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Electrophysiological Measures During Acupuncture-Induced Surgical Analgesia

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• **Electrophysiological recordings (electroencephalograms, somatosensory-evoked potentials, cognitive-evoked potentials) were made in five patients during acupuncture-induced analgesia for removal of a thyroid tumor. The electrophysiological measures were unchanged during the operation. Acupuncture's modes of action in producing analgesia are not revealed in this study.**

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Acupuncture has been used in China as an analgesic agent in surgical procedures, particularly those involving the brain and neck, when muscle relaxation is not essential.[1,2] The advantages of acupuncture for surgery include the preservation of alertness and the absence of complications associated with pharmacologic anesthetic agents, including postoperative depression of neurological function. Acupuncture is not used as an analgesic agent in operations performed in Western countries so opportunities for quantified studies of neural functions in such patients are rare. This article describes electrophysiological measures (electroencephalogram [EEG], somatosensory-evoked potentials [SEPs], and P300 cognitive auditory evoked potentials) performed in Hangzhou, China, on a group of five patients undergoing removal of thyroid tumors with acupuncture as the principal analgesic agent. These electrophysiological methods assess several parameters of neural function related to arousal (EEG), sensory processing (SEP),[3] and certain cognitive functions (P300)[4] that might provide insight into mechanisms active during acupuncture-induced analgesia.

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PATIENTS AND METHODS

Five patients with a thyroid mass were studied during surgical removal of their tumors using acupuncture as the principal anesthetic agent. They were informed the day of the operation that acupuncture would be used for analgesia and all consented to the study. Preoperatively the patients received 0.3 mg of scopolamine intramuscularly and a small dose, 0.05 to 0.10 mg, of fentanyl intravenously. Acupuncture needles were inserted in the ear lobes bilaterally (neck to lung point) and in the first dorsal interosseous muscle bilaterally (He Gu point). Square-wave stimulation at approximately 5 Hz was applied between the ear lobe needles or between the hand muscle needles for 20 minutes. The current intensity employed was not measured, but was sufficient to cause a small contraction of the first dorsal interosseous muscles. The acupuncture stimulus was reinstituted intermittently during the course of the operation for periods ranging up to 20 minutes. Not more than two additional doses of meperidine (pethidine), 25 mg, or fentanyl, 0.05 mg, were given intravenously during the operation. The patients were awake and alert during the operation, which lasted approximately 2 hours. They reported a sense of pressure on the neck but not pain even when the tumor mass, ranging from 2 to 5 cm, was being removed.

Electrophysiological studies were performed in the operating room. The EEG and event-related potentials to auditory and somatosensory stimulation were recorded using standard methods on a computerized system brought to Hangzhou for this study. The electrophysiological records were made before acupuncture was started, after acupuncture was initiated, during the operation, and immediately after the operation was completed and the skin sutured.

The EEG was analyzed by visual inspection for the patterns of ongoing activity. The evoked potentials were analyzed with regard to the latency of the components to somatosensory (N8, N13, and N20) and to auditory (N100, P200, and P300) stimulation. The electrophysiological tests obtained in the five patients are listed in the Table.

RESULTS

There were scarcely any changes in the electrophysiological measures, both during acupuncture and during the operation, when compared with both the preoperative and postoperative records. The EEG showed a normal waking record with alpha spindles present throughout the procedures. The alpha activity was attenuated when the patients opened their eyes. Activity in the delta band was infre-

	Electrophysiological Studies Completed*		
Patient	EEG	SEP	P300
1	+	−	−
2	+	+	−
3	+	+	+
4	+	+	+
5	+	+	−

*EEG indicates electroencephalogram; SEP, somatosensory-evoked potentials; P300, cognitive auditory-evoked potentials; plus sign, test performed; and minus sign, test not performed.

quent and no vertex waves compatible with drowsiness or sleep were encountered (Fig 1).

The SEP manifested stable latencies of the N13 spinal cord component and the N19, P22, and P27 cortical components. Even the later cortical components (P45 and N60), when present, persisted throughout the operative procedures. The records from three of the patients are illustrated in Fig 2 and show a remarkable consistency of the various components.

The long-latency auditory-evoked potential components, N100 and P200, did not change in latency during the procedures. P300 was detected in all stages of the operation in one of the patients (Fig 3), while the P300 component in the second patient, which was present both prior to and immediately after the procedures, became undetectable during the operation when this patient's mental count of the rare tones was inaccurate compared with her performance both prior to and after the operation. We were unable to clarify the reasons for that patient's poor performance at categorizing the rare tonal signals during the operation. In our experience, P300 components are usually not evoked if the subject does not engage in categorizing the signals.

COMMENT

The results show that acupuncture, effective for producing surgical analgesia, does not significantly alter the resting, waking EEG patterns, the latency of SEPs from stimulating a mixed motor-sensory nerve in the arm (the median nerve), and auditory long-

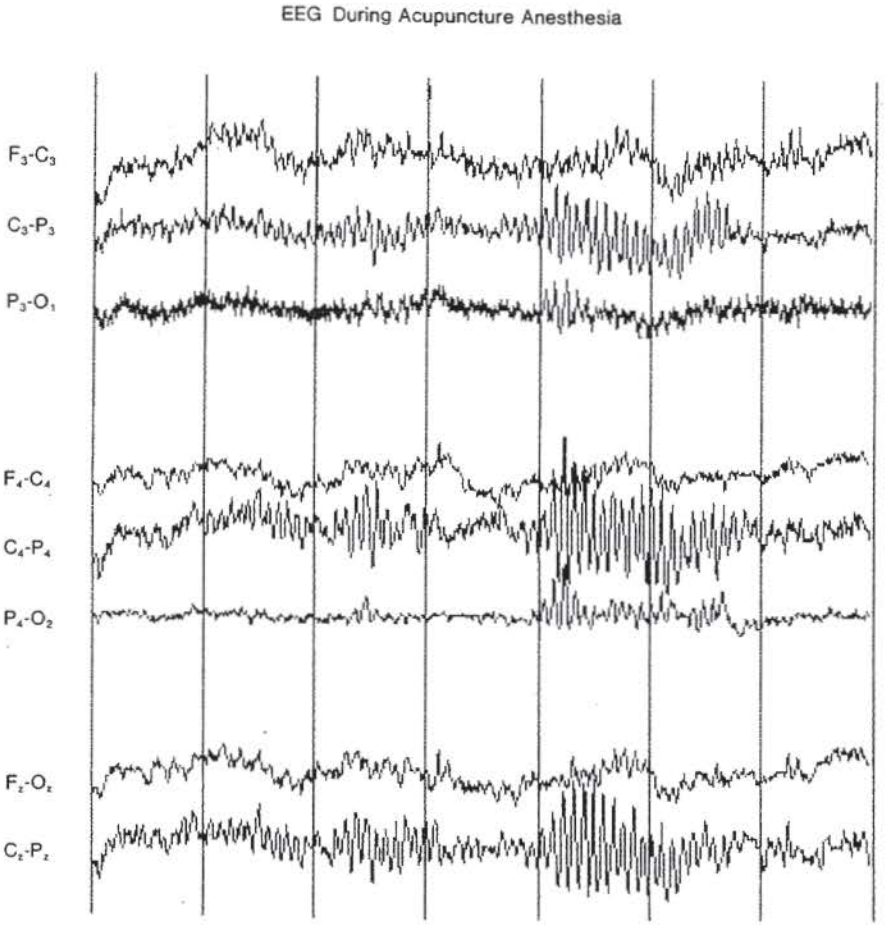

Fig 1.—To show the electroencephalogram (EEG) recorded from one of the patients during surgery for removal of a thyroid tumor. The recording montage is bipolar and parasagittal. The vertical lines are separated by 1 second. Note the well-formed alpha rhythms in the centroparietal (C_3-P_3, C_4-P_4, and C_z-P_z) records.

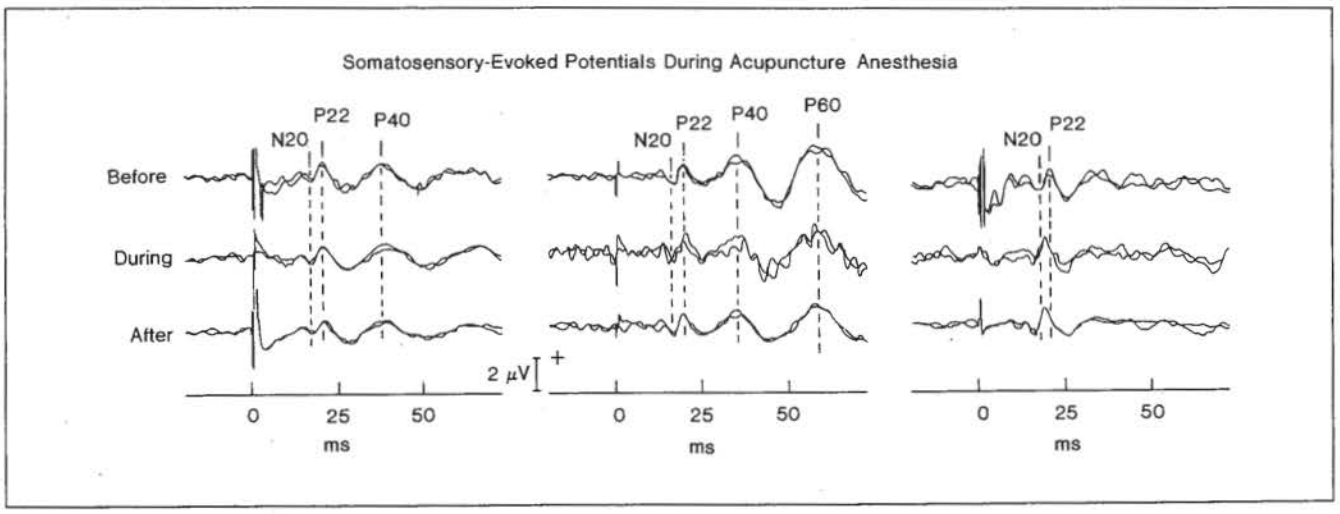

Fig 2.—To show somatosensory-evoked potentials for three of the patients before, during, and after the operation. The stimulus was to the left median nerve and recordings were made between C_4 referenced to F_{pz}. The components are identified by their polarity (P or N for positive or negative) and their approximate latency in milliseconds and are indicated by the interrupted vertical lines. Note that the components were remarkably stable during the procedures.

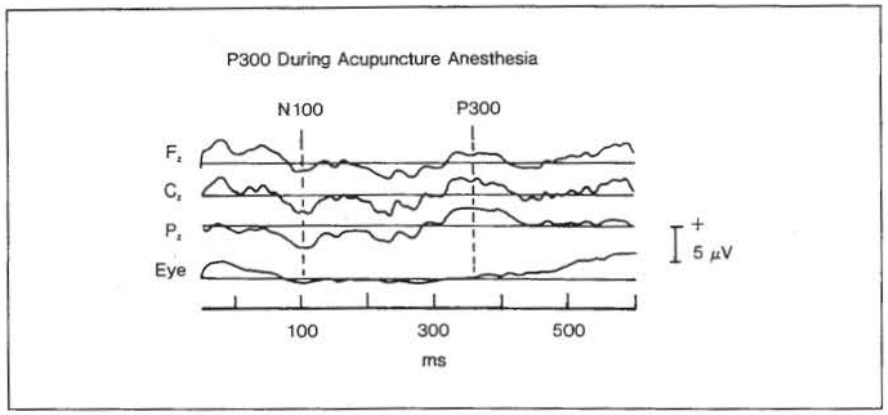

Fig 3.—Long-latency event-related potentials recorded during removal of the thyroid tumor using acupuncture as the analgesic agent. Eye movement potentials were also monitored. The occurrence of the N100 and P300 are indicated by the interrupted vertical.

latency (N100, P200) and, in one patient, even a cognitive component (P300) of auditory-evoked potentials. In retrospect, these results might have been anticipated since patients undergoing acupuncture for surgical analgesia can converse naturally, respond to requests rapidly and appropriately, and appear alert and aware of their surroundings. It is their subjective freedom from pain during the operation that distinguishes their neurological state.

There are several features of the acupuncture technique as applied to produce surgical analgesia that may be relevant for understanding the mechanisms underlying acupuncture-induced analgesia. First, the acupuncture points need to be stimulated for at least 20 minutes before analgesia is induced and then the points have to be periodically restimulated to maintain analgesia.[5,6] These observations suggest that the neural systems influenced by acupuncture require a long latency for their activation, and their effectiveness in modifying pain appreciation can persist for some time after the acupuncture stimulation is discontinued. Second, analgesia is not total and is benefited by the administration of additional medication such as fentanyl, which in the low doses employed, would not by itself be an effective analgesia for surgery.[7] Thus, the systems activated by acupuncture would seem to modify pathways subserving "pain" rather than directly blocking these pathways. Moreover, acupuncture can act synergistically with pharmacological analgesics to alter "pain" appreciation.

The electrophysiological results from this study provide objective evidence, in a negative sense, of the neural site(s) where acupuncture does *not* act. The failure to note changes in SEPs from stimulation of a mixed peripheral nerve indicates that the neural processes engaged by acupuncture do not act on the classic fast-conducting sensory pathways concerned with the transmission of tactile and proprioceptive information. The lack of any substantive EEG changes during the operation suggests that the neural systems affected by acupuncture are primarily subcortical in location with little direct influence on the resting EEG. The definition of a cognitive component of event-related potentials (P300) in one of the subjects that was similar in latency prior to, during, and after the operation indicates that acupuncture's effect is not on those neural systems related to cognitive processes of stimulus classification.

It is not novel to suggest that the endorphin neuronal system seems a likely substrate for the site of action of acupuncture analgesia.[8-11] The system is subcortical, originating in the midbrain, and descending along the periaqueductal gray to the spinal cord regions subserving nociceptive function.[12] Acupuncture-induced inhibition of brain-stem and spinal cord reflexes has been suggested to be mediated via this endorphin system.[13,14] The endorphin system does not act on the central pathways necessary for transmitting activity from large mixed nerves, such as the median and posterior tibial, to the cerebrum to obtain SEPs. Moreover, the endorphin system has been implicated in the regulation of the subjective appreciation of "pain" rather than the appreciation of other somatosensory inputs such as touch, position, and vibration. Endorphins may alter affective states, but have little influence on cognitive processes such as those involved in the successful completion of a task such as classifying signals. Thus, the application of these current electrophysiological methods to the study of a traditional Chinese technique, acupuncture, used for reducing the appreciation of "pain" has not been helpful in revealing the neural sites of action of acupuncture.

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