagram form the main aspects of the overall polarization process. Namely, evidence suggests that there is a small polarization at the outer and inner surfaces of the stratum lucidum and a larger polarization at the outer and inner surfaces of the basal membrane.

Now since the drift velocity of ions available for accumulation on the outer and inner surfaces of the basal membrane is relatively low (e.g. the drift velocity of Na^+ in ground substance is less than 7.8×10^{-5} cm/sec), and since the polarization begins within 1–2 μ sec, it can be surmised that the initial polarization is not only ionic in nature. Rather, the free electrons of atoms and molecules which are components of the cells, fibrillar tissues and body fluids of the skin propagate the applied energy almost instantaneously between the electrodes to charge the condenser formed by the epidermal basal membrane and the tissues on its inner and outer surfaces. Therefore it seems probable to think of the polarization as a combined phenomenon of charging of the above-mentioned condenser and ionic accumulation.

FIGURE 6

Current-Response Curves at Various Skin Depths

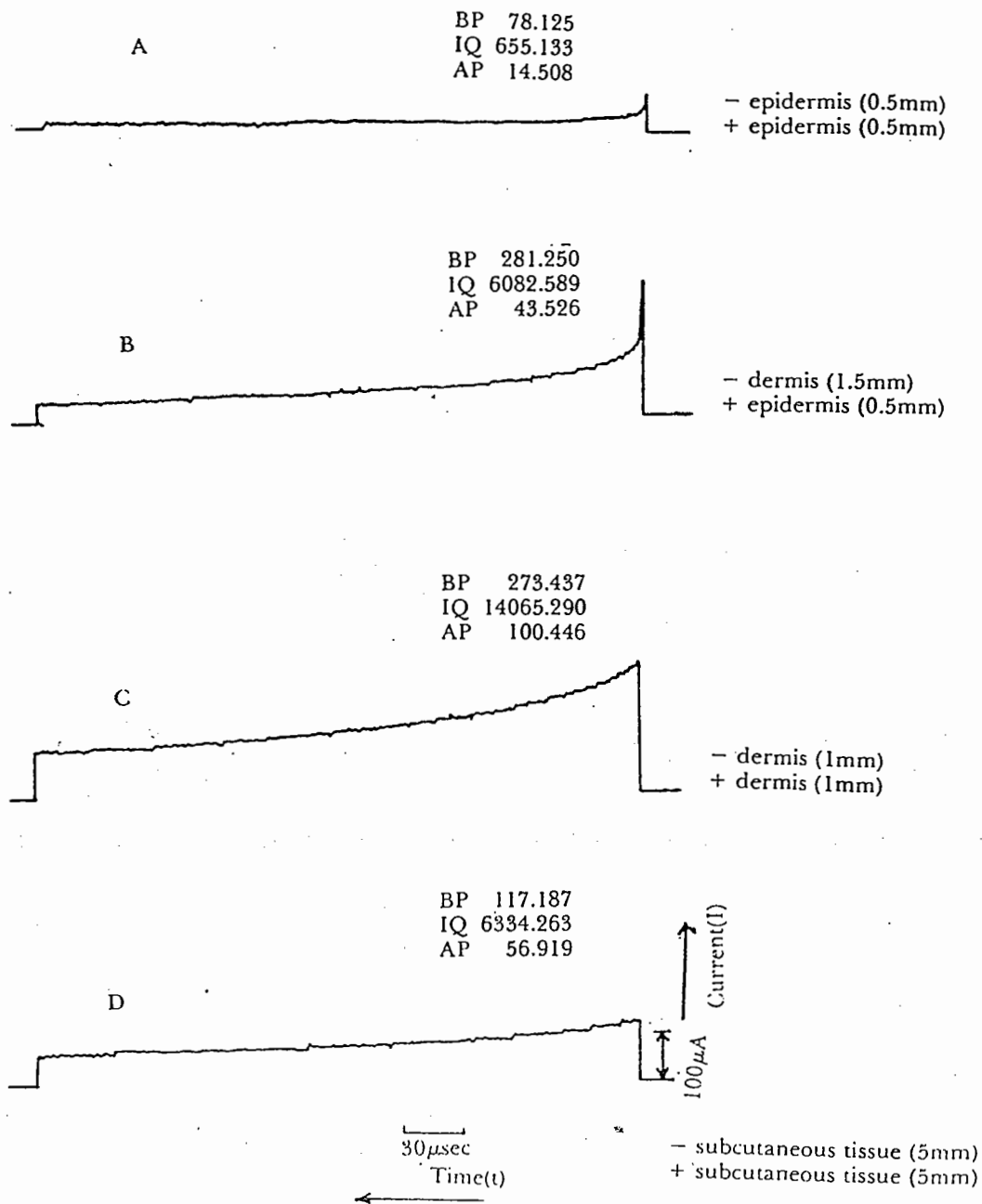
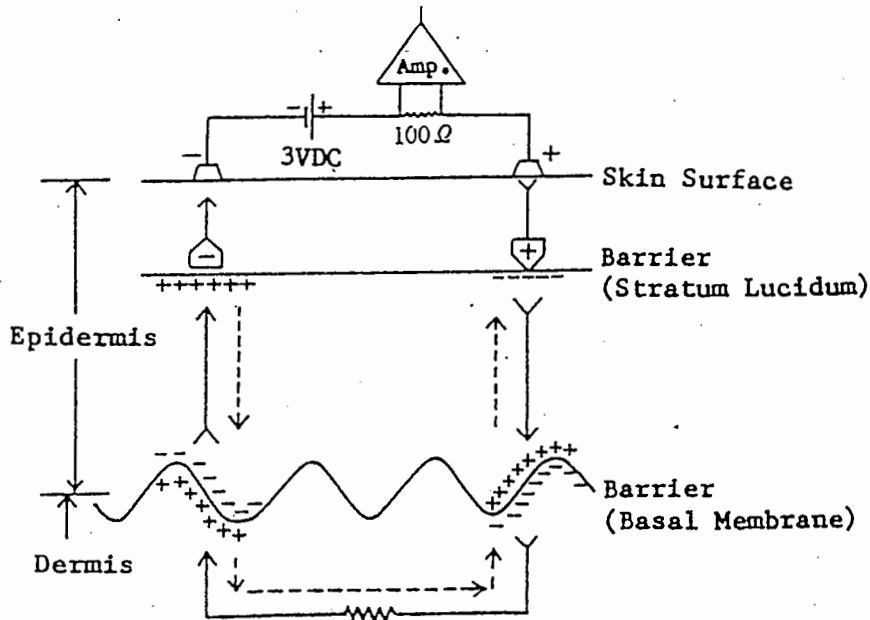


FIGURE 7

Generalized Diagram of Electrical Energy Accumulation in the Epidermis and Dermis



Thus in this model, the BP current is visualized as penetrating the two epidermal barriers and flowing in the dermis, while the AP current is considered as being restricted primarily to the epidermis by virtue of the large polarization buildup at the epidermal basal membrane. It is interesting to note here that clinical studies have indicated that the AP value tends to reflect autonomic nervous activity of the sweat glands; this ties in well with the fact that the epidermis and the nervous system are known to have the same embryological origin (the ectoderm).

ACUPUNCTURE MERIDIANS AND THE AMI TECHNIQUE

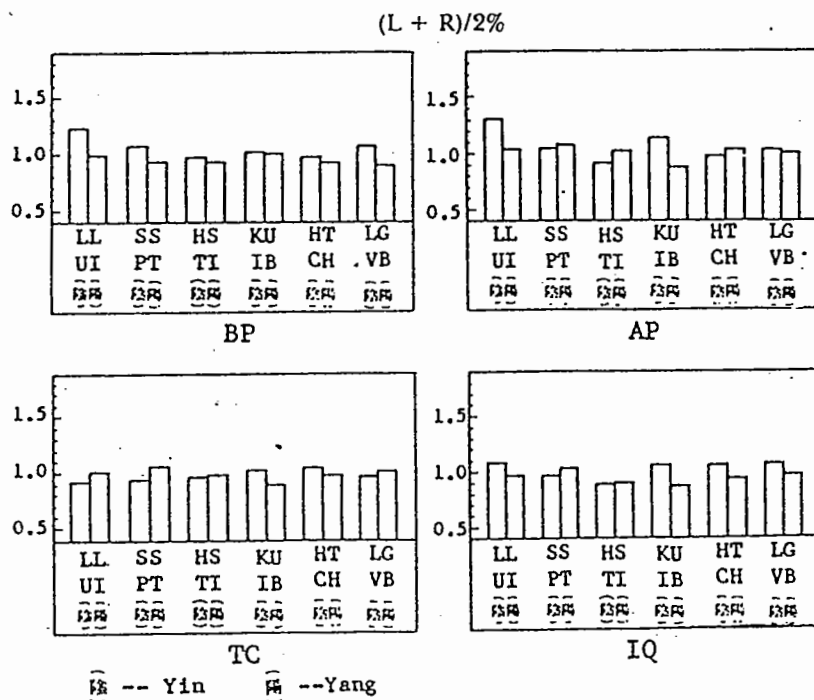
BP Appears to be a Parameter Reflecting Meridian Functioning

In one set of clinical experiments, for each of 29 healthy subjects, 3.0 Volt, 2-msec duration square-voltage pulses were sequentially applied between active electrodes attached to the terminal points of each of the meridians and an in-

different-electrode pair located on the wrists, and the resultant current-response waveforms recorded by the AMI.

FIGURE 8

Histograms of the Averaged Results from 29 Healthy Subjects



From the pooled normalized data of the 29 subjects, the averages of each of the four parameters (BP, AP, IQ and TC) for each of the meridians (right and left sides combined) were calculated and the data arranged in the form of histograms pairing the Yin-Yang meridian couples (Figure 8).

Before considering these results in detail, it is first necessary to briefly familiarize the reader with the traditional Yin-Yang meridian concept of acupuncture. According to traditional theory, it is thought that between the Yin and corresponding Yang meridian in a particular Yin-Yang couple (refer to Figure 9), there exists a strong "competitive" relationship. This "competition" is such that if one of these meridians begins to predominate, the other meridian acts to reduce this predominance, thus tending to restore the original balance. If however, this predominance becomes excessive, balance becomes unattainable and disease ensues.

FIGURE 9

The 6 Yin-Yang Meridian Couples of Traditional Acupuncture Theory

<u>YIN MERIDIAN</u>		<u>YANG MERIDIAN</u>
(1) Lung (LU)	—	Large Intestine (LI)
(2) Spleen (SP)	—	Stomach (ST)
(3) Heart (HT)	—	Small Intestine (SI)
(4) Kidney (KI)	—	Urinary Bladder (UB)
(5) Heart Constrictor (HC)	—	Triple Heater (TH)
(6) Liver (LV)	—	Gall Bladder (GB)

Now, examination of the histograms in the light of this traditional Yin-Yang meridian concept reveals the interesting finding that for the BP parameter the value of a Yin meridian is in each case greater than its corresponding Yang partner. On the other hand, no such clear relationship exists for any of the three other parameters (AP, IQ, or TC).

Repetition of this same analysis for a further 100 subjects revealed the same findings. These results can therefore be interpreted as suggesting that BP is a parameter reflecting meridian functioning.

CONCLUSION

Evidence suggests that the peak or before polarization (BP) current flows primarily in the water-rich phase of the dermal connective tissue and is, at the same time, a parameter reflecting meridian functioning. We therefore propose that the water rich-phase of the dermal connective tissue forms the physical basis of the acupuncture meridian. In this hypothesis, the water-rich phase in the connective tissue of the internal organs can be considered as meridians that are continuous with these superficial (dermis-based) meridians.

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