Technique to study fMRI changes induced by acupuncture over a thirty-minute period: a feasibility study

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Introduction

Due to MR scanner hardware limitations, it is difficult to acquire BOLD fMRI of the entire brain volume with a long stimulation paradigm, which may last 30 min or more. However, to attain the acupuncture analgesic effect, a continuous stimulation for 30 - 40 min is required [1]. In order to study the acupuncture induced analgesic effect, we developed a technique of using 5 consecutive runs to reveal changes in brain activation by acupuncture stimulation for 30 minutes.

Methods

After a neurological screening, six normal healthy volunteers (1 female, 5 male), aged 20-52, mean age of 40, participated in the study. An ON-OFF box-car paradigm was employed for the study. A sterile disposable acupuncture needle with diameter of 0.18 mm was inserted in the Hegu point (LI 4) of the right hand during the ON period with manual twisting at 1 Hz frequency. The needle was withdrawn during the OFF period. Each functional run consisted of four cycles of 30 sec ON and OFF periods followed by a 32-second baseline scan. Total time for each run was 4 minutes and 32 seconds. The entire study consisted of five consecutive runs with a 2-minute pause between runs. The total duration was about 30 minutes.

The functional MRI was performed on GE 1.5 T Echospeed Horizon with parameters of FOV 24 cm, TR/TE 4000/60, slice thickness 5 mm with no gap, 28 slices to cover the whole brain including the brainstem, a 64 x 64 matrix size in the axial plane. The data was analyzed using Statistical Parametric Mapping (SPM99b) [2] with a statistical significance threshold of $P < 0.02$. The data for each subject was normalized to Talairach space and analyzed both individually and as a group.

An activation map was obtained for every run. The activation maps for each run were then compared to the first run, which was designated as the reference run. The changes between the runs are quantified using percentage change (%) of activation volume. It is defined as

% Volume change = (Volume - Volume_ref) / Volume_ref

where Volume_ref is the total activation volume of the reference run (run 1). Both positive and negative activation were included in obtaining the volume of activation.

The run, which demonstrated the greatest volume of activation, was designated as the peak run. The run that preceded the peak run was defined as the pre-peak run, while the run immediately after the peak run was the post-peak run.

Results

The activation maps for all six subjects demonstrated a similar response pattern of delayed transient activation with varying latencies. A small difference in the activation (% Volume change) was seen between run 1 and run 2. A much larger difference in the activation (% Volume change) was seen between run 1 and run 3. For run 4, despite continued acupuncture stimulation, little or no activation was observed. For individual subjects, the peak response appeared at different times (range from run 2 to run 5) with an average of 22 min after acupuncture onset.

For the peak run, the average activation map showed positive activation in the frontal, temporal, occipital, insular, parietal lobes, limbic system (amygdala, parahippocampal gyrus, cingulate gyrus), basal ganglia (caudate, putamen, and globus pallidus), and thalamus (lamina, anterior nucleus, dorsomedial nucleus, centromedian nucleus, ventral anterior, and ventral anterior). Negative activation was found in the frontal and parietal lobes and in the cingulate gyrus. The total average activation volume for reference, pre-peak, peak, and post-peak run were 387, 240 (-38%), 688 (+78%), and 142 (-63%) voxels.

Conclusion

Using this technique, we have demonstrated the feasibility of performing a long stimulation (> 30 min) fMRI paradigm. The study demonstrated positive activation in anatomical areas known to be associated with endorphin analgesia, which is though to account for the analgesic effect of acupuncture (limbic system and the thalamus). The latency of the activation seen on fMRI corresponds to the clinical onset of acupuncture induced analgesia. The explanation for the consistently observed subsiding of the activation after the peak despite the continued acupuncture stimulation is an unexpected feature.

References

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