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Acupuncture fails to reduce but increases anaesthetic gas required to prevent movement in response to surgical incision

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Background: Acupuncture is used for clinical pain relief but has not been evaluated under clinical anaesthesia. This study was designed to compare movement in response to surgical incision in anaesthetized patients subjected to electro-acupuncture (EA) or sham procedures. Our hypothesis was that EA stimulation would reduce the requirements for anaesthetic gas.

Methods: Forty-six healthy women, scheduled for laparoscopic sterilization at a Swedish county hospital, were randomized to have either the electro-acupuncture (n = 23) or sham (n = 23) procedure between the induction of general anaesthesia and the start of surgery. The minimal alveolar concentration (MAC) of sevoflurane required to prevent neck or major limb movements in response to surgical incision was determined in each group of patients.

Results: The MAC for sevoflurane was found to be higher in the group given acupuncture than in the control group ($2.1 \pm 0.3\%$ vs. $1.8 \pm 0.4\%$; $P = 0.008$).

Conclusion: Electro-acupuncture given during general anaesthesia with sevoflurane failed to reduce but instead increased the clinical need for anaesthetic gas, possibly by reducing the anaesthetic effect of sevoflurane and/or by facilitating nociceptive transmission and/or reflex activity.

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Key words: Acupuncture; analgesia; anaesthesia, electric stimulation; inhalation; pain.

REPORTS have differed as to the clinical value of acupuncture, since the method was introduced as an anaesthetic technique in China in 1958 (1–5). One factor contributing to difficulties associated with clinical studies on acupuncture is the technical problem regarding blinding (6). Acupuncture stimulation should preferably induce Dechi, i.e. a characteristic feeling of local pain, heat, numbness or soreness, to be effective, whereas sham stimulation might induce diffuse noxious stimulation from needle penetration also in nonacupuncture point areas. This makes it virtually impossible to include sham arms in studies on acupuncture in conscious patients, although specific measures have been proposed to minimize the risk that patients notice or reveal to which study group they belong (5).

The present double-blind randomized study was designed to compare electro-acupuncture (EA) stimulation to a sham procedure in anaesthetized patients with respect to head or major limb movements on surgical incision. The hypothesis was that EA stimulation in surgical patients would reduce their requirements for anaesthetic gas supply.

Methods

Following approval by the Human Research Ethics Committee of Lund University, Sweden, we intended to include 92 adult female patients admitted for endoscopic sterilization at the Department of Gynaecology and Obstetrics at the Hospital of Helsingborg, Sweden. Exclusion criteria were physical status III or IV according to the American Society of Anaesthesiologists, regular use of analgesics, body mass index greater than $35\,kg\,m^{-2}$ and language difficulties. Before half of the patients had been included, the unblinded investigator responsible for acupuncture and sham

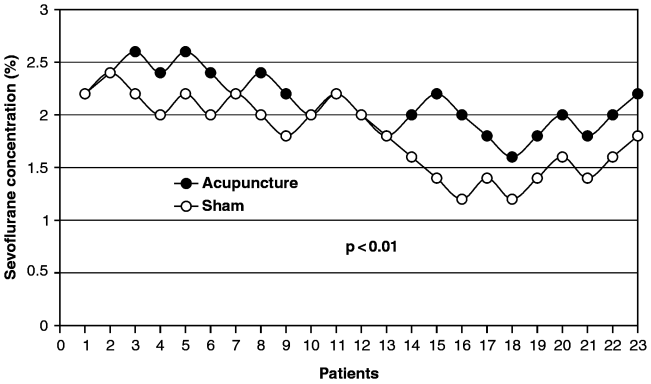

Fig. 1. Expired concentrations of sevoflurane preventing individual responses to skin incision in the study groups.

procedures noticed that considerably higher concentrations of sevoflurane were used in the acupuncture patients than in the sham patients (Fig. 1). The difference in sevoflurane concentration between the study groups was found to be highly significant on statistical analysis after inclusion of half of the patients. For ethical reasons we decided to include no further patients. Consequently, the results reported here are based on these 46 patients.

All patients received written and oral information at home in advance via mail and telephone, and had given written consent to participate in the study. They were prepared for surgery according to the established routines of the department. Adhesive, transparent dressing (Tegaderm®, 3M Health Care, Borken, Germany) was applied to the skin at all acupuncture points used in this study. A vertical drape was used to prevent the anaesthesia nurse, positioned at the head of the patient, from observing the rest of the patient (Fig. 2).

After induction of anaesthesia by facemask with 6–8% of sevoflurane in 6 $l\,min^{-1}$ of oxygen, EA

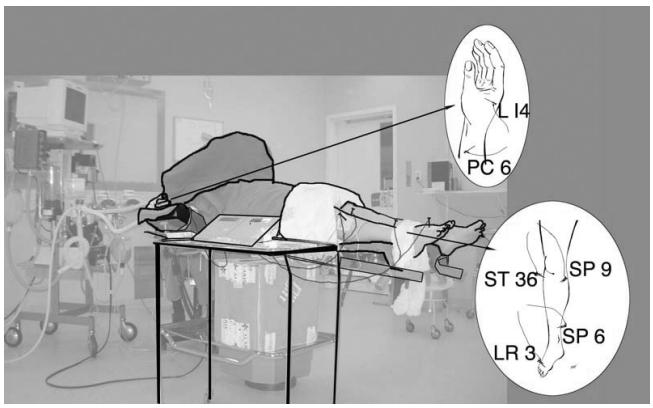

Fig. 2. Set-up with an acupuncture patient in the operating room. Acupuncture points are shown in circles. Electrodes were positioned accordingly in the sham patients.

(n = 23) or sham (n = 23) procedures were started according to a randomization list, in pairs of 10. Anaesthesia was maintained by facemask with sevoflurane in an oxygen-air mixture containing 30–40% of oxygen during the approximately 30-min study period.

Electro-acupuncture was given with an ACUS II stimulator (Cefar Medical AB, Lund, Sweden) using stainless steel 25-mm 25-G acupuncture needles (Carbo Trading Co. Inc, Scarborough, Ontario, Canada) introduced intramuscularly to a depth of 5–15 mm. Square pulses with alternating polarity (frequency 2 Hz, duration 180 μs, intensity 2.5 mA) were used for stimulation at three pairs of acupuncture points – LI4 (hegu) and PC6 (ximen)*, ST36 (zusanli) and SP9 (yinlingquan) and LR3 (taichong) and SP6 (sanyinjiao) – on the right side (Fig. 2). Previously this stimulation has been found to be tolerated well by conscious volunteers (unpublished observations, NK October 2001). These acupuncture points are considered to produce general analgesia and all have been frequently used for peroperative pain relief in China (personal communication from anaesthesiologist active during The Cultural Revolution of China, wishing to be anonymous, 2001). *To avoid accidental and unattended puncture of the radial nerve in these anaesthetized patients, we used a point located approximately 1 cm radial to the traditional point PC6 for stimulation with penetration to periosteal tissue of the radial bone (7).

In the control patients the electrodes were taped onto the skin at the same points and not connected to the electro-acupuncture device.

Acupuncture or sham procedures lasted for approximately 25 min, allowing stimulation in the acupuncture patients to be completed and alveolar concentration in all the patients to stabilize at the predetermined steady-state level.

The steady-state level of sevoflurane – defined as a difference of 0.2% or less between inspiratory and expiratory concentrations – to be used in each patient was determined from the response to surgical incision (as defined later) of the preceding patient in the same study group, according to Dixon's up-and-down method for determination of MAC (8). The first patient of each study group was exposed to 2.2% of sevoflurane at surgical incision. In each study group the concentration of sevoflurane in the next patient was increased or decreased by 0.2% depending on the motor response in the previous patient of the same study group. The MAC value of sevoflurane in each study group was defined as the mean concentration of that group (8).

Electrodes (and needles in the acupuncture patients) were removed when steady state was reached, and acupuncture points were covered with Band-aids. Reactions to surgical incision in terms of neck or limb movements as well as data on pupil size (small/dilated), orientation of eye axes (parallel/non-parallel), heart rate and blood pressure – the two latter recorded by a Datex S-5 anaesthesia monitor (Datex Ohmeda, Dansjö, Helsinki, Finland) – were assessed before and after incision by an independent observer who was not allowed to enter the room until immediately before incision. A positive reaction to surgical incision was defined as a motor response involving the neck or major limbs. From this point onwards surgery proceeded in endotracheal intubation anaesthesia according to established local guidelines.

The same two investigators were responsible for induction and initial maintenance of anaesthesia (CC), and for acupuncture or sham procedures (NK, an experienced acupuncturist), in all the patients.

Statistical methods

Originally it was calculated that 84 patients would be required to confirm a clinically relevant difference in MAC of $0.25 \pm 0.4\%$ (mean $\pm$ SD) with 95% accuracy and 80% power. We intended to include 92 patients to allow for 10% of drop-outs.

Results are given in the text, tables and figures as mean $\pm$ 1 SD for parametric data and as median with 25th and 75th percentiles in parentheses for non-parametric data.

Statistical analyses of parametric variables were made by comparing means between groups with unpaired two-sided Student's *t*-test. Differences between non-parametric variables were analyzed with the Mann–Whitney *U*-test. The SPSS software for Windows, release 11.0.0 (SPSS Inc, Chicago, IL) was used in all statistical analyses.

The level of statistical significance was set at $P < 0.05$.

Results

Surgical incision was found to induce movement of head or major limbs at a mean sevoflurane concentration of $1.8 \pm 0.4\%$ in half of the control patients and of $2.1 \pm 0.3\%$ in half of the acupuncture patients (Fig. 3) with a 95% confidence interval for the difference between means of 0.08–0.52 ($P = 0.008$).

Age, body mass index, time from induction to incision, and duration of acupuncture or sham procedures did not differ significantly between the two groups (Table 1).

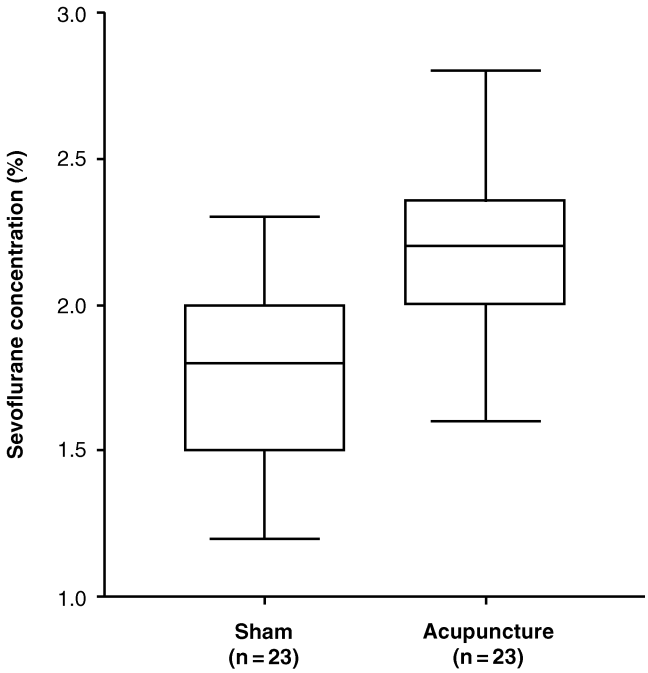

Fig. 3. Steady-state concentrations of sevoflurane used in the acupuncture and sham patients.

The mean arterial pressure was unaltered before compared with after incision in the acupuncture patients (80 and 79 mmHg, respectively) but increased significantly from 77 to 82 mmHg in the sham patients ($P = 0.028$).

Changes in pupil size, orientation of eye axes and heart rate were similar in the two groups. The mean difference between the inspiratory and expiratory concentrations of sevoflurane at steady state was $0.12 \pm 0.13\%$ in all patients, with a non-significant mean difference of 0.04% between the study groups.

Discussion

The minimal alveolar concentration of anaesthetic gas required to prevent response to surgical incision in half of the patients studied has not previously been determined to compare acupuncture and sham procedures. The higher concentration of sevoflurane found to be required in patients given EA contradicts our hypothesis that acupuncture stimulation during anaesthesia should reduce the need for anaesthetic gas on surgical incision.

The expiratory concentration of sevoflurane was adjusted to attain equal motor responses to surgical incision in the two study groups. Nonetheless, the mean arterial pressure increased significantly in the sham patients. Acupuncture patients were exposed to

Table 1

Demographic and time data (mean ± SD).

	Acupuncture group (n = 23)	Sham group (n = 23)
Age (years)	37 ± 3.6	37 ± 4.6
Body mass index (kg m^{-2})	24 ± 3.1	23 ± 2.4
Time from induction to incision (min)	32 ± 4	30 ± 4
Duration of acupuncture sham procedure (min)	24 ± 0.04	23 ± 0.03

15–20% more sevoflurane than the sham patients, which might explain their lack of blood pressure response to skin incision. It cannot be excluded from the results obtained here that EA, at least when applied under general anaesthesia, reduces autonomic responses more than motor responses to painful stimulation. Although acupuncture stimulation has also been reported to be associated with subjective stress or activation of the sympathetic system (9–11) we found no clinical signs of such activation in our patients.

The minimal alveolar concentration of sevoflurane determined in our control group, 1.8%, is in agreement with values reported by others in patients of similar age (12).

The interaction of other anaesthetic techniques with acupuncture has been studied before. In a randomized crossover study, infiltration with a local anaesthetic at the acupuncture point PC6 before acupuncture stimulation was reported to prevent an antiemetic effect achieved with acupuncture stimulation after similar local infiltration with saline (13).

To our knowledge five prospective, controlled studies on acupuncture for postoperative pain relief are reported in such detail that reproduction would be possible (1–5). An analgesic effect of acupuncture was found in three of these studies (1, 2, 5) but not in the other two (3, 4). However, the design of one study (1) reporting reduced use of analgesics in acupuncture patients during only the first two postoperative hours is dubious, since the control patients seem to have had an approximately half-hour shorter period of anaesthesia than the acupuncture patients.

In a recent experimental randomized and controlled study on analgesic effects of acupuncture under general anaesthesia no difference was found in MAC of desflurane between volunteers given acupuncture or placebo (14). In that study the effect of EA – given at three acupuncture points (ST 36, GB 38 and BL 60) on the legs during a period of time not reported, using alternating 2 Hz and 100 Hz stimulation with gradually increasing intensity up to a level immediately below that inducing muscle contractions - was assessed from physiological responses to noxious electrical stimuli applied close to the acupuncture points, increasing intensity up to a level immediately below that inducing muscle contractions.

Patients given peroperative electro-acupuncture at the ear together with transcutaneous nerve stimulation (TENS) under general anaesthesia for retroperitoneal lymph node dissection have been found to require far less fentanyl than control patients (1.2 vs. 23 μg kg^{-1}) despite similar heart rate and blood pressure levels (2).

In two randomized, double-blind studies (15, 16) it has been reported that lower concentrations of volatile anaesthetic were required during high-frequency TENS than during sham procedures. In those studies, the TENS electrodes were positioned regionally in hand surgery patients (15) or in front of the ear in healthy volunteers (16), and physiological responses to surgical incision and noxious electrical stimulation, respectively, were studied.

We have found only one randomized open study on acupuncture with results comparable to ours (17). Awake patients given manual stimulation at both local and general acupuncture points before dental extractions had higher total pain scores and were given more analgesics in the postoperative period than were control patients given no sham stimulation and patients given acupuncture postoperatively.

In conclusion, we have shown that stimulation with EA in patients under general anaesthesia with sevoflurane fails to reduce the need for general anaesthesia. Instead a higher concentration of anaesthetic agent was required to prevent major movement in response to surgical incision in the acupuncture group. Our study provides no data to confirm or reject possible explanations for these findings, e.g. mutual antagonism between anaesthetic agents and EA facilitation of nociceptive transmission or reflex activity at spinal level, activation of endogenous opioid antagonists, arousal resulting from pain induced by stimulation in acupuncture patients or contralateral hyperalgesia following ipsilateral acupuncture stimulation. Further studies are required to explain the effects of acupuncture in anaesthetized patients found in the present study.

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