Analgesic Effect of Electroacupuncture in Postthoracotomy Pain: A Prospective Randomized Trial

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Background. The role of electroacupuncture in postthoracotomy pain control is uncertain. We conducted a pilot study to evaluate the role of electroacupuncture in the management of early postthoracotomy wound pain.

Methods. A total of 27 patients with operable non–small cell lung carcinoma who received thoracotomy were recruited and randomized to receive either electroacupuncture or sham acupuncture in addition to routine oral analgesics and patient-controlled intravenous analgesia for postoperative pain control. All patients received acupuncture twice daily with visual analog pain score recorded for the first 7 postoperative days. Specific chest acupoints (LI 4, GB 34, GB 36, and TE 8) were targeted. Patient-controlled analgesia was used for the first 3 postoperative days in all patients, and the cumulative dosage used was recorded.

Results. Two patients were excluded after randomization because of complications unrelated to acupuncture. Interventions and data collection were completed for the remaining 25 patients (13 in the electroacupuncture group; 12 in the sham acupuncture group). There was a trend for lower visual analog scale pain scores in the electro-acupuncture group between postoperative days 2 and 6, although this did not reach statistical significance. The cumulative dose of patient-controlled analgesia morphine used on postoperative day 2 was significantly lower in the electroacupuncture group (7.5 ± 5 mg versus 15.6 ± 12 mg; $p < 0.05$). Such delay of onset of pain control may be related to the frequency of electroacupuncture used.

Conclusions. Electroacupuncture may reduce narcotic analgesic usage in the early postoperative period. A prospective randomized controlled trial using different electroacupuncture frequency is warranted to verify this benefit.

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Acupuncture has been widely practiced in China for more than 4,000 years. It is believed that fine needles inserted at specific points on the body can rebalance the flow of energy (*Qi*) along meridians, imparting specific health benefits. During the past few decades, there has been a growing appreciation of acupuncture in the West. One of the key potential benefits of acupuncture was its application in locoregional anesthesia for the treatment of various forms of pain. Recent studies showed promising results of the use of acupuncture in early postoperative pain management in various kinds of surgery [1–3]. In cardiothoracic surgery, the posterolateral thoracotomy is the gold standard of surgical access to the thorax for anatomic lung resection. Unfortunately, the standard thoracotomy is also arguably the most painful incision in all of surgery. Although in most of the cases, postthoracotomy wound pain could be satisfactorily controlled with narcotic analgesics, excessive usage is associated with side effects such as constipation, nausea, and respiratory suppression. There is a potential role of acupuncture in lowering the narcotic analgesic requirements in the early postoperative period.

Although widely practiced in China, there has been no conclusive evidence from clinical trials and meta-analyses in the Western world to support the use of acupuncture as an adjunct to anesthesia or postoperative pain control [4]. One intrinsic problem in developing a randomized controlled trial to test the effect of acupuncture is that no good sham control model has so far been established [5]. Without such a sham control group, it is difficult to isolate the placebo effect from the actual therapeutic effect of acupuncture.

Herein, we report a prospective, randomized, controlled trial of the use of acupuncture for postthoracotomy pain control. An effective control was established using a novel sham acupuncture device.

Patients and Methods

Patient Selection and Surgical Protocol

The study design was a randomized, double-blind, placebo-controlled trial conducted at the Cardiothoracic

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Table 1. Anatomic Locations and Therapeutic Effect of Acupuncture Points

Acupuncture Point	Location	Therapeutic Effect	Depth (inches)
Hegu (LI 4)	Dorsal aspect of the palm Midway between first and second metacarpal Midpoint of the lateral aspect of the second metacarpal	1. Numbness and paralysis of upper limbs 2. Cough 3. Pain relief	0.5–1
Yanglingquan (GB 34)	Indentation of skin just below the head of fibula	Shortness of breath	1–1.5
Sanyangluo (TE 8)	Dorsal aspect of forearm Midway between ulna and radius 4 cm caudal to the proximal wrist crease	Upper limbs pain relief	0.5–1
Waiqiu (GB 36)	7 inches caudal to the lateral malleolus Along the anterior border of the fibula	Chest wall pain relief	0.3–0.5

GB = gall bladder meridian of foot—*Shaoyang*; LI = large intestine meridian of hand—*Yangming*; TE = triple energizer meridian of hand—*Shaoyang*.

Surgical Unit of a tertiary referral university-teaching hospital in Hong Kong. Patients diagnosed to have operable non–small cell lung carcinoma, and whose primary tumor was equal or larger than 4 cm in diameter precluding a video-assisted thoracic surgery approach, were eligible for study. From January 2002 to August 2004, 32 consecutive patients referred to our unit for operable lung cancer fulfilled these inclusion criteria. Twenty-seven of them gave informed consent to our study, whereas 5 patients declined. The study design was approved by the Ethics Committees of the Chinese University of Hong Kong and of the Hospital Authority of Hong Kong.

All patients underwent anatomic lung resection with curative intent through a thoracotomy approach by a single thoracic surgeon. All patients received standardized doses of induction anesthesia (0.1 mg/kg morphine and 2 mg/kg fentanyl) and maintenance anesthesia (morphine 0.05 $mg \cdot kg^{-1} \cdot h^{-1}$). We use a controlled rib-fracture technique for our thoracotomy, and routinely place two 24F chest tubes. The chest tubes are removed when there has been no air leak for more than 24 hours and when the daily drain output is less than 150 mL.

The patients were randomized to receive either electroacupuncture (EA) or sham acupuncture (SA). Randomization lists were generated by a computer program and sealed in envelopes containing individual group allocation and consecutive number. The envelopes were opened and the results disclosed in the immediate postoperative period by the acupuncturist. Both the patients and all surgeons in charge of postoperative patient care were blinded to the nature of the acupuncture. There was no crossover between groups.

In addition to acupuncture, both groups of patients received intravenous patient-controlled analgesia (PCA) containing 1 mg of morphine per bolus with a lockout time of 5 minutes for the first 3 postoperative days. All patients were also prescribed oral analgesics containing 640 mg of acetaminophen and 65 mg of dextropropoxyphene four times per day for pain relief throughout their postoperative in-hospital stay.

Electroacupuncture and Sham Acupuncture (Placebo)

Acupuncture was commenced immediately on return of the patient to the ward after surgery. All patients received two 30-minute acupuncture sessions (both EA and SA groups) each day for the first 7 postoperative days. All acupuncture interventions were performed by two registered physiotherapists accredited with diplomas in acupuncture issued by Hong Kong Baptist University and International Acupuncture Institute. Single-use, silver-handle, sterile needle of size 50 mm × 0.25 mm were used for all acupunctures performed.

Selection of acupuncture points was based on a consensus between the chief acupuncturist (from the Clinical Trial Center of the Institute of Chinese Medicine, the Chinese University of Hong Kong) and the two physiotherapist-acupuncturists of this study. The points selected were the LI 4, GB 34, GB 36, and TE 8 points ipsilateral to the side of the thoracotomy, and which are recognized to influence the chest wall and upper body. To avoid interference with acupuncture, blood-sampling and intravenous catheters were prohibited in the ipsilateral upper and lower limbs. The anatomic location of these acupoints and their expected clinical effects are summarized in Table 1.

For EA, after needle insertion, a state of *De-Qi* characterized by sensation of heaviness, fullness, and numbness was reached by adjusting the intensity of the electrostimulator (IC-1107+, ITO Ltd, Tokyo, Japan). An alternating current at 60 Hz was applied to the acupuncture needle for 30 minutes per session.

For SA (the placebo control), a special blunt-tip needle (homemade) was used, and pseudostimulation from the electrostimulator was given. The blunt-tip needle was pressed to the same acupoints as in the EA group, mimicking the pinprick sensation without actual skin piercing, and was fixed with an opaque fixator to blind

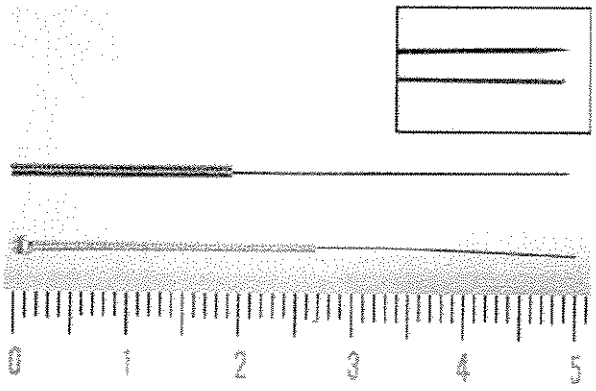

Fig 1. Contrast between the needle used in electro-acupuncture (upper, sharp tip) and sham acupuncture (lower, blunt tip).

the assessor to the intervention given. The appearance of the genuine and sham needle is shown in Figure 1. Pseudostimulation was given by deliberately connecting the needle to the incorrect output socket of the electrostimulator. Hence there was no flow of electrical current, and the state of *De-Qi* was not reached. The cross-sectional diagram of the SA setup is shown in Figure 2.

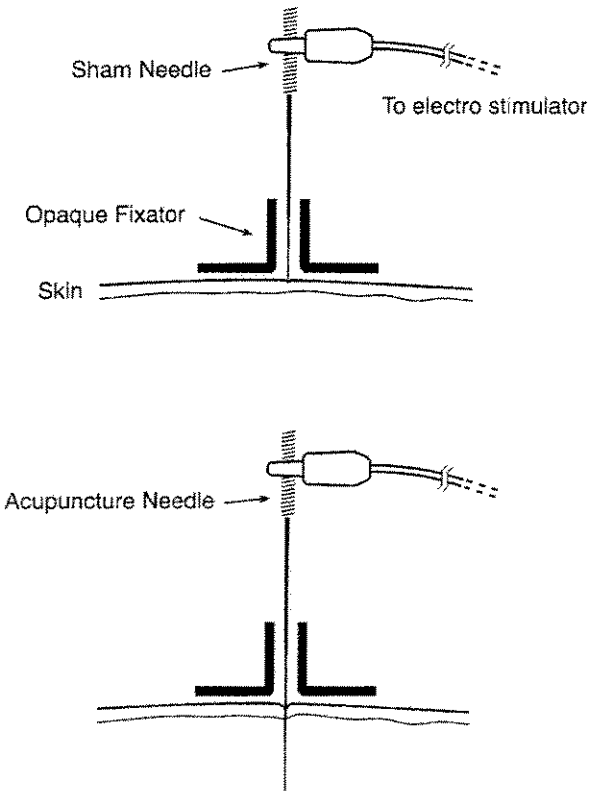

Fig 2. Cross-sectional diagram showing the difference in setup between the electroacupuncture (EA) and sham acupuncture (SA).

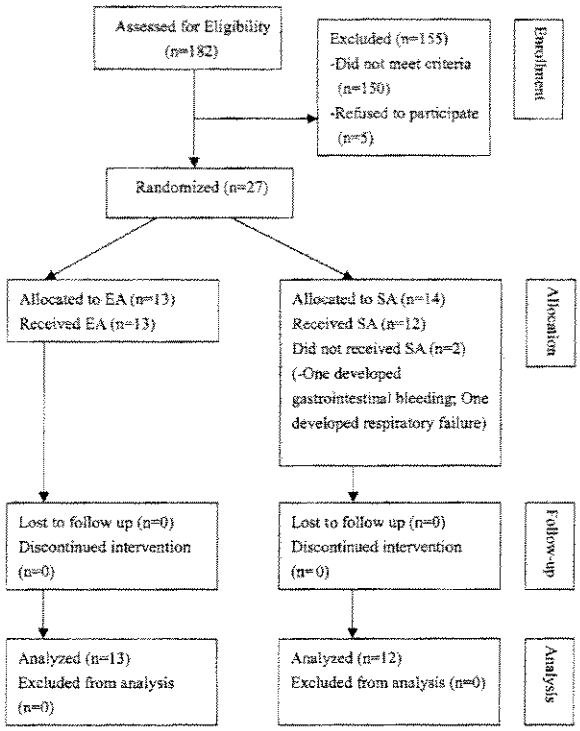

Fig 3. Flowchart of phases of randomized trial. (EA = electroacupuncture; SA = sham acupuncture.)

Data Collection

The postoperative visual analog scale pain score (on a scale of 0 mm to 100 mm), PCA morphine usage, peak flow rate, chest drain duration, and details of postoperative complications were collected by a dedicated assessor who was blinded to the results of randomization. These data were collected at 1 hour after surgery on day 0; at 8 AM, 2 PM, and 8 PM on day 1 to day 3; and at 8 AM daily from day 4 to day 7.

Data Analysis

The average visual analog scale pain scores and the cumulative PCA morphine usage were the primary outcome measures. The summary statistics are presented as the mean together with range. The results were analyzed with Student's t test using the Statistical Package for the Social Sciences software (Windows version 11.5; SPSS Inc, Chicago, IL). Two-sided p values of less than 0.05 were regarded as statistically significant.

Results

Subjects were recruited from January 2002 to August 2004. A total of 153 patients were screened, and 27 (17.6%) were enrolled. Two patients were subsequently excluded from the study because of postoperative complications unrelated to acupuncture: one patient experienced respiratory failure requiring ventilatory support and the other

Table 2. Demographic Data and Postoperative Variables of Electroacupuncture and Sham Acupuncture Groups

Variable	Electroacupuncture (n = 13)	Sham Acupuncture (n = 12)	*p* Value
Age	64.6 ± 8.0	64.5 ± 8.5	0.97
Sex			
M	n = 9 (62.9%)	n = 10 (83.3%)	NS
F	n = 4 (30.8%)	n = 2 (16.7%)	
Operation time (min)	134.2 ± 35.1	140.4 ± 44.1	0.70
Size of tumor (cm)	4.9 ± 1.7	5.2 ± 2.8	0.74
Chest drain duration (days)	4.5 ± 1.8	5.4 ± 2.1	0.27
Peak flow rate			
Day 0	171.5 ± 66.3	165.1 ± 98.6	0.86
Day 1	186.3 ± 70.0	197.1 ± 83.9	0.74
Day 2	230.4 ± 85.3	211.3 ± 88.1	0.60
Day 3	228.9 ± 98.1	224.4 ± 83.7	0.91
Day 4	253.7 ± 83.6	232.9 ± 76.6	0.53
Day 5	264 ± 100.6	225.8 ± 89.0	0.37
Day 6	211.7 ± 84.5	261.1 ± 90.3	0.30
Day 7	205.0 ± 78.8	281.6 ± 106.1	0.37
VAS			
Day 0	3.7 ± 1.6	3.0 ± 2.3	0.42
Day 1	3.9 ± 1.3	3.9 ± 1.4	0.96
Day 2	3.1 ± 1.4	3.8 ± 1.6	0.92
Day 3	2.9 ± 1.1	3.8 ± 1.9	0.15
Day 4	3.0 ± 1.5	4.4 ± 1.9	0.06
Day 5	2.5 ± 1.8	4.0 ± 1.1	0.02[a]
Day 6	3.2 ± 1.9	4.8 ± 2.1	0.15
Day 7	3.0 ± 3.6	3.0 ± 1.4	1.00
PCA			
Day 0	8.3 ± 4.9	7.8 ± 6.4	0.84
Day 1	18.0 ± 8.8	18.8 ± 9.8	0.83
Day 2	7.5 ± 5.0	15.7 ± 12.0	0.035[a]
Total PCA usage	33.9 ± 12.8	42.3 ± 21.3	0.25

[a] $p < 0.05$.

PCA = patient-controlled analgesia; VAS = visual analog scale.

had gastrointestinal bleeding necessitating endoscopic intervention. Of the 25 remaining patients, 13 were in the EA group and 12 in the SA group. The flowchart of phases of the pilot randomized trial was showed in Figure 3. There were no statistically significant differences between the two groups in terms of age, sex, operative time, and duration of chest-tube drainage (Table 2). There was no mortality, complication, or adverse reaction (such as infection and bleeding) related to acupuncture in both groups. None of the patients in the SA group questioned whether they were receiving genuine acupuncture or not.

The average usage of PCA morphine in the two study arms showed no significant difference on postoperative day 0 and day 1. There was a statistically significant difference in the PCA morphine usage on postoperative day 2, with average morphine usage of 7.5 ± 5 mg in the EA group and 15.7 ± 12 mg in the SA group ($p = 0.035$).

There was a trend for lower average visual analog scale pain scores from postoperative day 2 to day 6 in the EA group, but this did not reach statistical significance (Fig 4). This is most likely secondary to the β error from the small sample size.

Comment

There have been an increasing number of randomized controlled trials studying the role of acupuncture in chronic pain management in recent years. The possible mechanisms of action include activation of various endogenous opioid-related pain-inhibiting pathways by means of stimulation of peripheral nerve fibers, activation of the dorsolateral prefrontal cortex, profound alteration of local hemodynamics in the state of *De-Qi*, and activation of the diffuse noxious inhibitory controls system in which a spatially remote conditioning stimulus can reduce the response to a subsequent noxious stimulus elsewhere [6–11]. However, there have only been a few reports focused on postoperative pain control thus far.

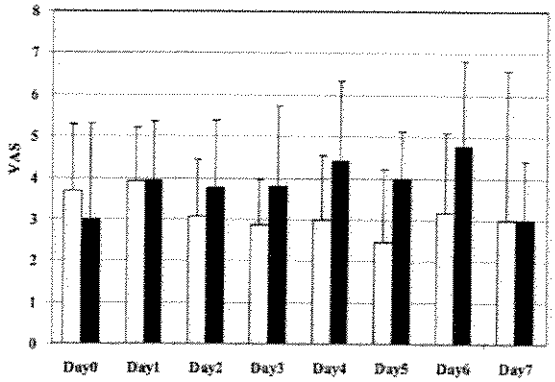

Fig 4. Comparison of average visual analog scale (VAS) pain score from postoperative day 0 to day 7. Solid bars are sham acupuncture group; open bars are electroacupuncture group.

Our results echo those of an earlier study by Christensen and colleagues in 1989 [12]. In their study comparing acupuncture versus no treatment in patients who underwent lower abdominal surgery, they showed the use of acupuncture resulted in a 50% decrease in narcotic analgesic usage. Another study by Lin and associates [3] using preemptive acupuncture to reduce postoperative pain after lower abdominal surgery also showed significantly lower analgesic requirements in the acupuncture group. In this latter study, the authors compared the effect of control (no acupuncture), sham acupuncture, and both low-frequency (2 to 4 Hz) and high-frequency (100 to 150 Hz) EA, and found that both low-frequency and high-frequency EA lowered postoperative analgesic requirements—with high-frequency EA being more effective. However, thoracotomy wounds are recognized to be more painful than lower abdominal incision wounds, and it is perhaps not surprising that the levels of significance from that study were not reproduced in ours.

From the results of our pilot study, the use of acupuncture was shown to significantly lower PCA morphine requirements on postoperative day 2, but not on day 0 and day 1. We note two possible explanations for this delayed effect. First, the intraoperative use of narcotic analgesia (morphine and fentanyl) may have overwhelmed the opioid-mediated pain inhibitory pathways and obscured the maximal analgesic effect achievable by acupuncture. Such observation is not uncommon, especially when we look into negative reports on acupuncture study for postoperative pain control [13]. Second, experiments in rats showed EA analgesia in uninjured animals was mediated by mu and delta opioid receptors at low frequency (2 to 15 Hz) through the release of enkephalin and by kappa opioid receptors at 100 Hz through the release of dynorphin [14]. Fei and coworkers [15] reported EA at mid-frequency (15 Hz) was able to produce partial activation of both enkephalins and dynorphins in rats. By acting on different pathways, there could be a difference in the onset of action [16]. We postulate that the frequency (60 Hz) of EA used in our study may act through slow-onset pain pathways, so that the effect of the acupuncture is cumulative and may only be observable on postoperative day 2. In our future studies, we will use different frequencies of EA and try to elucidate the underlying mechanism.

Our study has shown our design of sham acupuncture to be safe, feasible, and indistinguishable from genuine acupuncture by patients without prior exposure to acupuncture. The presence of the opaque fixator allowed us to place the needle at the exact location of the acupoint, avoiding the previously described method of placing the needle at a nearby incorrect point. This setup is recommended for use in future studies.

Our study has shown the selected acupuncture points (LI 4, GB 34, GB 36, and TE 8) to be useful points for the evaluation of acupuncture effects in thoracic surgery patients. We would recommend performing future studies to further define the anatomic location and depth of needle puncturing required for optimal therapeutic effect in postthoracotomy patients.

In conclusion, EA showed promising results in lowering early postoperative narcotic analgesic requirement in patients with thoracotomy. A large-scale prospective randomized controlled trial using different EA frequencies with longer follow-up is warranted to verify this benefit.

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