

The Meridian System And The Mechanism Of Acupuncture

By Charles Shang

Boston University School of Medicine

Box 275

80 E. Concord Street

Boston, MA 02118

ABSTRACT:

Understanding acupuncture points and the meridian system in terms of modern science is important to facilitate the study and application of related techniques. The model which relates organizing centers in morphogenesis and growth control to acupuncture points can qualitatively explain most of the established facts about the meridian system and acupuncture points, such as their distribution, high electrical conductance, response to non-specific stimuli and polarity of electrical stimulation. As a network of singularities in signal transduction, the meridian system plays an important role in physiological and growth regulation. The change of electrical activity is part of signal transduction and can precede anatomical change during morphogenesis as well as pathogenesis. Small perturbations around singular points can have decisive effects on a system. Therefore, manipulation of acupuncture points, the singular points in the signal transduction system, can be an efficient way of diagnosis and therapy, particularly at the early signal transduction stage prior to the stage of morphologic change. The model can also account for some observations in developmental biology and can be tested by available techniques. Converging discoveries in signal transduction and acupuncture are discussed.

1. Morphogenesis and the Meridian System

A modern scientific explanation of acupuncture points and the meridian is important to further the study and application of related techniques. According to the proposed Standard International Acupuncture Nomenclature, the meridian system in acupuncture consists of more than 400 acupuncture points and 20 meridians connecting some of the points. Most acupuncture points and meridian points are the high electrical conductance points on the body surface and vice versa. A model has been proposed that acupuncture points are organizing centers in morphogenesis. At the macroscopic level, they are singular points (e.g. sinks, sources) in the morphogen gradient, phase gradient and electromagnetic field. Meridians are separatrices.

The patterns of magnetic fields on the human scalp mapped by SQUID (Superconducting Quantum Interference Device) shows that the Governor Vessel is a major pathway of magnetic flux on the scalp, and also a separatrix which divides the scalp into two domains of different flow directions. Morphologically, the Governor Vessel is also a separatrix that divides the body surface into two symmetrical parts. The acupuncture point GV20 is a singular point - a major sink at the surface magnetic field. This pattern is consistent with the pattern of the meridian system, but different from the distribution of any major nerve, lymphatic or blood vessel on the scalp. Intrinsic electric fields and currents are important factors in growth control, cell migration and morphogenesis:

A variety of cells including neurons, myoblasts and fibroblasts are sensitive to electric fields of physiological strength. Somite fibroblasts translocate to the negative pole in a voltage gradient as small as 7 mV/mm. Asymmetrical Ca^{2+} influx is crucial in the galvanotaxis which can be blocked or even reversed by various Ca^{2+} channel blockers and ionophores. In most cases, there is enhanced cell growth toward cathode and reduced cell growth toward anode in small continuous, pulsed or focal electric fields. Some fast growing tissues, particularly tumors, are electrically negative in polarity. If a current from the positive pole is applied over a certain tumor, its growth can show significant retardation or even regression. This is consistent with the fact that the fluorescent dye rhodamine, which has a delocalized positive charge, binds preferentially to some cancer cells and inhibits the cell growth.

Flatworm *Dugesia tigrina* has an intrinsic dipole electric field with anterior negative and posterior positive. During regeneration, its anterior-posterior polarity can be reversed by an external electric field with an opposite polarity. The dorsal-ventral polarity of chick epiblast can also be partially reversed by an electric field of physiological strength. Imposed electric fields can cause polarization of mouse blastomeres.

Change of electrical activity correlates with signal transduction, and can precede morphologic change. For example, in axolotls and frogs, outward current can be detected at the site of future limb buds several days before the first cell growth. This indicates that the electrical conductance of the epithelium at the future limb bud, an organizing center, becomes higher before limb bud formation.

In development, the fate of a larger region is frequently controlled by a small group of cells. This small area is termed as an organizing center. Organizing centers are likely to be the high electrical conductance points on body surface: Epithelia appear to display their most active growth and morphogenesis in regions of high conductance. This is supported by the finding of a high density of gap junctions at the sites of organizing centers.

Epithelia usually maintain a 30-100 mV voltage difference across themselves with inside positive and outside negative. Points of local high conductance on skin will also be extreme points of current density - sinks or sources of surface current. These singular points are important in growth control and are likely to be organizing centers.

The importance of the electric field generated by epithelium in growth has been indicated in limb regeneration. After limb amputation, salamanders can regenerate their limbs - regenerators, while frogs can not - non-regenerators. The regenerators and non-regenerators have different electric field changes after amputation.

By simulating the electric field of regenerators on the limb stumps of non-regenerators, partial regeneration can be induced. Simulating the electric field of non-regenerators on the limb stumps of regenerators can inhibit their regeneration. The optimal current density used in the simulation is within the range of physiological current density. Development involves bifurcation of the singular points. The first bifurcation in vertebrate development leads to two singular points: the animal pole and the vegetal pole. In immature oocytes of both frogs and fish, a transcellular current enters the animal pole and exits the vegetal pole. This current is present prior to the development of the pigment asymmetry. Several calcium channel blockers can rapidly reduce this current and cause maturation. This result supports the notion that the change of the

electric field usually precedes the change in morphology and correlates with signal transduction.

Some singular points are connected by separatrices which serve as major pathways of intrinsic electric currents and divide the body into domains of different electric current directions. Separatrices can be folds in extended sheets, boundaries between different structures, or abrupt changes in the slope of a gradient.

The distribution of organizing centers, acupuncture points and singular points in electric fields are closely related to the morphology of the organism. For example, the auricle, which has no major nerves or blood vessels but has the most complex surface morphology, also has the highest density of acupuncture points. According to the "clock face" model, many organizing centers are at the extreme points of curvature on the body surface, i.e. the locally most convex points (e.g. apical ectodermal ridge, head of hydra and other growth tips) or concave points (e.g. zone of polarizing activity). The same is true for acupuncture points.

Most extreme points of the body surface curvature are acupuncture points, e.g. convex points: EX-UE11 Shixuan, EX-LE12 Qiduan, ST17 Ruzhong, ST42 Chongyang, ST45 Lidui, SP1 Yinbai, SP10 Xuihai, GV25 Suliao, EX-HN3 yintang ... concave points: LI4 Hegu, CV17 danzhong, KI1 Yongquan, SI19 Tinggong, TE21 Ermen, GB20 Fengchi, GB30 Huantiao, BL40 Weizhong, HT1 Jiquan, SI18 Quanliao, BL1 Jingming, CV8 Shenque ..

Those acupuncture points which are not the extreme points of surface curvature may be vestigial organizing centers or more related to the growth control of internal structures.

2. Mechanism of Meridian System Based Diagnosis and Therapy

As mentioned above, the conductance of organizing centers varies with morphogenesis. Similarly, the conductance of acupuncture points also varies and correlates with physical, emotional changes and pathogenesis. The fact that the change in electric field precedes morphologic change, and manipulation of the electric field can affect the change may shed light on medical diagnosis and treatment of many diseases. According to the model, the network of organizing centers retain their growth control function after morphogenesis, and communicate with each other (perhaps via gap junctions, nerves, etc.) to maintain proper forms and functions. Therefore, an abnormality inside the network may be detected by measuring the electrical parameters of some points on its surface. Malfunctions of some organs can be preceded by change of electric parameters from normal range and treated by manipulation of the interconnected singular points.

Singularity is a type of discontinuity, often indicating abrupt transitions from one state to another. Small perturbations around singular points can have decisive effects on a system. As James Clerk Maxwell observed: Every existence above certain rank has its singular points ... At these points, influence whose physical magnitude is too small to be taken account of by a finite being, may produce results of the greatest importance. As a technique of perturbation of singular points, acupuncture can be effective in treating various diseases such as common cold, chronic obstructive pulmonary disease, asthma, myopia, diarrhea, constipation, gastric and duodenal ulcers, diabetes, emesis, enuresis, postmenopausal syndrome, obesity, stroke, hypertension and cardiac arrest. An "annealing" mechanism may play a role in acupuncture and related techniques: Small perturbations at singular points elicit a "shock" to the system - activates and

shakes the biological system out of its abnormal and unstable state. After activation, the system has a better chance to settle at a normal, more stable state. This may explain why there have been few negative side effects of these techniques when properly administered, and the therapeutic effect can be achieved by a variety of stimuli including electricity, needling, temperature variation, laser, and pressure. Similarly, organizing centers can also be activated by nonspecific stimuli.

A principle in electroacupuncture therapy is that positive pulse stimulation of a point sedates its corresponding function while negative pulse stimulation tonifies the function. This is analogous to the fact that cell growth is enhanced toward cathode and reduced toward anode in a pulsed electric field, in consistence with the model that the mechanism underlying acupuncture is similar to that of growth control.

3. Calcium Mediated Signal Transduction in Meridian System and Acupuncture?

Calcium ion concentration in meridians and acupuncture points in a rabbit was significantly higher than that in non-meridian and non-acupuncture points. When calcium in the Quze (PC3) acupuncture point is chelated, the curative effect of arrhythmia by puncturing Neiguan (PC6) is blocked, suggesting that calcium is an important factor in acupuncture and probably involved in the activities of meridians. In both excitable cells and nonexcitable cells of almost all of the physiological systems, calcium is a second messenger, an intercellular messenger and morphogen that is involved in galvanotaxis, morphogenesis and various physiological functions. Its electrochemical gradient contributes to the electric potential across cell membranes. It can also affect membrane potential by mediating modification of the ion channels and pumps. The same calcium waves can be elicited by electrical, mechanical or laser stimulation as well as chemical exposure, and propagate through gap junctions. Similarly, the therapeutic effects of acupuncture can be achieved by a variety of stimuli including laser, mechanical and electrical stimulation.

4. Beyond Nerves and Blood Vessels

Research on acupuncture, particularly the endorphin effect of acupuncture analgesia and its blockage by naloxone, clearly shows that some effect of acupuncture is mediated through the nervous system. However, many meridians do not correlate with major nerves or blood vessels. The distribution of the Governor Vessel on the scalp and the auricular acupuncture points has not been satisfactorily accounted for by any model based on the nervous system and/or the circulatory system. The model reviewed above readily explains these facts, while accommodating the findings of acupuncture effects on the nervous system and circulatory system.

The meridian system is a distinct signal transduction system which can be measured by instrument, such as SQUID. It overlaps and interacts with other systems, but is not simply a part of the nervous system or circulatory system. Many "nonexcitable" cells have shown electrochemical oscillation, coupling, long range intercellular communication and can participate in the meridian signal transduction.

The model has explained many facts in acupuncture as well as developmental biology. It can be further tested by mapping the electric fields in vertebrate development with available techniques such as SQUID or vibrating probe. The model predicts that organizing centers in vertebrate development such as the dorsal lip of the blastopore, zone of polarizing activity and apical ectodermal ridge are major sinks or sources of

surface current. These points bifurcate and give rise to some of the acupuncture points in adult forms.

Current SQUID technology is adequate in detecting physiological electrical currents in embryo development generated by epithelium. Available data showed that SQUID is sensitive enough to detect the individual difference in current pattern at GV20. With the development of high T_c superconductors, the use of superconducting magnetic shields, and multi-channel SQUID in the study of the meridian system will yield further insights and circumvent the complications of the skin impedance measurements.

Author's Note:

I thank Drs. Magnus Lou, San Wan, Andrew Marino, Frederick Kao, John Kao, Sarah Mei, K.S.Tsai, S.J.Chen, Richard Nuccitelli, Lionel Jaffe, Kenneth Klivington and others for their invaluable help and support.

References

1. World Health Organization. A proposed standard international acupuncture nomenclature: Report of a WHO Scientific Group. World Health Organization, Geneva, 1991.
2. Saku K, Mukaino Y, Ying H, Arakawa K. Characteristics of reactive electropermeable points on the auricles of coronary heart disease patients. *Clin Cardiol* 1993;16:415-9.
3. Cui H-M. Meridian system - specialized embryonic epithelial conduction system. *Shanghai J Acupunct* 1988; 3: 44-45.
4. Jobst K, Chen JH, McPherson K, Arrowsmith J, Brown V, Efthimiou J, Fletcher HJ, Maciocia G, Mole P, Shifrin K. et al. Controlled trial of acupuncture for disabling breathlessness. *Lancet* 1986;2:1416-9.
5. Dundee JW, Yang J, McMillan C. Non-invasive stimulation of the P6 (Neiguan) antiemetic acupuncture point in cancer chemotherapy. *J R Soc Med* 1991;84:210-2.
6. Holden C. Acupuncture: stuck on the fringe. *Science* 1994;264: 770.
7. Carneiro NM, Li SM. Acupuncture technique. *Lancet* 1995;345: 1577.
8. Pomeranz B, Stux G, editors. *Scientific Basis of Acupuncture*. Berlin: Springer-Verlag, 1989.
9. Shang C. Singular Point, organizing center and acupuncture point. *Am J Chin Med* 1989;17:119-127.
10. Shang C. Bioelectrochemical oscillations in signal transduction and acupuncture - an emerging paradigm. *Am J Chin Med* 1993;21: 91-101.

Copyright 1996, All Rights Reserved, Charles Shang,
Email: cshang@acs.bu.edu

Reproduced courtesy of 21st, The VXM Network, <http://www.vxm.com>