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Single-blinded, randomised preliminary study evaluating the effects of 2 Hz electroacupuncture for postoperative pain in patients with total knee arthroplasty

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ABSTRACT

Objective To explore the point-specific clinical effect of 2 Hz electroacupuncture (EA) in treating postoperative pain in patients undergoing total knee arthroplasty (TKA),

Methods In a randomised, partially single-blinded preliminary study, 47patients with TKA were randomly divided into three groups: control group (CG, n=17) using only patient-controlled analgesia (PCA); EA group (EAG, n=16) with 2 Hz EA applied at ST36 (*Zusanli*) and GB34 (*Yanglingquan*) contralateral to the operated leg for 30 min on the first two postoperative days, also receiving PCA; and non-point group (NPG, n=14), with EA identical to the EAG except given 1 cm lateral to both ST36 and GB34. The Mann–Whitney test was used to show the difference between two groups and the Kruskal–Wallis test to show the difference between the three groups.

Results The time until patients first required PCA in the CG was 34.1±22.0 min, which was significantly shorter than the 92.0±82.7 min in the EAG ($p<0.001$) and 90.7±94.8 min in the NPG ($p<0.001$); there was no difference between the EAG and NPG groups ($p>0.05$). The total dosage of PCA solution given was 4.6±0.9 mL/kg body weight in the CG, 4.2±1.0 mL/kg in the EAG and 4.5±1.0 mL/kg in the NPG; there were no significant differences ($p>0.05$) among the three groups.

Conclusions In this small preliminary study, EA retarded the first demand for PCA in comparison with no EA. No effect was seen on the total dosage of PCA required and no point-specific effect was seen.

INTRODUCTION

Total knee arthroplasty (TKA) is considered an effective method for the treatment of severe degenerative knee-joint arthritis and has been widely used. It is a painful procedure that has prompted the implementation of a number of strategies to promote postoperative patient comfort and early mobilisation. These strategies can be divided into systemic (such as narcotics) and local procedures, which involve intervention at the level of the spinal cord, paravertebral nerves, or the joint itself.[1] The goal of postoperative analgesia is to make patients feel as comfortable as possible with the lowest possible morbidity from analgesic complications, such as cardiorespiratory or central nervous system (CNS) depression.[2]

Electroacupuncture (EA) has been used as an alternative method to relieve both acute and chronic pain.[3] Studies on the mechanism of action have shown that endogenous opioid peptides in the CNS play an essential role in mediating the analgesic effect of EA.[4 5] Most studies on the efficacy of EA have tested it for treating chronic pain syndromes.[6–9] Several studies have assessed the effect of EA in the treatment of acute pain, including postoperative situations, with varying results.[10–14] We propose that EA may be used to relieve postoperative pain after knee surgery. Two Hz, but not 100 Hz EA analgesia involves endomorphin-1 release at the spinal level[15] and β-endorphin and encephalin release in the CNS.[16]

As a preliminary study, we aimed to explore the effect on postoperative pain of 2 Hz EA applied at ST36 (*Zusanli*) and GB34 (*Yanglingquan*) contralateral to the operative leg. We wished to test the overall effectiveness and the point-specific effect.

PATIENTS AND METHODS

A single-blinded, randomised, controlled preliminary study was conducted in patients with severe degenerative knee joint arthritis requiring TKA. A total of 47 patients were randomly assigned to the following groups: control group (CG) without EA; EA group (EAG), EA at points; non-point group (NPG), EA at non-points. All groups received patient-controlled analgesia (PCA), which was used to evaluate the effect.

Because we could find no previous studies of this design, we had no basis on which to calculate the statistical power or sample size and recruited as many patients as volunteered during the study period. The trial was approved by the institutional ethics committee of the Veterans General Hospital, Taichung, Taiwan (IRB TCVGH number: 940118/456). Written informed consent was obtained from all the participants before the trial.

Patients

The patients had to have severe degenerative knee joint arthritis that required TKA and be older than 50 years. Patients were excluded if they had a history of morphine allergies, severe cardiac arrhythmias, seizure disorders or cardiopulmonary disorders such as heart failure, chronic pulmonary obstructive disease, and others. Patients who refused spinal anaesthesia or had a history of psychiatric disease or drug abuse, or who had had acupuncture treatment within 1 month before the trial, were also excluded.

Randomisation and blinding

Patients were randomly allocated to the groups according to a blank envelope containing a card indicating one of three groups; the envelope was opened immediately after closure of the operative wound. Patients and staffs were blinded to group allocation before the envelope was opened. Patients receiving EA were blinded to whether the EA was given at a point or not.

Interventions

The patients underwent a routine anaesthetic protocol before the TKA surgery. We used spinal (subarachnoid) anaesthesia over the L3–L4 levels with 0.5% bupivacaine (12–14 mg) for the intraoperative anaesthesia. The epidural PCA solution contained 1.5 μg/mL fentanyl and 0.1% bupivacaine (750 μg of fentanyl and 100 mg of bupivacaine in 500 mL of normal saline); a standard setup was used as the conventional treatment for postoperative pain control in each patient.

The CG received only PCA (1.5 μg/mL fentanyl and 0.1% bupivacaine). The EAG patients were treated with 2 Hz EA with 2 mA intensity and adjusted to produce visible twitching of the anterior tibial muscle for 30 min using a HANS electrical stimulation device (Healthtronic Inc, Singapore City, Singapore); two needles were inserted at ST36 and GB34 (disposal stainless steel acupuncture needles, 50 mm in length, 0.26 mm in diameter and insertion depth of 20–30 mm) contralateral to the operated leg. The NPG received the same intervention as the EAG, except that the needles were inserted and 2 Hz EA applied to needles inserted 1 cm lateral to ST36 and GB34. The PCA machine was set to each patient when the operation was finished. The PCA machine was started after the operation when the patients were sent to the recovery room. EA stimulation was performed when the PCA machine was started and repeated (identically in every respect to the first EA stimulation) 24 h later (figure 1).[17]

The main outcome measures were the time of first demand for PCA and the total dosage of PCA solution given in 48 h. The secondary outcome measure was the incidence rate of vomiting over a 48 h postoperative period. The time of first demand for PCA was recorded automatically by the PCA machine. The measurement of the incidence rate of vomiting was recorded by the caregiver of the patients. In addition, Visual Analogue Scale (VAS) scores were recorded by a member of staff before the PCA was set up. The data were analysed by Biostatistics Task Force, Taichung Veterans General Hospital, Taichung, Taiwan; they were blinded to the groups.

Statistical analysis

All data were represented as the mean±SD and the data were analysed using SPSS V.10.0 (Chicago, Illinois, USA). The differences between two groups were tested using the Mann–Whitney test and among the three groups using a Kruskal–Wallis test. In addition, a Pearson χ^2 test was used to compare the differences between sex (male and female) and vomiting. Our study defined a p value <0.05 as statistically significant.

RESULTS

Characteristics and baseline data

A total of 47 patients (36 female, 11 male; aged 59–84 years) with severe degenerative knee joint arthritis who had received TKA completed the study; the study period was from May 2005 to May 2006. No patients dropped out of the study. The CG consisted of 17 patients, the EAG 16 patients and the NPG 14 patients. There were no significant differences between groups in mean age, height, weight, sex and VAS pain score (table 1).

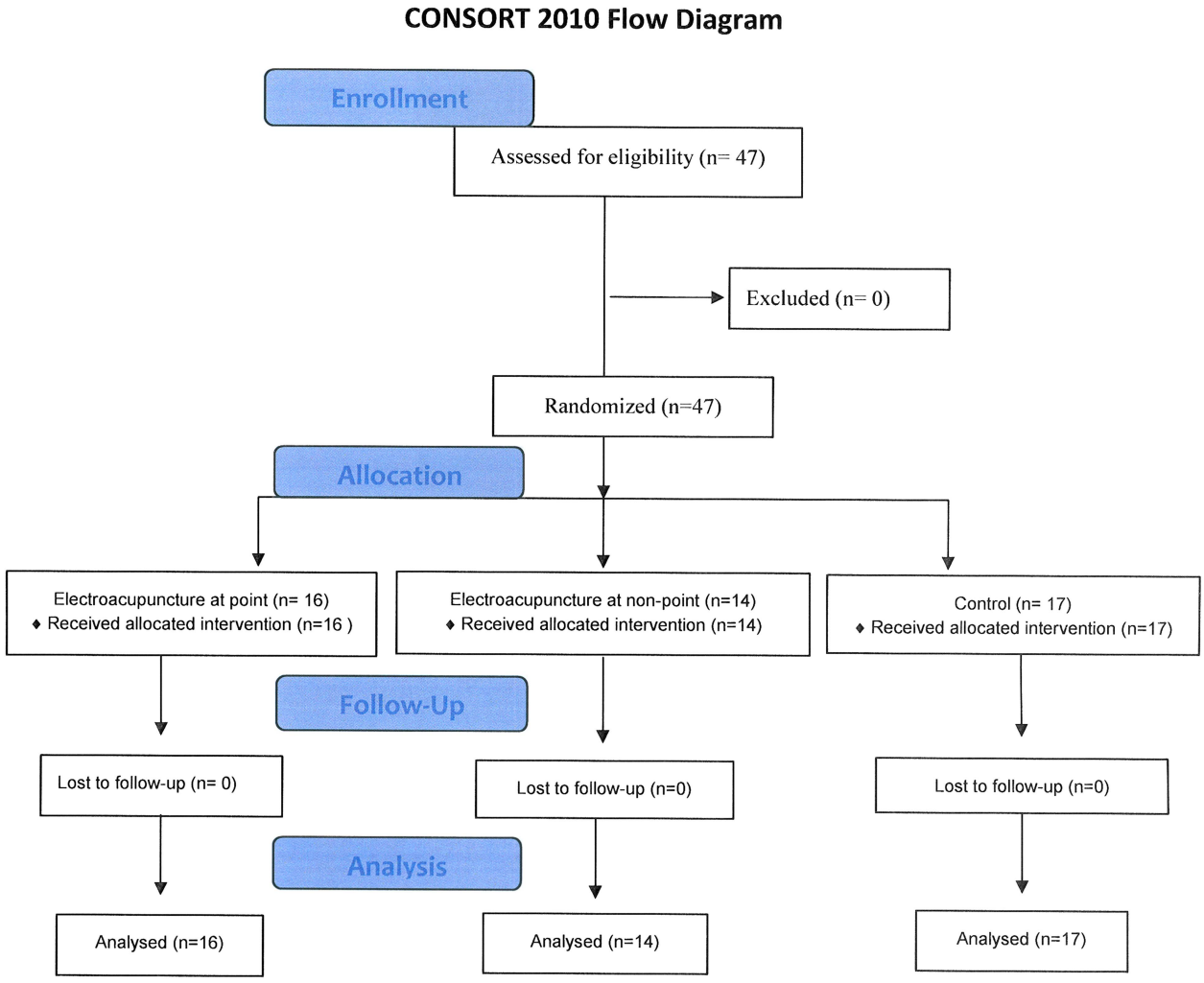

Figure 1 Flowchart.

Effect of 2 Hz EA on postoperative pain after TKA

The time for first demand of PCA in the CG was 34.1 ±22.0 min, which was significantly shorter than the 92.0±82.7 min in the EAG ($p<0.001$) and the 90.7 ±94.8 min in the NPG ($p<0.001$). There was no significant difference between time to first use of PCA in the EAG and NPG ($p>0.05$) (table 2).

The dose of PCA solution was calculated according to the body weight and is reported in table 2. There was no significant difference ($p>0.05$) among the groups.

The incidence of vomiting was 10/17 patients in the CG, 8/16 patients in the EAG and 6/14 patients in the NPG over a 48 h period after TKA. Again, there was no statistically significant difference among the three groups ($p>0.05$) (table 2).

DISCUSSION

Our results indicate that 2 Hz EA applied at ST36 and GB34 and at locations 1 cm lateral to these points, contralateral to the operated leg, may prolong the time until the patients first demand PCA after TKA for knee joint arthritis, compared with no EA. However, in this study we found that 2 Hz EA did not lead to a significant reduction in the dose of PCA or the incidence of vomiting.

Since there were no significant differences in patient characteristics that might explain this difference in outcome, these findings suggest that 2 Hz EA may

Table 1 Characteristics and basic data of the 47 patients undergoing total knee arthroplasty

Characteristics	CG (n=17)	EAG (n=16)	NPG (n=14)	p Value
Sex				
Female	14	12	10	0.328*
Male	3	4	4	
Age	70.1±6.9	69.6±5.6	71.4±7.3	0.738†
Height (cm)	154.1±7.0	156.0±6.8	157.2±8.3	0.517†
Weight (kg)	65.0±11.4	69.3±9.1	68.0±8.2	0.252†
Pain VAS	3.8±1.1	4.0±0.7	3.9±0.8	0.645†

Results are shown as mean±SD.
*Pearson χ^2 test; †Kruskal-Wallis test.
CG, conventional treatment group with only patient-controlled analgesia (PCA); EAG, point group, 2 Hz EA group; NPG, non-point group; both groups receiving EA also received PCA; VAS, Visual Analogue Scale.

Table 2 Effect of 2 Hz EA on postoperative pain and vomiting after total knee arthroplasty

	CG	EAG	NPG
Time to patients' initial demand for PCA (min)	34.1±22.0	92.0±82.7*	90.7±94.9*
Dosage of PCA (mL/kg body weight)	4.6±0.9	4.2±1.0	4.5±1.0
Incidence rate of vomiting	10/17	8/16	6/14

Results are shown as mean±SD.
*p<0.001 compared with the CG.
CG, conventional treatment group with only patient-controlled analgesia (PCA); EAG, point group, 2 Hz EA group; NPG, non-point group; both groups receiving EA also received PCA.

produce a transient relief or delay the onset of postoperative pain in patients who have undergone TKA, though the effect cannot be distinguished from the placebo response.

TKA is a painful procedure requiring vigorous analgesic management, usually a systemic narcotic agent.[17] However, an analgesic regimen given before the onset of pain may prevent sensitisation of the nervous system, reducing the patient's pain response.[18] EA (2 Hz) induces the release of β-endorphin and enkephalin, which activate μ and δ opioid receptors in the brain and may provide pre-emptive analgesia.[16] EA has been used to treat postoperative pain, although the evidence on its effectiveness is conflicting. Morioka *et al*[19] and Chernyak *et al*[20] reported that EA did not reduce the perioperative analgesic requirements, though most studies have reported positive effects.[10 12 14 21 22] Our results indicate that the total dosage of the PCA solution and the incidence rate of vomiting over a 48 h period after the operation were similar among the three groups. These results may be explained by the supposition that 2 Hz EA exerts only a transient analgesic effect, or our study was too small to identify an effect, or the stimulation used was inadequate. The incidence of vomiting was closely related to the dosage of the PCA solution, explaining the lack of difference between groups in both respects.[23–25]

Our study used contralateral treatment for obvious practical reasons. Though apparently unconventional, there is both a traditional Chinese medicine description of contralateral effects,[26] and a neurological explanation from opioid peptide release.[4] In addition, we have previously shown that 2 Hz EA at unilateral ST36 and ST37 depressed the contralateral R2 component of the blink reflex. This study also used only two points.[27] Further, acupuncture at left SJ5 increased capillary red blood cell velocity of the right nailfold microcirculation.[28]

We found no point-specific effect of ST36 and GB34 compared with nearby non-points, although our study had limitations (see below). It is likely that a segmental effect of the stimulation plays a critical role: ST36 and GB34 are located 3 and 6 cun below the knee, respectively, in the region innervated by the superficial peroneal nerve and L5. The locations of the control points, 1 cm lateral to ST36 and GB34, are also in the region of the superficial peroneal nerve and L5.[29] This explanation is consistent with our previous results, demonstrating that the segmental effect of the spinal nerve plays a critical role in the effects of acupuncture on nailfold microcirculation.[26] Nevertheless, it is essential to determine the long-term analgesic properties of acupuncture that are more effective at relieving pain during a postsurgical operation.

This study was limited by the small sample size. Furthermore, the difference in the location of the EA between the EAG and NPG was only 1 cm; therefore, comparing the therapeutic effect was difficult. Furthermore, we are not certain whether the number of points used, or the intensity of EA stimulation, were optimal. Future studies should include an adequate sample size and a sham CG and consider using four points instead of two to further examine the effectiveness of EA on postoperative pain.

In conclusion, we found that 2 Hz EA applied for 30 min on the first two postoperative days at ST36 and GB34 and 1 cm lateral to both the ST36 and GB34, contralateral to the operative leg prolonged the time to the first demand for PCA compared with no EA. We did not observe any effect on the total dosage of PCA solution or the incidence rate of vomiting, or any point-specific effect, but limitations to the study prevent definite conclusions. These findings suggest that 2 Hz EA may provide transient relief or delay the onset of postoperative pain.

Summary points

- We conducted a small study on the effect of electroacupuncture (EA) at classical points and at non-point locations on postoperative pain, compared with no EA.
- EA delayed the demand for analgesic drugs.
- There was no difference between the effect of EA at points and non-points.

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Contributors C-YT performed the experiment and wrote the paper; S-LC participated in the discussion and design; C-CW performed anaesthesia and helped with the experiment; C-LC and W-GC participated in the discussion; K-MT and K-CH helped with the experiment; C-LH participated in the discussion and design and revised the document.

Competing interests None declared.

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