Engineering, 2013, 5, 545-548
http://dx.doi.org/10.4236/eng.2013.510B112 Published Online October 2013 (http://www.scirp.org/journal/eng)

The Research on Acupuncture Anesthesia Based on fMRI

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Received 2013

ABSTRACT

Pain is one of the most important sensations in daily life, and the traditional Chinese medicine such as acupuncture has shown great potential in pain relief. The principle research of acupuncture anesthesia has been the focus of modern science. In this paper the noninvasive brain imaging technique fMRI (functional magnetic resonance imaging) was used. Eight volunteers were enrolled and received pain stimulation, and the brain response under TEAS (transcutaneous electrical acupoint stimulation) and manual needle stimulation were observed. The research finds pain has specific sensation region and the acupuncture anesthesia is realized through modulating the corresponding brain function region, but the manual needle has wider brain response region than TEAS.

Keywords: Acupuncture; Anesthesia; fMRI

1. Introduction

Pain is one of the most important sensations in daily life. Pain perception is much more complicated than any other human perceptions. Much research results in many fields have shown that pain is not only physical experience but also closely related to many other factors such as physiology, social background, cultural differences and mental state [1]. The official definition of pain by the International Association for the Study of Pain (IASP) consists of three elements: 1) it is associated with "injury" and "threat of injury"; 2) it is an "unpleasant" and "emotional" experience; and 3) it is "subjective" [2]. Since the International Association for the Study of Pain was founded in 1974, the research on pain developed steadily. But up to present the research and control on pain is still quite deficient. In contemporary medicine, acupuncture is considered an important adjuvant treatment and has attracted more and more attention. Especially in anesthesia, acupuncture was used more widely. Acupuncture was first successfully used in surgical analgesia in the 1950s [3]. In recent decades multidisciplinary experts explore the principle of acupuncture analgesia from the multi-level (from molecular and cellular level into gene level) and multiple perspectives (nerve, body fluids, meridian) [4].

The research of mechanism of acupuncture analgesia has become more and more important. The Traditional Chinese Medicine is difficult to explain many acupuncture phenomenons, so the use of modern medical technical in acupuncture treatment has become the research focus in recent years, especially the various noninvasive brain imaging technologies and their application in illustrating the cerebral mechanism of acupuncture anesthesia. It is a huge progress in revealing the scientific essence of acupuncture therapy effect [5-8]. These techniques mainly include Electroencephalograph (EEG), Magnetoencephalograph (MEG), Positron Emission Tomography (PET), Functional Magnetic Resonance Imaging (fMRI) and so on.

The paper applies Functional Magnetic Resonance Imaging to study brain activity changes in the different stimulation modes in LI.4 (Hegu acupoint). From a new aspect to discusses the analgesic effect in different acupuncture stimulation modes, to provide the visible and objective criterion for clinical application of acupuncture analgesia.

2. Methods

2.1. Subjects

Eight healthy volunteers were enrolled in the experiment (four male and four female), they are right handed, 22 - 28 years old. All volunteers were students in the university, none of them had neurological or psychological disorders and they were not taking medicine. All volunteers were informed and received acupuncture treatment, signed an informed consent of this experiment. The volunteers had no fMRI contraindications, such as metal prosthetic limbs, joint, heart pacemakers, etc.

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2.2. Experiment Materials

1) Acupuncture needle (contain gold 75%), length 40 mm, diameter 0.32 mm, Suzhou Hua Tuo factory production. Remove the metal wire which wrapped around the needles handle;

2) 75% alcohol, disinfection cotton-wool, medical paper tape;

3) Siemens 1.5 T Magneton Sonata. Provided by Radiology Department of the Second Hospital affiliated Zhejiang University;

4) Black eye shade, rubber ear plugs.

2.3. Protocol of the Experiment

Each participant should attend two experiments, after given the pain stimulation we use electrical stimulation and manual needle stimulation in LI.4 (Hegu acupoint). The two stimulations were given by random. For eliminate other factors disturbance, the time of interval of this two experiments is a week for the same volunteer.

In the experiment we use 75% alcohol cotton to disinfect acupoint, let the volunteers on the operation stage, using black eye shade and rubber ear plugs to cover eyes and ears. Using a magnetic resonance special mat padded the occipital and then using a pair of special sponge pad plug the each side of head and fixed the head.

This experiment process was shown in **Figure 1**. According to the acupuncture program this experiment divided into four stages. The first 3 min as B phase (resting phase) and the pain stimulation last for 2 min as P phase (pain phase), after 10 min acupuncture as S phase (stimulate phase), the last 3 min after needle as PO phase (resting phase 2). The whole process lasts for 18 min.

All subjects received pain stimulation by injection 3.5 ml mixture of herb medicine (angelica, a clinic medicine used widely in China) and Vit.B12 (2:1) in the subjects' left shoulder, the depth was about 2.5 cm.

2.4. The Experiment Stimulating Patterns

Acupuncture pattern: 1) Manual needle stimulation, which was operated by my professional doctor; 2) TEAS stimulation: Transcutaneous electric acupoint stimulation (HANS: Han's acupoint nerve stimulator, Model LH202H TEAS) was used. The stimulation frequency of TEAS was 2/100 Hz and the intensity was 3 - 8 mA, according to the standard to cause muscle shiver. Stimulation patterns were shown in **Figure 2**.

2.5. The Pain of VAS Score Record

Visual Analog Scale (VAS) for all volunteers, records every volunteer's pain score after give injection stimulation and after treatment.

Figure 1. The process of experiment.

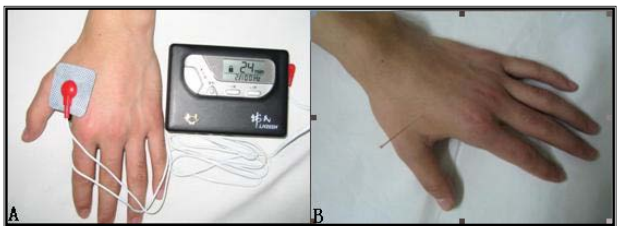

Figure 2. The acupuncture patterning of experiment ((A) TEAS; (B) Manual needle).

2.6. fMRI Data Processing

fMRI technology is based on brain activity caused by the change of physiological or metabolic changes. It is very sensitive to the blood flow and the blood oxygen level. The spatial resolution is only a few millimeters and time resolution is also a few seconds [9]. The statistical parameter mapping (SPM) was used for brain imaging data processing [10-13].

3. Results

3.1. The VAS Score

The VAS score of each experiment was recorded. The VAS of the manual needle group (Mean ± SD) was 5.73 ± 2.28, after Manual needle stimulation treatment was 1.63 ± 1.11, The VAS of TEAS group was 5.15 ± 1.84, after transcutanclus electrical acupoint stimulation the VAS was 1.13 ± 0.48. The VAS values of the two groups were significantly decreased after acupuncture treatment, as shown in **Table 1**.

3.2. The Analyses of the Activated Brain Functional Areas

After the pain stimulation and acupuncture treatment (manual needle and TEAS) the corresponding brain areas would be activated. The definition of activated areas: more than 5 voxels (body element) activation, confidence level is 0.05.

1) *The activated brain functional areas* after the pain stimulation

According to the Broadmann partition, when the body received the pain stimulation the activated brain areas mainly distributed in: 1) the first somatosensory cortex of postcentral gyrus (BA 3, 1 and 2) and postcentral gyrus (BA 40), precentral gyrus, paracentral lobule; 2) the post nodules of thalamus and left thalamus; 3) the right ventral lateral nucleus and the right side of the ventral posterolateral nucleus; 4) bilateral superior temporal gyrus (BA 38) and transverse temporal gyri; 5) bilateral superior temporal gyrus, middle frontal gyrus, inferior frontal

Table 1. The vas value of the two groups.

Experiment group	After pain stimulation (Mean ± SD)	After treatment (Mean ± SD)
Manual needle group	5.73 ± 2.28	1.63 ± 1.11
TESA group	5.15 ± 1.84	1.13 ± 0.48

gyrus and medial frontal gyrus; 6) bilateral suboccipital back, occipital visual cortex (BA 18 and 19), the right of superior occipital gyrus; 7) caudate nucleus; 8) the right of lenticular nucleus, the right of red nucleus; 9) lateral globus pallidus, geniculate body, corpus callosum. Activated areas were shown in **Figure 3**.

2) *The activated brain functional areas* after Manual needle stimulation

Figure 4 shows the activated brain functional areas after the needle stimulation on LI.4 (Hegu acupoint). 1) central vault gyri and the left of vault gyri; 2) precentral gyrus and the left of postcentral gyrus; 3) angular gyrus, the corpus callosum and inferior corpus callosum; 4) bilateral cingulated gyrus, the left of caudate nucleus and the left of fusiform gyrus; 5) the left of superior temporal gyrus, the left of transverse temporal gyri and supramarginal gyrus; 6) the left of parietal lobe, inferior parietal lobule and the left of precuneus; 7) the left of hippocampus and hippocampal gyrus, the left of lingual gyrus, uvula, the right of middle occipital gyrus and the right of pulvinar thalami; 8) the right of BA partition 11, 13, 28, 34, 43, the left of BA partition 3, 7, 19, 30, 31, 36, 41, 44.

3) *The activated brain functional areas* after TEAS

After the TEAS treatment the brain activated area mainly distributed in: 1) the right side of the main bilateral occipital lobe visual cortex (BA19); 2) the left of precuneus; 3) the left of superior parietal lobule; 4) the right of BA partition BA 30, 31, and 34. As it was shown in **Figure 5.**

4. Discussions

In this paper we established the pain model in healthy people and used the blood oxygen levels dependence functional MRI (magnetic resonance imaging) technology to observe the brain functional areas activation after the TEAS and manual needle stimulation in LI.4 (Hegu acupoint). The paper explored the neurological basis of meridian contact and communication and the principles of acupuncture treatment to investigate the mechanism of acupuncture analgesia.

In the experiments we found after stimulation of all volunteers' pain perceptions and response activities almost involve the whole brain, including part of thalamus, hypothalamus, reticular formation of brain stem, limbic system, cerebral cortex and other parts. After manual needle stimulation on LI.4 (Hegu acupoint), the activated

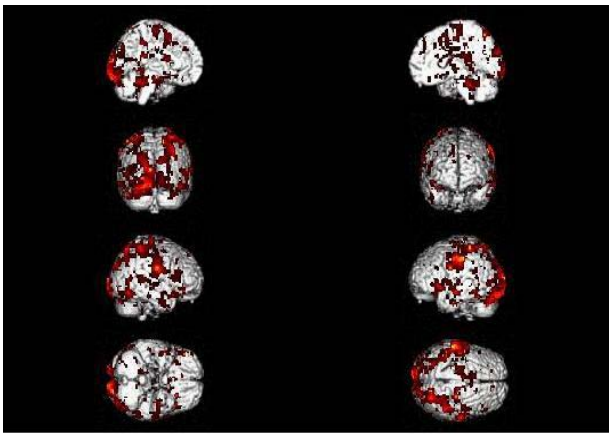

Figure 3. The fMRI of brain functional areas activation after pain stimulation.

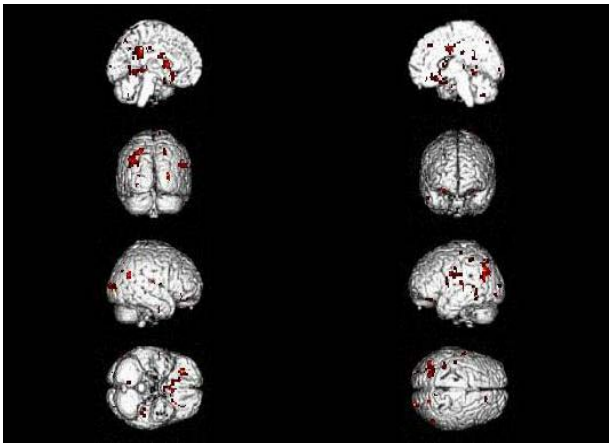

Figure 4. The fMRI of brain functional areas activation after needle stimulation hegu acupoint.

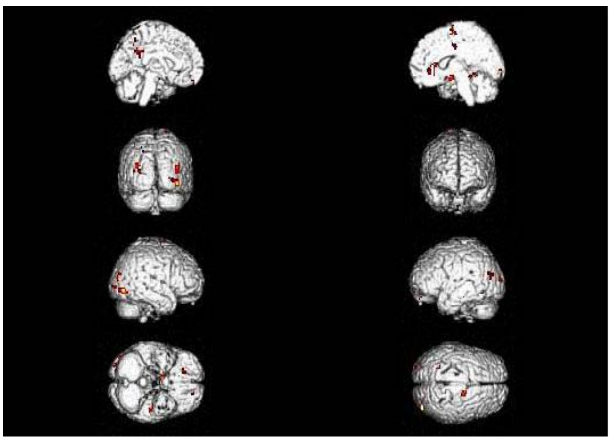

Figure 5. The fMRI of brain functional areas activation after transcutanclus electrical acupoint stimulation.

brain function area is mainly distributed in: precentral gyrus, the left of inferior corpus callosum, the right of thalamus, middle occipital gyrus, the right of cingulate gyrus, the left of caudate nucleus, fusiform gyrus, hippo-

campus, the left of superior temporal gyrus, middle temporal gyrus, supramarginal gyrus, angular gyrus, left of the superior parietal lobule and inferior parietal lobule. But after the TEAS on LI.4 (Hegu acupoint), the activated brain functional area is mainly distributed in: the right side of the main bilateral occipital lobe visual cortex (BA19), anterior cingulated, hippocampal gyrus, left of the precuneus and the BA partition of 30, 31, 34. Manual needle stimulation and transcutaneous electrical stimulation of acupuncture analgesia through activate the multiple brain areas related pain modulation and then to realize, but manual needle stimulation activation area is wider than TEAS, and the degree of activate is stronger.

5. Conclusion

Studies have shown that acupuncture (manual needle stimulation and TEAS) is an effective means in pain relief. Acupuncture analgesia mainly through activating the multiple brain areas related pain modulation, but the activated brain functional area is different between TEAS and manual needle stimulation. Transcutaneous electrical acupoint stimulation mainly activated the right side of the cerebral cortex-based, while the ordinary manual needle stimulation activated the wider areas.

6. Acknowledgements

The research was supported by the Natural Science Foundation of Zhejiang Province. The authors would like to appreciate their thanks to them.

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