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원 저

Correlation between Acupuncture Stimulation and Cortical Activation - Further Evidence

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초 록

침자극이 대뇌피질의 활성화에 미치는 영향

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목적 : 이 실험의 목적은 경혈에 대한 침자극이 대뇌피질에 어떠한 영향을 미치는가에 대하여 체계적이고 객관적으로 증명하는 것이다.

방법 : 시각과 관련이 있는 광명(GB37), 청각과 관련이 있는 협계(GB43) 및 외관(SJ5)을 자극하고 fMRI를 통하여 대뇌피질의 활성정도를 관찰하였다.

결과 : 이들 경혈의 자극으로 시각과 청각과 관련된 피질의 활성이 나타났다. 자극에 의한 대뇌피질 활성을 fMRI를 통하여 고찰한 결과 특정한 경혈의 자극이 대뇌피질을 활성화시킨다는 사실을 알 수 있었다.

결론 : 치료 효과는 그 경혈의 자극에 의한 대뇌피질의 활성과 관련이 있음을 말하는 것으로, 경혈지극과 대뇌와의 상관성을 증명하는 것이다.

중심단어 : 침, 대뇌피질, fMRI, 시각, 청각

Ⅰ. Introduction

One of the most important scientific milestones of this century is the development of neuroscience, the science which leads us to better understand the human brain.

Through a better understanding of our human brain, we can tackle many problems hitherto unimagined, Many centuries of medical mysteries, such as phantom pain, are better understood through neuroscience[1]. Not only do we know about the nature of the pain, we are now able to treat the pain. acupuncture, a medical puzzlement in the West, is now becoming more familiar to many people in both the East and West [2,3,4,5], Increasing awareness and use of acupuncture, one of the jewels of Oriental medicine, is now supported by the federal government of the United States, namely the National Institutes of Health(NIH) which has begun to show interest and support for acupuncture research. In parallel to these developments, there is also the development of neuroimaging techniques which might help us unravel and understand the basic mechanisms of acupuncture, the three–millennia–old mystery, by examining cortical activation in conjunction with acupuncture stimulatio[6]. In this paper, we will show the first extensive and carefully–controlled experiments studying three different acupoints distributed over the visual to auditory cortices which clearly show the correlation between a specific acupoint and its corresponding cortical activation using functional MRI (fMRI). This study demonstrates clues with which we can hypothesize how acupuncture mat affect our central nervous system with the goal of better understanding its mechanism in therapy, eventually refining and standardizing acupuncture treatment. Although the present study does not prove that there is a curative effect of acupuncture and the real clinical effect can only be demonstrated on the basis of a double–blind clinical study, neverthless it is clearly interesting that at the very least it shows that acupuncturists are using relevant areas for their treatments and are not sticking needles at random. Perhaps, clues may be gained from this work to help understand the mechanism for acupuncture therapy.

Neuroscience in the 80's and 90's, has many remarkable developments, from neurochemistry to neuroanatomy and neurobiology. Perhaps, a most important event in neuroscience is the technological developments of neuroimaging, such as Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging(fMRI). With these techniques, we can now visualize the anatomic details of our brain in-vivo and also demonstrate the functional activation of our brain with unprecedented resolution in time and space[7,8,9,10]. To be more specific, with functional MRI, we are now able to visualize minute changes in blood oxygenation in vascularized areas such as the visual cortex of the brain by simple external stimulation (such as visual light stimulation of our eyes) in a non-invasive manner with no known hazards[11,12,13,14,15,16]. Shortly after these new developments, it has become routine to visualize cortical activation with various stimuli, such as finger tapping and the flashing into the eyes. It has become apparent that most of stimulation can be visualized in the corresponding cortical areas, similar to mapping of the homunculus by Penfield[17] in the 30's and 50's, but this time in a non-invasive manner.

In the field of acupuncture, many important discoveries have been made, which include the beta-endorphin theory of acupuncture analgesia as well as many studies which proved that the concepts known as "Qi" and "Meridians", the hypothetical " energy " and "energy transporting channels," are nothing more than the peripheral nervous system[2,18,19,20]. In fact, the anatomy of the peripheral nervous system given in many anatomical books[21,22] shows that many acupoints correspond with points where small nerve bundles penetrate the fascia. According to the massive study conducted in China, 309 acupoints are situated on or very close to nerves, while 286 acupoints are on or very close to major blood vessels, which are surrounded by small nerve bundles[23]. The latter is, indeed, interesting since it leads us to think that acupuncture signals are possibly projected to the brain via the spinal cord and the brainstem, and many of them may terminate in upper cortical areas, such as the sensory cortex or subcortical areas. At this time, clues to the acupuncture-to-cortex relationship can only be drawn indirectly from the acupuncture literature[2,3] or through the observations of experienced acupuncturists. From all these studies, although not specifically mentioned, it has been implied that the disease treatment claimed for the acupuncture points may have somatotopic or sensory-related cortical correspondence.

For example, acupoint GB37, which is known as one of the acupoints used for the treatment of eye-related diseases, is suspected to have a cortical relationship in the visual cortex. Another example is acpoint G-B43. which is also one of the acupoints known to be effective for the treatment of ear-related diseases, such as deafness and tinnitus, is suspected to be related to the auditory cortex. But, acupoint GB43 is also used in the treatment of hemiplegia. These disease treatment effects described in the literature for acupoints may have been discovered in ancient times, at least in the initial stages, by accident. Later, all the cumulative results may have been systematized by some scholarly minded acupuncturists or by order of royal physicians of the time.

II. Methods and Results

In consultation with experienced acupuncturists and from the literature, GB37 was chosen for the vision-related acupoint, which may be expected to demonstrate activation in the visual cortex when stimulated, similar to the our previous experiment with BL67[6].

One the other hand, GB43 and SJ5 were chosen for the auditory-related acupoints, each of which may be expected to show activation in the auditory cortex. An illustrative example is given in Fig.1 where both the acupuncture points overlaid on the peripheral nervous system (a) and cortical activation (b) due to the stimulation of GB37 and GB43 are shown. Note the absence of any activation after non-acupoint stimulation sh-own in Fig.1(b-i). Experiments were pe-rformed using the gradient echo Echo Planar Imaging (EPI) sequence with GE or Siemens 1.5T MR scanners.

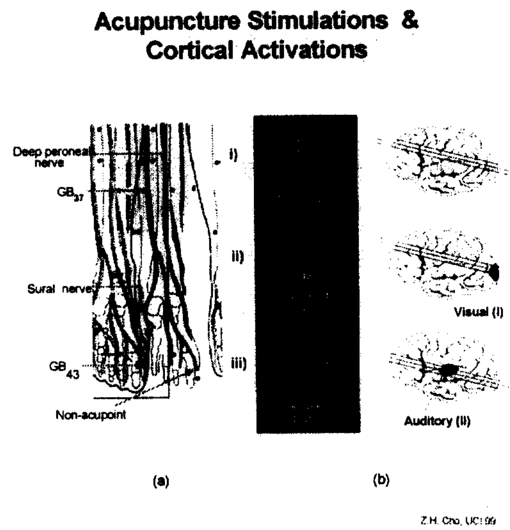

Fig.1. A typical example of peripheral nerves innervated in the leg and some acupoints overlaid on the nerves. (a) Acupoints overlaid on the peripheral nerves. (b) Cortical activation due to stimulation of : i) a sham point (non-acupoint), ii) stimulation of acupoint GB37 (vision related), and iii) stimulation of acupoint GB43 (audition related), respectively.

In Fig.2, some details of cortical activation of vision-related experiments with GB37 are shown. In this figure, cortical activation after direct visual stimulation with flashing light into the eyes (this is referred to as reference data) and acupuncture stimulation of a vision-related acupoint, GB37, are shown. The visual cortex is activated in both cases[6]. In Fig.2(a), we see the activation of five selected slices of the brain in the region of

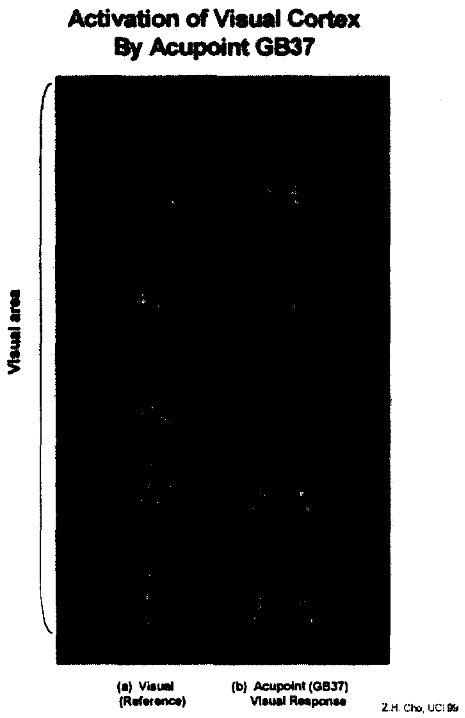

Fig.2. Activation of the visual cortex by the vision-related acupoint GB37. (a) Cortical activation due to direct visual stimulation with flashing lights (produced for reference). (b) Cortical activation in the visual cortex by stimulation of acupoint GB37. In the latter, note the clear activation in the visual cortex in slices III and IV. We have also noticed a small and relatively weak activation in the auditory cortex as seen in slices VI and VII. The latter we believe is the secondary activation while the former (visual activation) is the primary activation.

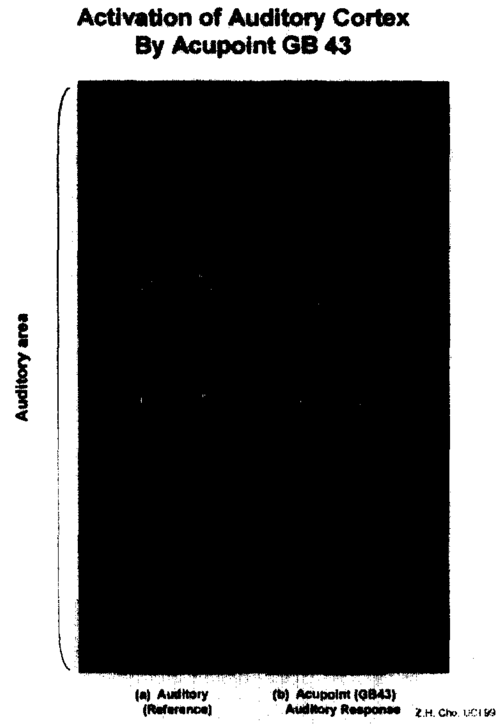

Fig.3. Activation of the auditory cortex by stimulation of the hearing-related acupoint GB43. (a) Cortical activation due to direct auditory stimulation (music) produced as a reference. (b) Cortical activation in the auditory cortex by stimulation of acupoint GB43. In the latter, note the small activation in the visual cortex in slice IV. The latter (visual cortex activation), we believe, is the secondary activation (compare with Fig.2 where the auditory cortex activation is regarded as the secondary activation).

the occipital cortex where the visual cortex is situated when the eyes are exposed to flashing lights (reference data). Three slices around the visual cortex are activated, namely, slices III, IV, and V. For the same subject, when acupuncture stimulation of acupoint GB-37 is applied, nearly the same areas are activated, except slice V. In addition, there was small and weak activation in the auditory cortex, as shown in the lower parts of the Fig.2(b), namely slices VI and VII. It appears that the auditory cortical activation due to GB37 acupoint stimulation is a secondary activation while visual is the primary activation. For the study of auditory-related cortical activation, we have chosen another acupoint, GB43, which is known for ear-related disease treatment and the result is shown in Fig.3. Again, conventional auditory stimulation (music) is applied to obtain the reference data for fMRI as shown in Fig.3(a). Subsequent stimulation of acupoint GB43 shows nearly the same activation in slices III, IV, and V as shown in Fig.3(b). Note the small activation in the area of the visual cortex in slice IV in Fig.3(b). This seems to be the result of a secondary activation of GB43 in a similar manner to the case of GB37 where auditory cortical activation appears as secondary .In Fig.4, an experimental result of another auditory-related acupuncture study of acupoint SJ5 is shown. Acupoint SJ5 is also known for the treatment of ear-related disease and is located on the hand. In Fig.4(a), the auditory cortex is activated with music and the activation result is seen in slices II and III. In Fig.4(b), with the same subject, the cortical activation result from acupuncture stimulation of SJ5 is shown. Activation is shown throughout slices III, IV, and V. SJ5 experiment was done with electro-acupuncture since acupoint SJ5 is located on the hand and found to be difficult to reach in MRI setting by conventional needling (acupuncture)*.

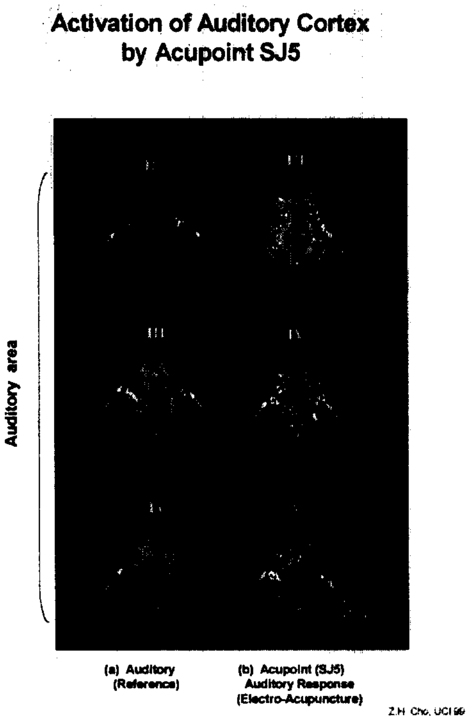

Fig.4. Activation of the auditory cortex by stimulation of another hearing-related acupoint SJ5. (a) Cortical activation due to direct auditory stimulation (music) produced for reference. (b) Cortical activation in the auditory cortex of the same subject by stimulation of acupoint SJ5. In this experiment, we have used electro-acupuncture (see text).

* This electro-acupuncture experiment is interesting since it was our first trial of electro-acupuncture and activation results were similar to the conventional one. Efficacy of electro-acupuncture was also tested in other acupoints such as GB37 and we found similar results to that of conventional needle acupuncture.

III. Discussions

Many interesting aspects need further study to be clarified and understood, such as the secondary activation which seems closely related to the well known summing-effect in acupuncture practice. Also, the intra-abdominal areas are available for pioneering research where many sympathetic and parasympathetic autonomic nerves are innervated, but with little known cortical representation. The present findings and the confirmation and broadening of our preliminary report[6] support strongly that there is correlation between an acupoint and its cortical activation in the brain. At this stage of neuroscience development, our observation may not answer all the questions, but it may lead to many plausible hypotheses hitherto unavailable. For example, it may be possible to hypothesize that acupuncture stimulation of a specific acupoint could deliver information to the corresponding cortical area (s), thereby enabling higher centers of the brain to make necessary decisions such as balancing hormonal levels, the autonomic nervous system, and the neurochemical activity in conjunction with other centers in the brain such as the hypothalamus[24]. For this to occur, it may be necessary that the corresponding cortical centers be activated by external stimuli, such as acupuncture stimulation. Another hypothesis to be considered is the concept of "crosstalk" , a term which describes electro-magnetic signals jumping from one wire (conduit) to another. Perhaps, the nerves from the foot may at some point come close to the nerves for the visual system, allowing for crosstalk to occur. One can imagine an ancient acupuncturist sticking needles at several points in the body, when his subject saw a visual phenomenon, the acupuncturist may have decided to treat visual problems by stimulating that acupoint. Therefore, the only way to prove clinical efficacy of acupuncture therapy would be to do a double-blind clinical study using acupoints which have strong activation in corresponding cortical areas, such as visual and auditory cortices.

In summary, clues to the basic mechanism and the mystery surrounding acupuncture may be revealed through our modern scientific tools such as PET and fMRI. If indeed, after the extensive study, correlations between acupoints and corresponding cortical areas are found, it will allow us to perform more accurate and reliable treatment for the millions of patients who desperately need acupuncture therapy. Although the full account of the mystery of acupuncture is not yet available with the present results, they may provide the bases of future work to better understand the nature of acupuncture. Even if the cortical correlation of acupuncture stimulation has been found to be of no direct curative effect for diseases as the Oriental acupuncture literature has described, it is still interesting in modern neuroscience point of view since it could provide a method of studying the wiring diagram of the nervous system in connection with the historical development of the Oriental medicine. One of the plausible arguments of present work is that it successfully complements the existing beta-endorphin theory of acupuncture analgesia developed by the many acupuncture scientists[2,19,20,24]. It can easily be extended beyond the pain relief theory to the treatment of disease by balancing of the humoral and autonomic nervous system of our body by incorporating the fact that the acupuncture stimulation signal is projected to the cortical areas, since it means that such as the hypothalamus, a master control center of our homeostasis, could be controlled or influenced by the higher centers of our brain, namely prefrontal cortex. This is an interesting new area of research and there are only a few published research reports of this nature. Although we can find a few references, most of them are available only in the form of abstracts or short conference summaries[25,26,27].

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