High-frequency Brain Oscillations (600 Hz) In Human Somatosensory Evoked Potentials - Quantification Of Effects After Needling And Stimulating Large Intestine 4 Using New EEG-electrodes

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Citation

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Abstract

High-frequency brain oscillations (600Hz) and conventional early somatosensory evoked potentials were investigated for the first time in 14 healthy volunteers (7 f, 7 m; mean age 22.7 + 3.3 years; range 19 - 32 years) during acupuncture at Large Intestine (LI-4, Hegu). Inserting the needles and manual stimulation produced significant ($p < 0.05$; Kruskal-Wallis ANOVA) decreases of amplitudes of 600Hz signals from generators located in the vicinity to the thalamus. Modulation of subcortical structures may be an important mechanism by which acupuncture exerts its complex effects.

INTRODUCTION

Human median nerve somatosensory evoked potentials (SEPs) contain an oscillatory burst of low-amplitude high-frequency (600Hz) wavelets superimposed on the N20 component.[1]

Acupuncture has been used to treat diseases for thousands of years in China. While some studies have shown that acupuncture could modify conventional SEPs [2,3] no study has been published on 600Hz brain oscillations and acupuncture.

In the present study we report for the first time the effects of manual acupuncture and needle stimulation of acupoint LI-4 (Hegu) on high-frequency (600Hz) components in human SEPs using a new EEG recording technique.

METHODS

HEALTHY VOLUNTEERS

SEPs including 600Hz oscillations were investigated in 14 healthy volunteers. Seven persons were females and seven males. The mean age ± standard deviation was 22.7 ± 3.3 years (range 19 – 32 years). None had a history of psychiatric or neurological disorders or head trauma with loss of consciousness, or intake of tranquilizing drugs in the last 7 days. All healthy volunteer adults had some knowledge of acupuncture but had never received treatment. No subjects were in pain or distress at the time of the study. The study was approved by the ethics committee of the University of Graz and all subjects were paid and gave written informed consent.

STIMULATION, RECORDING AND EVALUATION PARAMETERS

The elucidation of the SEPs was performed using peripheral electrical stimulation of the median nerve at the wrist of the right hand. The impulse duration was 0.2 ms, stimulus rate was 4.7 Hz, stimulus intensity was 3.0 – 9.2 mA and sampling frequency 10 kHz. Special adhesive electrodes (Nicolet, 019-768700) were used for stimulation. The distance between the anode and the cathode was 4.3 cm.

SEPs and 600Hz oscillations were recorded using new active electroencephalographic electrodes [4,5].

Figure 1

Fig. 1a,b: Stimulation (a) and recording (b) of 600Hz brain oscillations using new active EEG electrodes for direct amplification of brain activity at the University of Graz

Figure 2

The application of the new electrodes was performed with a conventional conductive and adhesive paste (Grass, EC2). The skin-electrode impedance was below 2 kOhm. The recording position was at the cortical location C3' with a reference electrode over the frontal area (Fpz). Conventional SEPs were filtered with a band pass of 5 -–1500 Hz (- 6 dB points, 12 dB/octave). Simultaneous online digital highpass and lowpass filters (500 -–1 kHz) were applied to isolate the high-frequency bursts.

The evaluation parameters were the amplitudes of N20/P25, the maximal amplitude of 600Hz oscillations and the absolute latency of N20 component.

ACUPUNCTURE AND PROCEDURE

During the experiments the subjects were in a comfortable position on a bed in our laboratory. During continuous stimulation and recording of SEPs and 600Hz oscillations the subjects were instructed to close their eyes and relax throughout the recording session. After a ten-minute resting period 250 trials of electrical stimulation were averaged (control phase a). Then acupuncture needles were inserted into both Large Intestine 4 (LI-4, Hegu) acupoints.

Hegu (LI-4): On the dorsum of the hand, between the 1st and 2nd metacarpal bones, in the middle of the 2nd metacarpal bone on the radial side. The points were punctured perpendicularly after local disinfection of the skin with sterile single use needles 25 x 0.25 mm (Huan Qiu, Suzhou, China).

Immediately after inserting the needles the next SEP-600Hz-recording (phase b), and two minutes after starting acupuncture the next control measurement were performed (phase c). Five minutes after inserting the needles a manual stimulation of the needle was performed (phase d). The stimulation consisted of a combination of rotating and thrusting movements. A tonifying method was used. The last two recordings were made 15 minutes after inserting the needles (phase e) and two minutes after removing the acupuncture needles (phase f).

In addition in one person (age 22 years, female) a placebo measurement using identical conditions but without inserting the needles in the skin was performed.

STATISTICAL ANALYSIS

The data were tested with Kruskal-Wallis one way analysis of variance on ranks using SigmaStat software (Jandel Scientific Corp., Erkrath, Germany). The results were given as means ± standard error ((x ± SE). The criterion for significance was $p < 0.05$.

RESULTS

Figure 2 shows a typical example of SEPs and 600Hz brain oscillations in a 25-year-old healthy volunteer.

Figure 3

Fig. 2: Primary cortical SEP component and 600Hz brain oscillations in a 25-year-old female. Note the different digital filters and the different amplitudes in the responses

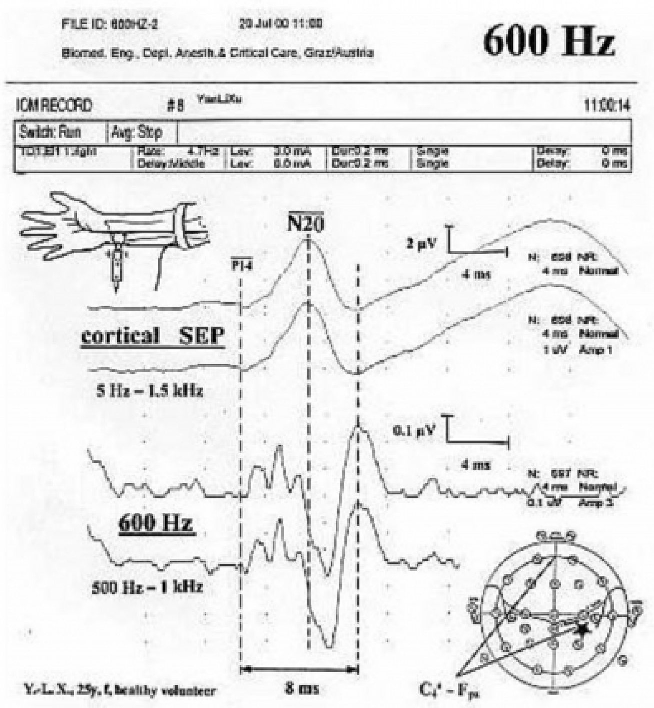


Figure 3 shows the decrease of amplitudes in N20-components and in 600Hz oscillations after acupuncture at acupoint LI-4. In addition (Fig. 3d) the result of the placebo measurement is graphically demonstrated. There was no change in amplitude or latency after placebo (simulated) needling.

Figure 4

Fig. 3: Decrease of N20 and 600Hz amplitudes after acupuncture (a-c). Note there was no decrease in amplitudes after performing placebo acupuncture

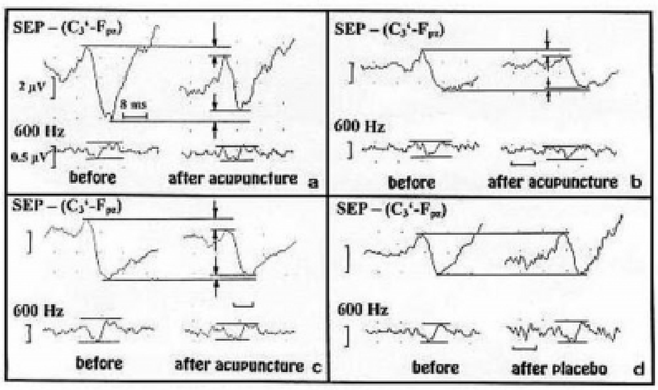
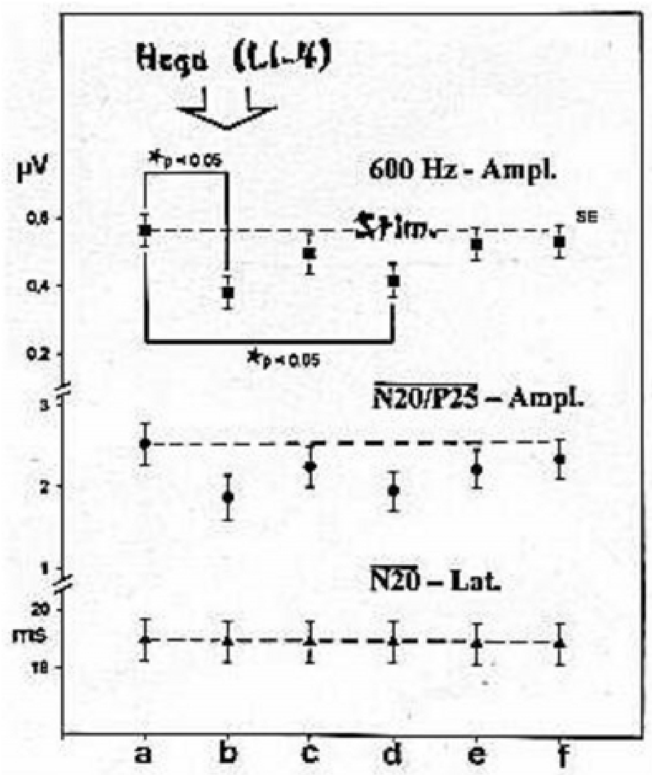


Figure 4 summarizes the data of all healthy volunteers at different phases (a-f).

Figure 5

Fig. 4: Amplitude of 600Hz brain oscillations, amplitude of the SEP-N20/P25 component and absolute latency of the N20 wave before (a), immediately after acupuncture (b), 2 minutes after starting acupuncture (c), during manual acupuncture stimulation (d), 15 minutes after inserting the needles (e) and 2 minutes after removing the needles (f). Note the significant decrease in 600Hz amplitude immediately after (b) and during acupuncture stimulation (d) in 14 healthy volunteers



DISCUSSION

The registration of SEPs is a neurophysiologic method which is used increasingly in comatose patients and in intraoperative monitoring. Normal values are necessary to interpret clinical data. The generation of SEPs has been explored extensively. However, few studies have been performed for the 600Hz bursts [6,7,8,9,10].

EEG, magnetoencephalography and electrocorticography recordings have established that the SEP-N20 component is generated by excitatory postsynaptic potentials in area 3b pyramidal cells whereas several source sites for the high-frequency oscillations have been discussed, such as thalamus, thalamocortical fibers or postsynaptic activities in the sensorimotor primary cortex 7.

Although acupuncture has a long history, the mechanisms underlying its effects are still unclear in detail. The neuromonitoring method of SEPs has been adopted in the scientific research of acupuncture since the 1970s 2,3,[11,12,13]. The effects of acupuncture on conventional SEPs are controversial 13. Since the conventional SEP is mediated mainly by fast conducting sensory nerve fibers, the methodology, especially for recording short-latency SEP, may be inadequate for studying acupuncture mechanisms13. In the case of the long-latency cortical SEPs, there is too little data available to judge the effects of acupuncture 13.

Kang and Ma11 for example reported that after manual acupuncture at the Neiguan acupoint no significant difference was detected in the early N20 component. However in one patient with abnormal SEP the latencies were improved after acupuncture, when acupuncture simultaneously decreased pain 11.

Chen and Hung2 studied SEPs evoked by electrical stimulation of the median nerve. Acupuncture was applied to the point Hegu (LI-4) at both hand. They found no significant SEP changes in 16 volunteers. However, in a study published recently, Wei et al.3 found changes in amplitudes after needling acupoint LI-4. They also studied SEPs elicited by acupuncture itself. They also chose the acupoint LI-4, because clinical observations show that there are often some special sensations when LI-4 is needled 3. Their most interesting finding was the marked differences of N20 amplitude between SEPs with acupoint stimulation and stimulation of a control point. The authors postulated that the differences between SEPs to acupoint and median nerve stimuli might be mainly due to the different distances from the stimulated regions to the cerebral cortex, and the diversity and number of activated fibers.

Hui et al.[14] recently used functional magnetic resonance imaging (fMRI) to investigate effects of acupuncture in normal subjects. Acupuncture needle manipulation was performed also at LI-4 on the hand. Needle manipulation on either hand produced prominent decreases of fMRI signals in the nucleus accumbens, amygdala, hippocampus, parahippocampus, hypothalamus, ventral tegmental area, anterior cingulate gyrus (BA24), caudate nucleus, putamen, temporal pole, and insula in all subjects who experienced acupuncture sensation. In marked contrast, signal increases were observed primarily in the somatosensory cortex 14. Two subjects of this study who experienced pain instead of acupuncture sensation exhibited signal increases instead of decreases in the anterior cinculate gyrus, caudate nucleus, putamen, anterior thalamus, and posterior insula. Superficial tactile stimulation to the same area elicited signal increases in the somatosensory cortex as expected, but no signal decreases in deep structures 14. The authors concluded that acupuncture needle manipulation at LI-4 modulates the activity of the limbic system and subcortical structures. This modulation of subcortical structures may be an important mechanism for acupuncture exerting its complex multisystem effects 14.

The results of our present study showed no changes in latency of N20 component after needling and manual stimulation of acupoint LI-4 during simultaneous electrical median nerve stimulation. Nevertheless we found a marked decrease in amplitude of the N20 component after inserting the needles in the LI-4 acupoints of both hands, and also a decrease in amplitude during stimulation of this acupoints. However, the most prominent finding in our study was a significant decrease in amplitude of 600Hz brain oscillations during the situations mentioned above.

In contrast to the N20 source amplitudes which are significantly reduced at higher stimulus rates, the source amplitudes of the 600Hz oscillations remain stable at different stimulus rates, as shown by Gobbelé et al.6. In their study, they demonstrated that N20 and 600Hz components are functionally dissociated and have different source origins.

High-frequency thalamic SEP oscillations probably reflect a superposition of slightly asynchronously triggered population spikes, generated e.g. by bursting thalamocortical relay cells 8.

CONCLUSION

Our study shows that acupuncture (LI-4) modulates the amplitude of 600Hz brain oscillations. The generators of these oscillations are discussed to be close to the thalamus and seems to originate from deep axon segments of thalamocortical fibers and from sources located in the vicinity of the primary somatosensory hand cortex 7.

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