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Systematic Review

Brain functional connectivity network studies of acupuncture: a systematic review on resting-state fMRI

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ABSTRACT

Background: Functional magnetic resonance imaging (fMRI) is a novel method for studying the changes of brain networks due to acupuncture treatment. In recent years, more and more studies have focused on the brain functional connectivity network of acupuncture stimulation.

Objective: To offer an overview of the different influences of acupuncture on the brain functional connectivity network from studies using resting-state fMRI.

Search strategy: The authors performed a systematic search according to PRISMA guidelines. The database PubMed was searched from January 1, 2006 to December 31, 2016 with restriction to human studies in English language.

Inclusion criteria: Electronic searches were conducted in PubMed using the keywords “acupuncture” and “neuroimaging” or “resting-state fMRI” or “functional connectivity”.

Data extraction and analysis: Selection of included articles, data extraction and methodological quality assessments were respectively conducted by two review authors.

Results: Forty-four resting-state fMRI studies were included in this systematic review according to inclusion criteria. Thirteen studies applied manual acupuncture vs. sham, four studies applied electro-acupuncture vs. sham, two studies also compared transcutaneous electrical acupoint stimulation vs. sham, and nine applied sham acupoint as control. Nineteen studies with a total number of 574 healthy subjects selected to perform fMRI only considered healthy adult volunteers. The brain functional connectivity of the patients had varying degrees of change. Compared with sham acupuncture, verum acupuncture could increase default mode network and sensorimotor network connectivity with pain-, affective- and memory-related brain areas. It has significantly greater connectivity of genuine acupuncture between the periaqueductal gray, anterior cingulate cortex, left posterior cingulate cortex, right anterior insula, limbic/paralimbic and precuneus compared with sham acupuncture. Some research had also shown that acupuncture could adjust the limbic-paralimbic-neocortical network, brainstem, cerebellum, subcortical and hippocampus brain areas.

Conclusion: It can be presumed that the functional connectivity network is closely related to the mechanism of acupuncture, and central integration plays a critical role in the acupuncture mechanism.

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1. Introduction

Acupuncture has been used as a traditional medicine in China for over 2000 years [1], and is now rapidly gaining popularity in Western alternative and complementary medicine practice for its undeniable therapeutic effects [2]. Exploring the mechanism of acupuncture has been a hot topic in the research of alternative and complementary medicine.

Since the 1970s, many studies in animal models have shown that the integration of the central nervous system is involved in the effect of acupuncture [3]. In the last 20 years, extensive functional magnetic resonance imaging (fMRI) research has focused on the study of the neurophysiological mechanism of acupuncture. Using neuroimaging technologies, researchers have been able to examine the acupuncture process in the brain noninvasively [4]. fMRI is a new method to quantify how acupuncture affects changes in the brain network [5–8]. Many resting-state fMRI (rs-fMRI) studies have indicated that acupuncture regulates the activity of some cortical and subcortical brain regions [9–11].

This review presents a summary of current studies about brain functional connectivity networks in acupuncture research. The authors discussed aspects of study participants, acupoints, acupuncture methods, research methodology and their associated challenges. For this purpose, the study outcomes are discussed in several subgroups. The results provide an overview of changes in functional connectivity networks stimulated by different acupuncture acupoints or methods.

2. Methods

2.1. Literature search

The authors adopted a systematic search strategy according to the PRISMA guidelines [12]. Electronic searches were performed in PubMed using the keywords “acupuncture” and “neuroimaging” or “resting-state fMRI” or “functional connectivity”. Then the articles were screened by title and abstract. The PubMed database was initially searched from January 1, 2006 to December 31, 2016 with restriction to human studies in English language.

2.2. Eligibility criteria

Original studies of acupuncture on the brain functional connectivity network using rs-fMRI were included in this review. We

excluded meta-analyses, reviews, non-fMRI studies, non-needle acupuncture studies and non-functional connectivity studies.

2.3. Study selection

Initially, studies were screened for relevance using the title and abstract. Repeated studies, reviews, unrelated studies and works without available full text were excluded. Then, the full texts of potential studies were assessed following the inclusion and exclusion criteria. The study characteristics and variables of interest were then transferred to Excel [7]. The following data were extracted: publishing data (including author, publication year, title and journal), methodology (including number of participants, number of intervention groups, and number of treatment sessions), needling details (including acupuncture style: manual/electro; acupuncture points: unilateral/bilateral), control intervention (including types of control intervention, and size of intervention groups), technology (technical device, and data processing method) and outcomes (including findings, group differences, increase/decrease, and activation/deactivation).

3. Results

3.1. Study inclusion

A literature search was conducted, including publications from 2006 to 2016. Our search terms retrieved 136 records. After screening the title and abstract, the number was reduced to 83 articles. A further 39 articles were excluded when the full text failed to meet the inclusion criteria, leaving 44 articles for use in this study (Fig. 1). The publication year of all articles is shown in Fig. 2.

3.2. Result tables

A comparison of all included studies with regard to acupoints used, control intervention, number of participants, outcomes and so forth can be found in Table 1.

3.3. Participants

A total of 44 studies with 1 191 participants were divided as follows: 19 studies [13–31] with 574 healthy subjects, 14 studies [32–45] with 289 subjects affected by nervous system diseases, 6

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