Anaesthesia, 2002, **57**, pages 1159–1163

MAIN ARTICLE

The effect of auricular acupuncture on anaesthesia with desflurane

A. Taguchi,[1] N. Sharma,[1] S. Z. Ali,[1] B. Dave,[2] D. I. Sessler[3,4] and A. Kurz[5,6]

1 Research Fellow, Department of Anaesthesiology, Washington University, St Louis, Missouri, USA 2 Assistant Professor, Department of Anaesthesiology, Washington University, Pain Control Center, Creve Coeur, St. Louis, Missouri, USA 3 Associate Dean for Research, Director OUTCOMES RESEARCH™ Institute, Weakley Distinguished University Professor, University of Louisville, Louisville, Kentucky, USA 4 Professor and Vice-Chair, Ludwig Boltzmann Institute, University of Vienna, Vienna, Austria 5 Associate Professor, Director, Division of Clinical Research, Department of Anaesthesiology, Washington University, 660 S. Euclid Avenue, St. Louis, MO 63110, USA 6 Professor, Department of Anaesthesiology and Intensive Care Medicine, University of Vienna, Vienna, Austria

Summary

In most acupuncture studies it is difficult or even impossible to conduct a truly double-blind trial. However, this is possible when treatments are carried out on anaesthetised patients. Because acupuncture provides analgesia, we tested the hypothesis that needle stimulation of a combination of four ear acupoints would significantly reduce anaesthetic requirement. Ten healthy volunteers were anaesthetised with desflurane and randomly assigned to no treatment or acupuncture; the alternative treatment was given on a subsequent study day. Auricular acupuncture was performed with needles placed at the Shen Men, Thalamus, Tranquiliser and Master Cerebral Points on the right ear. Anaesthetic requirement, determined by the Dixon up-and-down method, was defined by the average desflurane concentration that prevented purposeful movement of the extremities in response to noxious electrical stimulation. Volunteers required a greater desflurane concentration to prevent movement on the control than on the acupuncture day: 4.9 (0.7; SD) vs. 4.4 (0.8) - vol. %, $p = 0.003$. Acupuncture thus reduced anaesthetic requirement by 8.5 (7)%.

Keywords *Acupuncture*: auricular. *Anaesthesia*: desflurane.

Correspondence to: Dr A. Kurz
Accepted: 10 July 2002

Acupuncture has been an integral part of traditional Chinese medicine for more than 2500 years. Acupuncture is thought to prevent or treat disease and pain by stimulating certain points on the body. Acupuncture theory is based on patterns of energy flow through the body that are thought to combine circulation and neurological function. However, the scientific basis for acupuncture remains unclear because the traditional system of acupuncture points does not correspond to Western concepts of anatomy or neurology.

Surprisingly few acupuncture studies meet contemporary research standards. The vast majority of studies consist of case reports, case series or interventional studies with designs inadequate to assess efficacy. However, inadequate validation has not stopped acupuncture from becoming a popular pain treatment in the USA.

During general anaesthesia it is possible to completely double-blind acupuncture treatments. To the extent that acupuncture provides analgesia, it might be expected to reduce the need for conventional anaesthetic drugs. Reduced drug use would not only directly decrease cost but also might indirectly decrease cost and improve patient care by speeding postoperative recovery.

We recently reported the first fully double-blinded and randomised crossover study of acupuncture analgesia [1]. It showed that electro-acupuncture at the Lateralisation-Stabilisation Point reduces anaesthetic requirement by 11%. Whereas highly statistically significant, this 11% reduction in anaesthetic requirement is of questionable

clinical importance. However, it does offer the intriguing possibility that other types of acupuncture might provide a clinically important reduction in anaesthetic requirement. Our goal was thus to evaluate another type of acupuncture in the hopes that it would provide greater benefit.

Because we hope to develop a system that can be incorporated into routine practice by practising clinicians, we restricted our search to acupuncture methods that are relatively easy to use and can thus be learned without special training. We further restricted our search to techniques that are believed to provide generalised (as opposed to local or regional) analgesia because they could be used more widely. Finally, we combined stimulation at a number of acupuncture points in an effort to increase the total effect. We tested the hypothesis that needle stimulation of a combination of four auricular acupuncture points would significantly reduce the anaesthetic requirement for desflurane in healthy volunteer subjects.

Methods

With Institutional Review Board approval and informed consent, we studied 10 volunteers (9 men, 1 woman). Each was evaluated on two randomly assigned study days, separated at least by at least 48 h. None was obese, pregnant, taking any medication or had a history of infection, recent fever, diabetes or problems with general anaesthesia. No volunteer had a history of chronic pain. The volunteers reclined on a padded table in the Anaesthesia Clinical Research Area during the study.

Each set of studies began at the same time of day because circadian rhythms may influence anaesthetic requirement [2]. Volunteers fasted and refrained from smoking for at least 8 h before arriving at the laboratory. No premedication was given. An 18-gauge catheter was inserted in a left forearm vein for fluid and drug administration. On each study day, anaesthesia was induced with $\approx$ 3–4 mg.kg^{-1} intravenous propofol. After loss of the eyelash reflex, a laryngeal mask airway was inserted. Ventilation was assisted until spontaneous breathing was re-established.

Anaesthesia was maintained with desflurane in 80% oxygen and 20% nitrogen. We used 80% oxygen because we have shown previously that it halves the incidence of postoperative nausea and vomiting [3, 4] without causing atelectasis [5]. Hypothermia reduces anaesthetic requirement by $\approx$5% per °C [6]. We thus used surface warming to maintain a core temperature near 36 °C.

After induction of anaesthesia, the volunteers' assignments were determined by opening sequentially numbered opaque envelopes containing a computer-generated code. On treatment days, acupuncture was performed by or under direct observation of an experienced specialist. The acupuncture needles (0.2 × 30 mm, Seirin Kasei Co. Ltd, Japan) were inserted 1–2 mm under the skin at four auricular points on the right ear. The first was the Shen Men, located at the superior and central to the curving tip of the Triangular Fossa. The second point was the Thalamus Point (subcortex), located at the base of the Concha Wall, which lies behind the Antitragus. The third point was the Tranquiliser Point, located at the inferior Tragus as it joins the face, and the last point was the Master Cerebral, located where the ear lobe meets the face (Fig. 1). These points are believed to provide generalised analgesia as well as sedation. On control days, needles were not inserted.

On both treatment and control days, a bulky gauze bandage was secured over the treatment area so that it was impossible for other investigators to determine whether needles had been inserted. A second team who were unaware of the volunteer's treatment status then replaced the initial anaesthetist and investigator.

Anaesthesia was initially maintained with desflurane, 5.5 vol.-%. Anaesthetic requirement was defined by the average partial pressure of desflurane required to prevent movement in response to noxious electrical stimulation. The electrical stimulation was given via two 25-G needles that were inserted intradermally into the lower portion of each anterior thigh. A 65–70 mA, 100-Hz tetanic electrical current, applied to both thighs and maintained

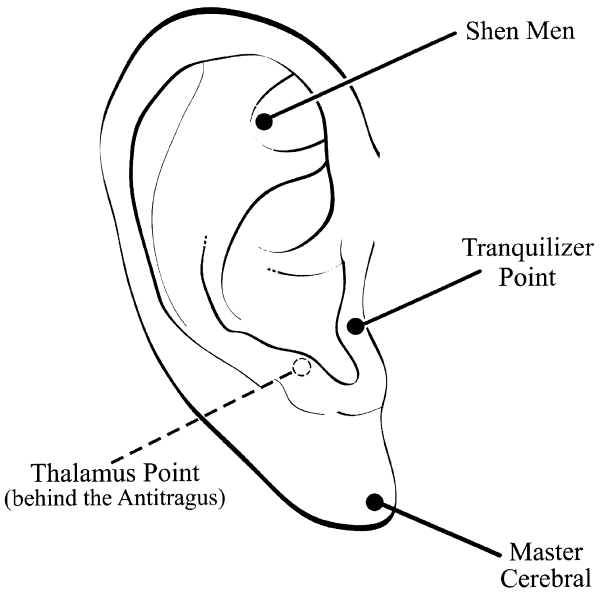

Figure 1 The auricular four acupuncture points used in the study: Shen Men, Thalamus Point (behind the Antitragus), Tranquiliser Point and Master Cerebral [22].

for 10 s, provided the noxious stimulus. A tetanic stimulus even 20% of this intensity is unbearable to anaesthetised subjects. To prevent desensitisation at the needle insertion site, the electrodes were moved cranially by 1 cm after each stimulation. The first stimulation was given 1 h after induction.

We first evaluated movement after the end-tidal desflurane concentration had been constant at 5.5 vol.-% for 15 min. If the volunteer moved in response to noxious electrical stimulation, the desflurane concentration was subsequently increased by 0.5 vol.-%. In contrast, the desflurane concentration was reduced by 0.5 vol.-% when the volunteer did not move. A purposeful movement of one or more extremities defined a positive response to noxious electrical stimulation. Grimacing and head movement were not considered purposeful responses.

The new end-tidal desflurane partial pressure was maintained for 15 min to allow alveolar-to-brain equilibration, and the process repeated. We continued this up-and-down sequence until the volunteer 'crossed-over' from movement to non-movement four times. This paradigm is referred to as the 'Dixon up-and-down' method [7] and is the standard technique for evaluating anaesthetic potency [8].

At the end of the study, the blinded investigators left the room, and the non-blinded investigators removed the acupuncture needles. Anaesthesia was discontinued, and the study day ended after a suitable period of supervised recovery. Because acupuncture needles are so fine, it was impossible for the recovering volunteers to determine whether they had been given acupuncture on any particular study day.

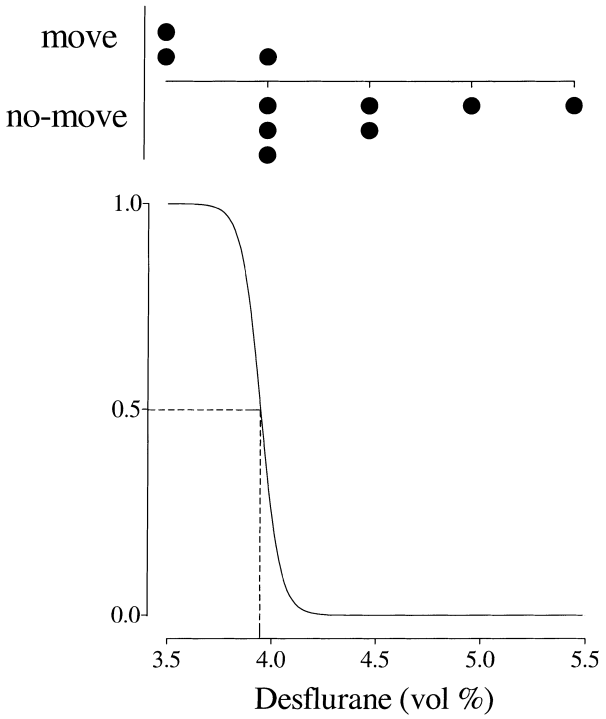

Figure 2 Typical results from a single volunteer on one study day. Movement and lack of movement are shown for each tested end-tidal desflurane concentration. The resulting logistic regression identifies the desflurane partial pressure at which there is a 50% chance of movement in response to noxious electrical stimulation.

Measurements

We recorded morphometric and demographic characteristics of the volunteers. End-tidal desflurane vol.-% and carbon dioxide were measured using an Ohmeda Rascal monitor (Ohmeda Inc, Salt Lake City, UT) that was calibrated daily. The resolution of this device is 0.1% desflurane. End-tidal concentrations of volatile anaesthetic agents and carbon dioxide are virtually identical to alveolar concentrations [9].

All standard anaesthetic safety values were monitored and recorded. These included heart rate and blood pressure, which were determined oscillometrically (Modulus CD, Ohmeda, Inc.) at 5-min intervals and before every tetanic stimulation. A pulse oximeter continuously determined arterial oxygen saturation. Core body temperature was measured from the tympanic membrane using Mon-a-Therm® thermocouples (Tyco-Mallinckrodt, Inc. St. Louis, MO, USA).

Before discharge, we asked the volunteers to guess whether they had been treated with acupuncture. We separately asked the blinded investigators the same question.

Data analysis

Haemodynamic responses, core temperature, and end-tidal P_{CO_2}, were first averaged over each study day for each volunteer, and then averaged among the volunteers given each treatment. Logistic regression was used to determine the partial pressure of desflurane that produced a 50% likelihood of movement in response to noxious stimulation in each volunteer on each study day (Fig. 2).

Values on the acupuncture and control days were compared with two-tailed, paired *t*-tests. The reduction in anaesthetic requirement resulting from acupuncture was calculated as a percentage of the control requirement. Results are presented as mean (SD); $p < 0.05$ was considered statistically significant.

Results

The mean age of the volunteers was 26 (6) years, weight was 74 (9) kg and height was 175 (9) cm. The duration of anaesthesia averaged 199 (40) min. Five subjects devel-

Table 1 Potential confounding factors.

	Control	Acupuncture	p
Induction propofol; mg.kg^{-1}	3.8 (1.1)	3.7 (1.2)	0.91
Mean arterial pressure; mmHg	71 (12)	74 (11)	0.21
Heart rate; beat.min^{-1}	65 (11)	66 (10)	0.66
Core temperature; °C	36.6 (0.4)	36.5 (0.2)	0.75
End-tidal P_{CO_2}; mmHg	46 (2)	45 (2)	0.06
Acupuncture stimulus left side; mA	71 (9)	69 (7)	0.97
Acupuncture stimulus right side; mA	70 (7)	69 (7)	0.96
Time to first crossover; min	119 (22)	131 (43)	0.38

Crossovers were defined by the transition from movement to no movement in response to noxious electrical stimulation. Values are presented as mean (SD). Values were compared with two-tailed, paired *t*-tests.

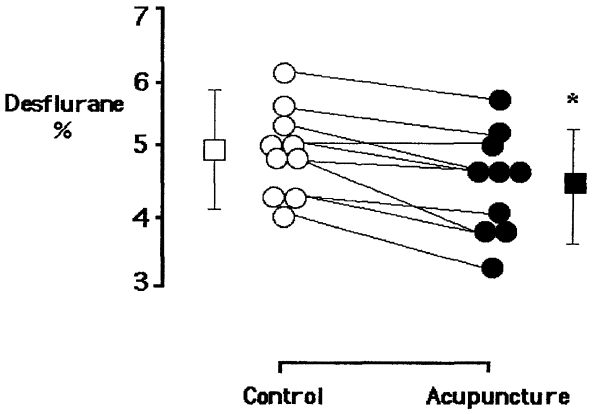

Figure 3 Circles show the individual concentrations of desflurane required to prevent movement in response to intense electrical stimulations in volunteers, with acupuncture and without acupuncture (control). Squares indicate the averages for each treatment, along with standard deviations. Asterisk (*) identifies difference from control, $p < 0.05$.

oped postanaesthetic nausea and/or vomiting (one after both study days, three after a control day, and one after an acupuncture day).

Potential confounding factors were similar on the acupuncture and control days (Table 1). The subjects required a greater desflurane concentration to prevent movement on the control day than on the acupuncture day: 4.9 (0.7) vs. 4.4 (0.8) vol.-%, $p = 0.003$ (Fig. 3). Acupuncture thus reduced anaesthetic requirement by 8.5 (7)%.

Discussion

Acupuncture has been reported to be effective in numerous non-blinded [10, 11] and sham-controlled trials [12–14], whereas others report no benefit [15–21]. Our recent study in anaesthetised volunteers constitutes the first fully double-blinded trial demonstrating acupuncture-induced analgesia [1]. Acupuncture reduced desflurane requirement by 11% ($p < 0.001$) in that study.

Consequently, we focused on four of the most important and common auricular points, which are associated with analgesia and sedation (Fig. 1). Stimulation of the first point, Shen Men, is associated with both calming and analgesic effects. The second point, the Thalamus Point (subcortex), is also associated with both calming and analgesic effects. The Tranquiliser Point, our third point, is associated with a general sedative effect facilitating overall relaxation and relieving generalised anxiety. Our fourth point, Master Cerebral, is associated with diminishing nerve anxiety and fear.

Acupuncture needles inserted into the skin, the subcutaneous tissue and deeper structures of fascia, muscle, tendon and periosteum appear to stimulate primarily small myelinated A-afferent nerve fibres and small myelinated group II and group III nerve fibres in muscles. Depending on the depth of insertion, different efficacy can occur. Consequently, the acupuncture in our study was done under observation of an acupuncture specialist.

Using the above points, our results were similar to the previously performed double-blinded and randomised crossover study using electro-acupuncture at the Lateralisation-Stabilisation Point [1]. Acupuncture at that point provided a statistically significant reduction in anaesthetic requirement −5.5 (1.0) on control day vs. 4.6 (0.6) on the acupuncture day. However, the overall reduction in anaesthetic requirement was ≈11%. In our study, the reduction in anaesthetic requirement was slightly less (8.5%). This can be explained by the fact that the previous study evaluated equal numbers of men and women and the reduction in anaesthetic requirement was significantly more pronounced in the female population (≈ 13%). In our study we mainly studied male volunteers (9 of 10 total) and their reduction in anaesthetic requirement was similar to the male population in the previous study.

The subjects were given propofol 3–4 mg.kg^{-1} at induction. Propofol is a short-acting drug and following a single bolus injection, whole blood propofol levels decrease rapidly as a result of both reduction and

elimination. Nevertheless, we waited 1 h before we administered the first stimulation, to make sure that no propofol effect would remain and a constant desflurane level had been established.

In summary, our subjects required more desflurane to prevent movement on the control day than on acupuncture day: 4.9 (0.7) vs. 4.4 (0.8) vol.-% ($p = 0.003$). Auricular acupuncture thus reduced anaesthetic requirement by 8.5%. Although the reduction we observed is relatively small, this study does demonstrate that acupuncture decreases anaesthetic requirement in a rigorously double-blinded protocol. This work thus suggests that additional studies, evaluating other types of acupuncture, are warranted.

Acknowledgements

Supported by Jewish Hospital Foundation (Louisville, KY), NIH Grant GM 58273 (Bethesda, MD), the Joseph Drown Foundation (Los Angeles, CA), and the Commonwealth of Kentucky Research Challenge Trust Fund (Louisville, KY). Tyco-Mallinckrodt Inc. (St. Louis, MO) donated the thermocouples we used. None of the authors has any financial interest in products related to this study.

References

1 Greif R, Laciny S, Mokhtarani M *et al.* Transcutaneous electrical stimulation of an auricular acupuncture point decreases anesthetic requirement. *Anesthesiology* 2002; **96**: 306–12.

2 Munson ES, Martucci RW, Smith RE. Circadian variations in anesthetic requirement and toxicity in rats. *Anesthesiology* 1970; **32**: 507–14.

3 Greif T, Laciny S, Rapf B, Hickle RS, Sessler DI. Supplemental oxygen reduces the incidence of postoperative nausea and vomiting. *Anesthesiology* 1999; **91**: 1246–52.

4 Goll VOA, Greif R *et al.* Ondansetron is no more effective than supplemental intraoperative oxygen for prevention of postoperative nausea and vomiting. *Anesthesia and Analgesia* 2001; **92**: 112–17.

5 Akça O, Podolsky A, Eisenhuber E *et al.* Comparable postoperative pulmonary atelectasis in patients given 30% or 80% oxygen during and for two hours after colon resection. *Anesthesiology* 1999; **91**: 991–8.

6 Eger EI II, Johnson BH. MAC of I-653 in rats, including a test of the effect of body temperature and anesthetic duration. *Anesthesia and Analgesia* 1987; **66**: 974–6.

7 Dixon WJ. Quantal-response variable experimentation: the up-and-down method. In: McArthur, JW, Colton, T, eds. *Statistics in Endocrinology*. Cambridge, MA: MIT Press, 1970; 251–67.

8 Fahey MR, Sessler DI, Cannon JE, Brady K, Støen R, Miller RD. Atracurium, vecuronium, and pancuronium do not alter the minimum alveolar concentration of halothane in humans. *Anesthesiology* 1989; **71**: 53–6.

9 Lockhart SH, Cohen Y, Yasuda N *et al.* Absence of abundant binding sites for anesthetics in rabbit brain: an *in vivo* NMR study. *Anesthesiology* 1990; **73**: 455–60.

10 Tsunoda Y, Sakahira K, Nakano S *et al.* Antagonism of acupuncture analgesia by naloxone in unconscious man. *Bulletin of Tokyo Medical and Dental University* 1980; **27**: 89–94.

11 Tseng CK, Tay AA, Pace NL, Westenskow DR, Wong KC. Electro-acupuncture modification of halothane anaesthesia in the dog. *Canadian Anaesthetists Society Journal* 1981; **28**: 125–8.

12 Lao L, Bergman S, Hamilton GR, Langenberg P, Berman B. Evaluation of acupuncture for pain control after oral surgery: a placebo-controlled trial. *Archives of Otolaryngology – Head and Neck Surgery* 1999; **125**: 567–72.

13 Simmons MS, Oleson TD. Auricular electrical stimulation and dental pain threshold. *Anesthesia Progress* 1993; **40**: 14–19.

14 Lenhard L, Waite PM. Acupuncture in the prophylactic treatment of migraine headaches: pilot study. *New Zealand Medical Journal* 1983; **96**: 663–6.

15 Vilholm OJ, Moller K, Jorgensen K. Effect of traditional Chinese acupuncture on severe tinnitus: a double-blind, placebo-controlled, clinical investigation with open therapeutic control. *Anesthesia and Analgesia* 1998; **32**: 197–204.

16 Tavola T, Gala C, Conte G, Invernizzi G. Traditional Chinese acupuncture in tension-type headache: a controlled study. *Pain* 1992; **48**: 325–9.

17 Takeda W, Wessel J. Acupuncture for the treatment of pain of osteoarthritic knees. *Arthritis Care and Research* 1994; **7**: 118–22.

18 Mendelson G, Kidson MA, Loh ST, Scott DF, Selwood TS, Kranz H. Acupuncture analgesia for chronic low back pain. *Clinical and Experimental Neurology* 1978; **15**: 182–5.

19 Gaw AC, Chang LW, Shaw LC. Efficacy of acupuncture on osteoarthritic pain. A controlled, double-blind study. *New England Journal of Medicine* 1975; **293**: 375–8.

20 Hansen PE, Hansen JH, Bentzen O. Acupuncture treatment of chronic unilateral tinnitus – a double-blind cross-over trial. *Clinical Otolaryngology* 1982; **7**: 325–9.

21 Jerner B, Skogh M, Vahlquist A. A controlled trial of acupuncture in psoriasis: no convincing effect. *Acta Dermato-Venereologica* 1997; **77**: 154–6.

22 Oleson T. *Auriculotherapy Manual. Chinese and Western Systems of Ear Acupuncture*, 2nd edn. Los Angeles, CA: Health Care Alternatives, 1998: 35.

