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Physiological Effects of Stimulation at Acupuncture Loci: A Review

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Recent studies reporting significant physiological effects associated with electrical and manual stimulation at several traditional Chinese acupuncture loci are reviewed. Other reports on the anatomy and electrical properties (DC resistance and potential, AC impedance) of these sites indicate that many are significant local skin resistance minima and may also be points of locally more positive DC potential. Further investigation of the basic properties of the acupuncture system and its mode of action is fully warranted by these preliminary findings.

INTRODUCTION

Since its re-introduction to the West in 1972, many evaluations and reports on acupuncture therapy have appeared [1–10]. The practice of acupuncture is not, however, the novelty it now seems. It was first introduced to Western medical practice as early as the seventeenth century [11], and remained in at least occasional use throughout the nineteenth [12–15].

At first, the idea that the mere subcutaneous insertion and manipulation of a fine needle can produce real physiological effects is outrageous. On second thought, it is no more unrealistic than the present use of dorsal column stimulators for the relief of chronic pain. The best argument for examining this concept more closely is that it does work. Many explanations for the reputed efficacy of acupuncture treatment have been put forward. Most postulate a mode of action in some way related to the nervous system [16–22], some proposing various modified gate control theories [23–28]. Other hypotheses call upon the systemic effects of histamine release at the needle insertion site [29], through bioholographic information processing [30] to hypnosis [31–34], although there are reported differences between the effects of hypnosis and acupuncture analgesia [35]. It has been suggested that acupuncture may work through a combination of several factors, including its effects on the peripheral nervous system and such placebo effects as are involved in all treatment modalities [36,37]. The best results are obtained when the patient experiences a feeling of "warmth" or "heaviness" at the needle site. Thus the practice of acupuncture therapy requires the active cooperation of the patient to ensure optimal placement of the needles. This leads to obvious difficulties in the design of a truly double-blind study, although these might be alleviated in part by the use of electroacupuncture rather than traditional manual stimulation [38,39].

It would seem, however, that the question of the physical reality of the acupuncture system and its mode of action should be examined before attempting an evaluation of its possible clinical applications. While many of the early reports were primarily anecdotal in nature, there is a growing literature concerning the physiological effects of stimulation at various acupuncture loci, both in laboratory and clinical situations. We propose, therefore, to review the basic non-clinical evidence for the existence of the acupuncture system.

ANATOMY

While Bull states that the acupuncture network has no relationship to the anatomy of the peripheral nervous system [40], Dornette [41], Fleck [42] and Matsumoto [43] have noted that many acupuncture loci appear to correspond to concentrations of sensory receptors. Gunn et al. suggested that a revised system of nomenclature for the loci based on their relationship to known neural structures might prove useful [44]. Matsumoto and Lyu have pointed out that some acupuncture loci are in sites utilized for local and regional nerve blocks [45].

Bossy et al., in superficial dissection of 201 acupuncture loci, found that 29% were located directly over a cerebrospinal nerve and an additional 37% over a vascular or nervous pedicle [46]. In an experimental study, Liu et al. found that many acupuncture loci are closely related to motor points [47]. Bong Han claimed to have discovered previously unknown anatomical structures delineating the classical meridians and acupuncture loci [48]. These findings are generally considered to be of questionable validity. Kellner, in a painstaking histological study of a large number of sites, did find some differences in the distribution of receptors and effectors between skin samples from acupuncture and non-acupuncture areas. He was unable, however, to substantiate Bong Han's results [49]. Rabischong et al. reported that the epidermis is thinner and the dermal collagen fibers modified at acupuncture sites [50].

Nothing can yet be said with any degree of certainty about the topological relationship of acupuncture loci to the peripheral nervous system. The histological studies have relied on extremely subtle distinctions in many variables between experimental and control samples. Such studies cannot be meaningful if, as at present, they are undertaken without any prior indication of which of the several factors present are significant.

PHYSIOLOGICAL EFFECTS

Chan and Fung reported total suppression of the cutaneous polysynaptic reflex in 20 precollicular decerebrate cats for 100–200 msec following 100 Hz electrical stimulation (biphasic sine, sawtooth, or triangular pulses of 20 msec duration) at point St-36 (lower leg), with subtotal inhibition persisting for over 800 msec. Control stimulation at points as little as 0.5 mm away from this acupuncture locus had negligible effects and intramuscular anesthetization in the vicinity of the locus diminished the effect [51]. Rohner and Planche found that the magnitude of evoked potentials in exposed cat sciatic nerve decreased significantly after about 15 minutes of electrical stimulation at several acupuncture loci (including St-36), disappearing completely after 25–30 minutes. Stimulation of the same intensity at non-acupuncture loci had no effect. However, the effect could be attained at placebo sites with increased stimulus intensity [52]. Shen et al. examined viscero-somatic reflex discharges evoked by electrical stimulation of the splanchic nerve in adult cats. These were suppressed by electroacupuncture (1–2 V, 0.1 msec pulses at a frequency of 100 Hz) at several hind limb loci. The inhibitory effect of acupuncture was diminished by spinal transsection at the cervical or upper thoracic levels; decerebration had no effect [53]. Linzer and Van Atta demonstrated that thalamic neurons which respond differentially to painful stimuli are affected by electroacupuncture (80–100 Hz square pulses with a duration of 0.1 msec) [54,55].

G.T.C. Lee studied the effects of electrical stimulation (unidirectional pulses of 2 msec duration and a frequency of 2 Hz) at locus St-36 in rats. He reported significant decreases in RBC velocities and carotid arterial pressure during treatment, with the opposite occurring during control stimulation [56]. M.O. Lee et al. investigated the

cardiovascular effects of 50 Hz electrical stimulation at locus St-36 in dogs. They found significant decreases in cardiac output and stroke volume coupled with increased peripheral resistance during acupuncture treatment [57,58]. Chu and Affronti found that electroacupuncture affected immune responses in rats and guinea pigs [59].

During a pilot study, Bresler observed changes in the electroencephalogram, electrocardiogram, electrooculogram, galvanic skin response, galvanic skin potential, respiration rate, and body temperature following stimulation at several traditional acupuncture loci (including St-36, St-44 and Li-4) in human subjects. Specifically, changes in the heart rate were associated with stimulation at locus St-36 [60]. Aso et al. observed changes in plasma levels of LH, FSH, progesterone and estradiol after electroacupuncture (10 V, 1–3 Hz) in female subjects [61].

Doenicke et al. compared values of serum albumin, triglycerides, cholinesterase, free fatty acids, hematocrit and blood sugar on 8 volunteers before and after acupuncture treatment (15 minutes manual stimulation followed by 15 minutes of low frequency electrical stimulation). They reported that free fatty acid levels increased while albumin, hematocrit and serum cholinesterase levels decreased after stimulation at several loci. The other parameters did not change significantly [62].

Sjölund and Eriksson found that intravenous administration of naloxone hydrochloride was followed by a return of pain sensation in 3 of 5 subjects in whom analgesia had previously been achieved by means of electrical stimulation at various acupuncture loci. Saline injection (compared to naloxone in a double-blind protocol) had no effect. They concluded that the analgesic effect of acupuncture may be mediated by the release of endogenous morphine-like substances [63].

Ikezono et al. studied evoked responses from the brain, spinal cord and muscle of 8 human subjects following manual stimulation at locus St-36. While there was considerable variability among subjects, the amplitude of the early component of the scalp evoked response decreased 15–20 minutes after the onset of stimulation. Also, the amplitude of the H wave and the ratio of the H to the M waves of the evoked electromyogram decreased. There were no changes in the evoked electrospinogram [64]. Sovak and Engel compared the effects of acupuncture (electrical stimulation at frequencies of 5, 45, and 110 Hz for 25 minutes) and hypnosis on somato-sensory evoked potentials in volunteer subjects. They reported that acupuncture and hypnosis had similar effects. The location of the needles, whether placed at supposed acupuncture loci or not, was not an important factor [65]. Chen and Hung also found that acupuncture had no significant effect on evoked cortical potentials due to electrical stimulation of the median nerve. They tested both manual and electrical (4–15 V, 2 Hz or 20 Hz) stimulation at acupuncture locus Li-4 on both hands of 16 subjects [66]. On the other hand, Pauser et al. reported that thalamic evoked potentials in 17 subjects were significantly depressed after 20 minutes of electrical stimulation at several acupuncture sites [67].

DC POTENTIAL MEASUREMENT

To date, very little work has been reported pertaining to DC potential measurements at acupuncture loci. This is an intrinsically difficult procedure, as great care must be taken to eliminate the perturbing effects of electrode bias potentials. Silver-silver chloride elctrodes are conceded to be the most reliable for skin potential recording, but require considerable care in use and storage to ensure reliable data [68, 69].

Brown et al. reported that acupuncture loci can be found by means of their DC

potential levels. Many of the loci they studied were positive with respect to the surrounding skin [70]. However, they used an Ag-AgCl reference electrode together with a metallic silver probe connected to an amplifier with a rather low input resistance (1 megohm), so the possibility of electrode bias and amplifier loading effects cannot be definitively excluded.

Fleck and Spring recorded the DC potentials from coaxial microelectrodes inserted at acupuncture loci. High-frequency potential variations, perhaps due to distortion of the surrounding neural structures, were recorded only during manipulation of the electrodes [71].

Becker et al. studied DC potentials at acupuncture loci using standard methodology, and found that some sites exhibit a significantly more positive potential than their surroundings [18].

Even though the reported results are suggestive of some differences in surface DC potential at various acupuncture loci [18,70], more data would be needed before any definitive conclusion can be reached.

RESISTANCE AND IMPEDANCE

There appears to be general agreement among practitioners that the acupuncture sites are skin resistance minima [34,73], although some investigators claim that they are not, after all, absolute minima [72].

In any measurement of skin resistance with hand-held electrodes, there is a possibility that contact pressure variations might influence the results [72,73]. In addition, the voltage output of many commercially available acupuncture locus detectors is high enough to produce long-lasting physiological effects which can affect any subsequent measurements [74].

Using electrodes designed to minimize contact pressure variations, Reichmanis et al. demonstrated that many traditional acupuncture loci are significant local resistance minima [73,75]. They also found differences in the AC impedance between acupuncture and control sites [76].

SUMMARY

Many of the traditional acupuncture loci are indeed local skin resistance minima [73–77], and may also be points of locally more positive DC potential [18,70,74].

There are a number of reports of definite systemic physiological (including neurological) effects of stimulation at acupuncture loci [51,52,56–58,60,64].

Further investigation of the basic electrical properties of the acupuncture system, together with a study of the physiological effects arising from acupuncture therapy, appears to be fully warranted by the preliminary findings. The difficulties inherent in histological analysis of tissue samples from acupuncture loci preclude this approach to the question of the physical reality of the system for the present. In our opinion, clinical trials of acupuncture therapy, while valuable, show little promise of elucidating its mode of action. Continued basic studies may establish the physiological basis of the acupuncture system, which would substantially enhance the effectiveness of future clinical investigation by placing it on a firmer theoretical foundation than is presently the case.

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REFERENCES

1. Bonica, J.J. Therapeutic acupuncture in the People's Republic of China. JAMA 228: 1544–1551, 1974.
2. Bonica, J.J. Acupuncture anesthesia in the People's Republic of China. JAMA 229: 1317–1325, 1974.
3. Bresler, D.E., Cohen, J.S., Kroening, R., Levin, N., Sadoff, A. The potential of acupuncture for the behavioral sciences. Am Psychol 30: 411–414, 1975.
4. Chapman, C.R. Psychophysical evaluation of acupunctural analgesia: some issues and considerations. Anesthesiology 43: 501–506, 1975.
5. Chen, J.Y.P. Acupuncture. In J.R. Quinn (Ed.), Medicine and Public Health in the People's Republic of China. DHEW Publication No. (NIH) 72–67, 1972, pp 65–90.
6. Mann, F. Acupuncture: the Ancient Chinese Art of Healing. New York, Vintage Books, 1972.
7. Rogers, P.A.M., White, S.S., Ottoway, C.W. Stimulation of the acupuncture points in relation to analgesia and therapy of clinical disorders in animals. Vet Ann, in press (1977).
8. Rogers, P.A.M., Ottoway, C.W. Success claimed for acupuncture in domestic animals, a veterinary news item. Irish Vet J 28: 182–191, 1974.
9. Tan, L.T., Tan, M.Y.C., Veith, I. Acupuncture Therapy: Current Chinese Practice. Philadelphia, Temple University Press, 1973.
10. Veith, I. Acupuncture: ancient enigma to East and West. Am J Psychiatry 129: 333–336, 1972.
11. Carrubba, R. Bowers, J.Z. The Western world's first detailed treatise on acupuncture: Willem Ten Rhijne's De Acupunctura. J Hist Med 29: 271–298, 1974.
12. Cassedy, J.H. Early uses of acupuncture in the United States, with an addendum (1826) by Franklin Bache, M.D. Bull NY Acad Med 50: 892–906, 1974.
13. Haller, J.S. Acupuncture in nineteenth century Western Medicine. NYSJ Med 73: 1213–1221, 1973.
14. Quen, J.M. Acupuncture and Western medicine. Bull Hist Med 49: 196–205, 1975.
15. Rosen, G. (D.M. Schullian, Ed.). Lorenz Heister on acupuncture: an eighteenth century view. J Hist Med 30: 386–388, 1975.
16. Becker, R.O. The significance of bioelectric potentials. Bioelectrochem & Bioenergetics 1: 187–199, 1974.
17. Becker, R.O. The basic biological data transmission and control system influenced by electrical forces. Ann NY Acad Med 238: 236–241, 1974.
18. Becker, R.O., Reichmanis, M., Marino, A.A., Spadaro, J.A. Electrophysiological correlates of acupuncture points and meridians. Psychoenergetic Systems 1: 105–112, 1976.
19. Li, D.C. Neurological basis of pain and its possible relationship to acupuncture analgesia. Am J Chin Med 1: 61–72, 1973.
20. Tien, H.C. Neurogenic interference theory of acupuncture anesthesia. Am J Chin Med 1: 105–122, 1973.
21. Toyama, P.M., Nishiziwa, M. The physiological basis of acupuncture therapy. J Natl Med Assoc 64: 397–402, 1972.
22. Wancura, I., Konig, G. On the neurophysiological explanation of acupuncture analgesia. Am J. Chin Med 2: 193–198, 1974.
23. Man, P.L., Chen, C.H. Acupuncture "anesthesia"—a new theory and clinical study. Curr Ther Res 14: 390–394, 1972.
24. Man, P.L., Chen, C.H. Mechanism of acupunctural anesthesia, the two-gate control theory. Dis Nerv Syst 33: 730–735, 1972.
25. Melzack, R., Jeans, M.E. Acupuncture analgesia, a psychophysiological explanation. Minn Med 57: 161–166, 1974.
26. Melzack, R. Acupuncture and pain mechanisms. In A. Arias et al. (Eds.). Recent Progress in Anesthesiology and Resuscitation. Amsterdam, Excerpta Medica, 1975, pp 27–30.
27. Melzack, R. Akupunktur und Schmerzbeeinflussung. Anaesthetist 25: 204–207, 1976.
28. Umlauf, R. Gate mechanisms in relation to the analgesic action of acupuncture. Cas Lek Cesk 115: 681–686, 1976.
29. Popkin, R.J. Histamine explanation of acupuncture. JAMA 220: 1359, 1972.
30. Greguss, P. A model for making acupuncture consistent with Western concepts of biological information processing. In H.P. Jenerick (Ed.), Proceedings of the NIH Acupuncture Research Conference. DHEW Publication No. (NIH) 74–165, 1974, pp 95–98.
31. Collison, D. Acupuncture and hypnotherapy. Med J Aust 2: 112, 1974.
32. Kroger, W.S. Hypnotism and acupuncture. JAMA 220: 1012–1013, 1972.
33. Kroger, W.S. Acupunctural analgesia: its explanation by conditioning theory, autogenic training, and hypnosis. Am J Psychiatry 130: 855–860, 1973.
34. Kroger, W.S. A scientific explanation for the rationale of acupunctural analgesia. In J.G. Llaurado et al. (Eds.), Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields. Springfield, Ill., Charles C. Thomas, 1974, pp 220–226.
35. Nemerof, H., Rothman, I. Acupuncture and hypnotism: preliminary experiments—and a warning. Am J Clin Hypnosis 16: 156–159, 1974.
36. Bresler, D.E., Kroening, R.J. Acupuncture: a multi-determined phenomenon. Psychoenergetic Systems 1: 137–139, 1976.

37. Bresler, D.E., Kroening, R.J. Three essential factors in effective acupuncture therapy. Am J Chin Med 4: 81–86, 1976.
38. Chein, E.Y.M., Shapiro, A.K. Evaluation of acupuncture. JAMA 224: 1533–1534, 1973.
39. Mark, L.C. Acupuncture and suggestion. JAMA 223: 922, 1973.
40. Bull, G.M. Acupuncture anesthesia. Lancet 2: 417–418, 1973.
41. Dornette, W.H.L. The anatomy of acupuncture. Bull NY Acad Med 51: 985–902, 1975.
42. Fleck, H. Acupuncture and neurophysiology. Bull NY Acad Med 51: 903–913, 1975.
43. Matsumoto, T. Acupuncture and U.S. medicine. JAMA 220: 1010, 1972.
44. Gunn, C.C., Ditchburn, F.G., King, M.H., Benwick, G.J. Acupuncture loci: a proposal for their classification according to their relationship to known neural structures. Am J Chin Med 4: 183–195, 1976.
45. Matsumoto, T., Lyu, B.S. Anatomical comparison between acupuncture and nerve block. Am Surg 41: 11–16, 1975.
46. Bossy, J., Maurel, J.C., Godlewski, G. Substratum macroscopique des points d'acupuncture. Bull Assoc Anat (Nancy), 59: 357–362, 1975.
47. Liu, Y.K., Varela, M., Oswald, R. The correspondence between some motor points and acupuncture loci. Am J Chin Med 3: 347–358, 1975.
48. Bong Han, K. Kyungrak system and theory of sanal. Proc Acad Kyungrak DPRK. Pyongyang, Medical Science Press, 1965.
49. Kellner, G. Bau und Funktion der Haut. Presented at the Thirteenth International Acupuncture Congress (Vienna, 1965).
50. Rabischong, P., Niboyet, J.E.H., Terral, C., Senelar, R., Casez, R. Bases éxpérimentales de l'analgésie acupuncturale. Nouv Presse Med 4: 2021–2026, 1975.
51. Chan, S.H.H., Fung, S.J. Suppression of the polysynaptic reflex by electro-acupuncture and a possible underlying mechanism in the spinal cord of the cat. Exp Neurol 48: 336–342, 1975.
52. Rohner, J.J., Planche, D. Modification des potentiels évoqués associatifs par stimulation des points d'acupuncture chez le chat. C R Soc Biol (Paris) 176: 1180–1185, 1973.
53. Shen, E., Ts'ai, T., Lan, C. Supraspinal participation in the inhibitory effect of acupuncture on viscero-somatic reflex discharges. Chin Med J 1: 431–440, 1975.
54. Linzer, M., Van Atta, L. Effects of acupuncture stimulation on activity of single thalamic neurons in the cat. Adv Neurol 4: 799–811, 1974.
55. Linzer, M., Van Atta, L. Electrophysiological assessment of acupuncture's effect on single thalamic neurons in the cat: neural coding for pain at a thalamic level. Am J Chin Med 1: 305–316, 1973.
56. Lee, G.T.C. A study of electrical stimulation of acupuncture locus tsusanli (St-36) on mesenteric microcirculation. Am J Chin Med 2: 53–66, 1974.
57. Clifford, D.H., Lee, M.O., Lee, D.C. Sympathetic and parasympathetic effects of acupuncture on the cardiovascular system of dogs under halothane anesthesia. Archives 5: 6–10, 1976.
58. Lee, M.O., Lee, D.C., Kim, S., Clifford, D.H. Cardiovascular effects of acupuncture at tsu san li (St-36) in dogs. J Surg Res 18: 51–63, 1975.
59. Chu, Y.M., Affronti, L.F. Preliminary observations on the effect of acupuncture on immune responses in sensitized rabbits and guinea pigs. Am J Chin Med 3: 151–163, 1975.
60. Bresler, D.E. A comparison of the effects of acupuncture, local anesthetic and systemic analgesic drugs, and hypnosis on experimental pain thresholds. In H.P. Jenerick (Ed.), Proceedings of the NIH Acupuncture Research Conference. DHEW Publication No. (NIH) 74–165, 1974, pp 50–51.
61. Aso, R., Motohashi, R., Murata, M., Nishimura, R., Kakizaki, K., Kimura, S. The influence of acupuncture stimulation on plasma levels of LH, FSH, progesterone, and estradiol in normally ovulating women. Am J Chin Med 4: 391–401, 1976.
62. Doenicke, A., Kamipik G., Praetorius, B., Schmidt, M. Veränderung blutchemischer Parameter bei gesunder Versuchspersonen durch Akupunktur. Anaesthetist 25: 235–238, 1976.
63. Sjölund, B., Eriksson, M. Electroacupuncture and endogenous morphines. Lancet 2: 1085, 1976.
64. Ikezono, E., Ohama, K., Nagayama, K., Sawa, T., Yoshida, T., Yokogama, K., Shimoji, K. The effects of acupuncture needling on the evoked responses of brain, spinal cord and muscle in man. Am J Chin Med 4: 53–59, 1976.
65. Sovak, M., Engel, R. Über den Mechanismus der Akupunktur-Analgesie. Anaesthetist 25: 208–214, 1976.
66. Chen, R.C., Hung, T.P. Acupuncture: its effect on somato-sensory cerebral evoked potentials in man. J Formosan Med Assoc 47: 341–344, 1975.
67. Pauser, G., Benza, H., Bischko, J., Ganglberger, J., Haider, M., Mayrhofer, O., Schmid, H., Semsroth, M., Thoma, H. Klinische und experimentelle Ergebnisse mit der Akupunktur-Analgesie. Anaesthetist 25: 215–222, 1976.
68. Janz, G.J., Ives, J.G. Silver, silver chloride electrodes. Ann NY Acad Sci 148: 210–221, 1968.
69. Lykken, D.T. Properties of electrodes used in electrodermal measurement. J Comp Physiol Psychol 52: 629–634, 1959.
70. Brown, M.L., Ulett, G.A., Stern, J.A. Acupuncture loci: techniques for location. Am J Chin Med 2: 67–74, 1974.
71. Fleck, H., Spring, M. The acupuncture point: study of events. NYSJ Med 74: 1060–1064, 1974.

72. Noordergraaf, A., Silage, D. Electroacupuncture. IEEE Trans Biomed Eng BME-20: 364–366, 1973.
73. Reichmanis, M., Marino, A.A., Becker, R.O. Electrical correlates of acupuncture points. IEEE Trans Biomed Eng BME-22: 533–535, 1975.
74. Bresler, D.E. Electrophysiological and behavioral correlates of acupuncture therapy. In Z. Rejdak (Ed.), Konference o Vyzkumu Psychotroniky, Prague, Sbornik Referatu, 1973.
75. Reichmanis, M., Marino, A.A., Becker, R.O. DC skin conductance variation at acupuncture loci. Am J Chin Med 4: 69–72, 1976.
76. Reichmanis, M., Marino, A.A., Becker, R.O. Laplace plane analysis of transient impedance between acupuncture points Li-4 and Li-12. IEEE Trans Biomed Eng BME-24: 402–405, 1977.
77. Frost, E., Orkin, W.R. Localization of acupuncture sites. In H.P. Jenerick (Ed.), Proceedings of the NIH Acupuncture Research Conference. DHEW Publication No. (NIH) 74–165, 1974, pp 121–123.