Randomised, controlled study of preoperative eletroacupuncture for postoperative pain control after cardiac surgery

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ABSTRACT

Background This study aims to evaluate the effects of preoperative electroacupuncture (EA) on the need for opioids in the postoperative stage of conventional cardiac surgery.

Methods A prospective, randomised and controlled study was conducted at Unimed Hospital Centre in Joinville, SC, Brazil. The day before the surgery, 32 patients undergoing cardiac surgery were randomised into two groups: patients from the treatment group received preoperative EA at bilateral points (LI4–LI11, LR3–ST36, PC6–TE5) for 30 min with alternating frequencies of 3 and 15 Hz. Patients from the control group received sham transcutaneous electrical nerve stimulation (TENS). Use of fentanyl during the postoperative period was measured.

Results 10 patients were excluded because of hemodynamic and ventilatory instability leaving 13 (10 male) in the treatment group and 9 (4 male) in the control group. The average total doses of fentanyl given were 13.1±2.2 and 16.3±1.6 μg/kg in the treatment and control groups respectively ($p<0.002$). The doses of patient controlled analgesia were 4.1±2.0 and 6.9±1.7 μg/kg in the treatment and control groups respectively ($p<0.003$). The number of boluses issued also differed (treatment 13.9±7.0 vs control 24.8±7.0, $p<0.002$). Pain intensity scores differed between the groups (treatment 2.5±1.1 vs control 4.0±2.0, $p<0.04$). One patient from the control group experienced drowsiness that justified a change in fentanyl infusion, as decided by the anaesthetist.

Conclusion Preoperative electro-acupuncture in conventional cardiac surgery may reduce the postoperative consumption of fentanyl.

INTRODUCTION

Postoperative pain is the result of surgical trauma. Several inflammatory mediators are locally diffused (prostaglandin, histamine, substance P, bradicinine and serotonine), which can increase local nociceptive sensitivity. Sensitisation of the central nervous system increases as a result of segmental and suprasegmental reorganisation.[1–3]

Postoperative pain can be regarded as inevitable because of intense surgical trauma, but if not controlled can cause several clinical risks such as atelectasis, venous thrombosis and elevated blood glucose levels with increased risk of infection, as well as cardiac risks such as higher blood pressure with increased left ventricle afterload and increased myocardial oxygen consumption.[1 2]

Multiple nociceptive stimulants occur in thoracotomy procedures such as surgical incision, insertion of chest tubes and mediastinal and parietal pleura stimulation, making the provision of analgesia quite complex and requiring a combination of techniques and medication.[4] Efficient pain control can reduce post-thoracotomy complications.[4] As one of the analgesic methods available, pre-emptive analgesia aims to reduce central sensitisation and amplification processes in the spinal cord before injury has occurred.[1]

In most cases, pain control is obtained from the administration of opioids, which might in turn incur several undesirable side effects like nausea, vomiting and decreased level of consciousness. The use of customised strategies for analgesia such as patient controlled analgesia (PCA) is introduced to reduce these side effects by reducing consumption of opioid analgesics.[1 2] However, even using this technique, the incidence of side effects is still high.

Electroacupuncture (EA) has shown potential to reduce the amount of medication given to general surgery patients. Its association with PCA has been reported as having achieved a decrease in the amount of medication during the immediate postoperative period after thoracotomy.[5] Acupuncture has been recommended by The American College of Chest Physicians as complementary therapy for lung cancer patients that suffer from postchemotherapy nausea and post-thoracotomy pain.[6] The analgesic action results from its direct inhibitory effect on the spinal cord interneurons involving the opioid mechanism and also from the increasing release of enkephalins and β endorphins at central levels.[3 7]

Several studies have demonstrated the effect of EA on pain control[5] and postoperative nausea.[8–11] The use of preoperative EA in conjunction with PCA in cardiac surgery has not been used systematically in a way that allows

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for a detailed analysis of their effectiveness. The use of EA in the preoperative of gynaecological surgery permitted the reduction in the consumption of opioids during and after surgery.[12] However, the use of preoperative EA is not a common practice as EA sessions are usually conducted immediately before surgery. That fact reduces its practical application because of other intensive demands of the surgical centre at that critical time and acupuncturists' reality (most acupuncturists do not work at hospitals and very few hospitals have a structured acupuncture department), which hinders the use of this technique immediately before surgical procedure.

This study aims to evaluate the effect of preoperative EA given the day before conventional cardiac surgery on the postoperative opioid demand in and side effects of opioids.

METHODS

We conducted a prospective, randomised and controlled study conducted in the Unimed Hospital Centre, Joinville-SC, Brazil, from April 2009 to June 2010. All patients were informed of the purpose of the study and received instructions regarding the pain scale and the correct use of PCA 1 day before the surgery. The study was approved by the local research ethics council (number 08042) and all patients involved signed a 'Free and Clarified Consent Term'.

Patients undergoing elective heart conventional surgery were participants in the study. Exclusion criteria were as follows: significant haemodynamic instability (need of high doses of vasoactive amines), need of prolonged endotracheal intubation (longer than 6 h after admission in the intensive care unit (ICU)/critical care unit), significant changes in consciousness level that might prevent the use of PCA, rejection of protocol, non-comprehension of PCA use and events that might prevent surgery or PCA use.

The day before the surgery, patients were randomised into permutation groups (randomised in block) in order to provide the best balance in terms of number of patients in both groups. All patients signed the consent form. The EA procedure was performed only the day before the surgery. The acupuncturist in the study (LEFC) has a medical PhD and postgraduate qualifications in acupuncture and intensive care medicine.

Patients from Group 1 (treatment) were given preoperative EA (12–18 h prior to the surgery) and postoperative PCA. EA was applied to three pairs of acupuncture points on each side (LI4–LI11, LR3–ST36, PC6–TE5) for 30 min using 4 s alternating frequencies of 3 and 15 Hz. Power was determined according to individual maximum tolerance. The shape of the pulse wave of the EA device is a typical biphasic waveform without galvanic component (initial square wave followed by exponential inverted wave in the second phase). An electrostimulator machine was used (EL502; NKL Laboratories, Brusque-SC, Brazil). *De qi* (electric shock feeling) was not elicited. Needles were inserted 1–2 cm deep. At ST36 point, insertion depth was 2.3 cm and *de qi* was elicited by manual stimulation before EA. The needles used were sterile and disposable DongBang (Dong Bang Acupuncture, Korea) 0.25×40 mm. None of the patients wore a pacemaker and no stimulation was given across the thorax.

In patients from Group 2 (control), electrocardiogram electrode patches were stuck onto the skin at acupuncture points (LI4–LI11, LR3–ST36). Electrical stimulation was applied with NKL EL502 with 300 Hz frequency for 5 s. After that, the device was turned off but remained connected to patients for 30 min.

In both groups, patients were given postoperative analgesia in the ICU according to protocol, which consisted of us of PCA pump with continuous injection of 0.4 µg/kg/h fentanyl dose (0.04 ml/kg/h fentanyl solution 50 ml + physiological saline solution 200 ml) together with the option of 0.3 µg/kg bolus (0.03 ml/kg of the solution) with a minimum 15 min interval between each bolus as well as a total limit of 30 ml in the 4 h period. Neither non-hormonal anti-inflammatory drugs nor local anaesthetic were used. The anaesthetic procedures were not standardised and were under the anaesthesiologist responsibility. Due to minimum intervals between additional bolus for safety reasons, patient-administered supplementary doses of morphine or fentanyl were allowed according to the criteria of the ICU specialist on duty. The use of antiemetics also depended on the usual criteria used in the ICU.

Nursing staff measured the pain levels of patients after extubation. Verbal pain scale was used every 2 h, while patients were instructed to use PCA if suffering pain was 4 points or above (0=no pain and 10=worst possible). The anaesthesiologist, surgeon, patient, intensivist and nursing staff did not know which group patients belonged to. The anaesthesiologist periodically evaluated fentanyl infusion and changed its flow according to the presence or intensity of side effects (nausea, vomiting or drowsiness).

Total fentanyl dosage, bolus volume, number of boluses as well as the need of dosage modification as a result of side effects were recorded for 24 h from the start of fentanyl infusion.

The National Cancer Screening Service software (Statistical Software 2000 and PASS 2000: Power Analysis, Sample Size and GraphPad Prism 4) were used for statistical treatment of data. Continuous variables are presented as mean±SD and compared using Student t test. Categorical variables were expressed as their absolute and relative values and compared with the χ^2 test. A p value of <0.05 was considered of statistic significance.

RESULTS

Thirty-two patients were randomised but 10 were excluded (figure 1). Exclusions were due to instability (4), late extubation (3), preoperative heart attack (1), analgesia by epidural catheter (1) and mental confusion (1). Twenty-two patients were included in the study, 13 in the treatment group (10 male) and nine (four male) in the control group (table 1). Surgical procedures were myocardial revascularisation (eight in the treatment group and eight in the control group) and valve replacement (five in the

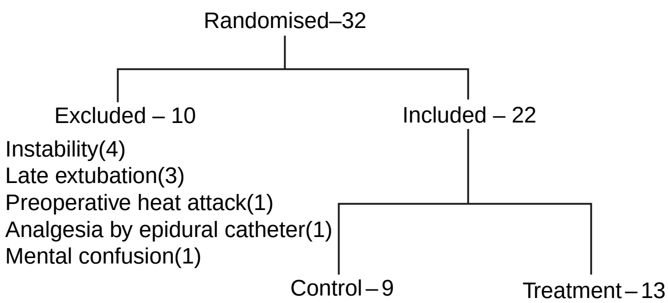

Figure 1 Flow of participants through the study.

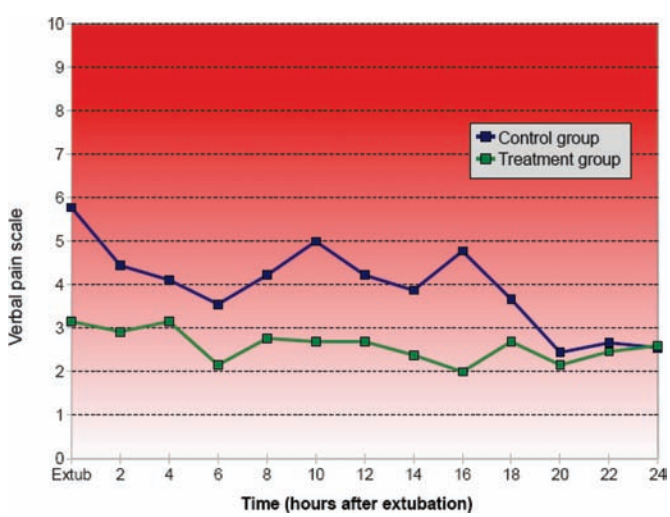

Figure 2 Pain score by time after extubation.

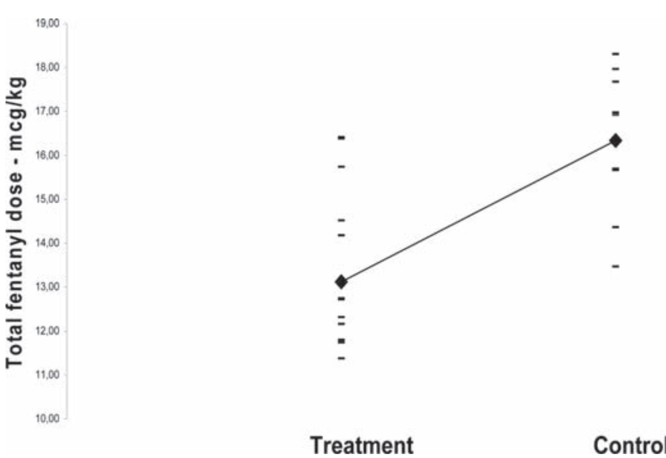

Figure 3 Total dose of fentanyl in 24 hr.

treatment group and one in the control group). All patients, including those excluded from the study, survived surgery.

The average total dose of fentanyl in conventional surgery was 20% lower in the treatment group: 13.1±2.2 and 16.3±1.6 µg/kg in the treatment and control groups respectively (p<0.002) (table 2 and figure 3). Effective bolus self-administered by patients was 41% lower in the treatment group: 4.1±2.0 and 6.9±1.7 µg/kg in the treatment and control groups respectively (p<0.003). The number of effective bolus doses issued also differed significantly (treatment 13.9±7.0 vs control 24.8±7.0, p<0.002) (table 2). There was a significant difference in pain intensity evaluation levels between the groups (treatment 2.5±1.1 vs control 4.0±2.0, p<0.04). One patient in the control group was sufficiently drowsy for the anaesthetics to reduce the rate of PCA infusion, while no side effects were reported in the treatment group.

The average hospitalisation time was 8.5±5.7 days in the treatment group and 10.7±11.2 days in the control group (p=0.55).

Table 1 Demographic data

	Conventional surgery		
	Control	Treatment	p Value
Age (years)	62.5±10.8	56.2±11.8	0.21
Sex M/F	4/5	10/3	

Table 2 Fentanyl dosage during first 24 h after operation and pain scale

	Conventional surgery		
	Control	Treatment	p Value
Fentanyl dosage	16.3±1.6	13.1±2.2	<0.002
Bolus dosage	6.9±1.7	4.1±2.0	<0.003
Bolus number	24.8±7.0	13.9±7.0	<0.002
Pain scale	4.0±2.0	2.5±1.1	<0.04

DISCUSSION

The study reveals that the use of preoperative EA significantly reduced the fentanyl dosage necessary to achieve optimal analgesia (ie, scoring below 4 points in the verbal pain scale) in conventional cardiac surgery. Furthermore, the study has shown that patients that received EA presented fewer reported side effects as well as lower pain intensity. It is important to mention that groups were heterogeneous in terms of gender, which may explain some of the observed differences.

The benefits of preoperative EA arise from increased levels of enkephalins and β endorphin using low frequency stimulation.[3 13–15] The optimal frequency for stimulating Aδ fibres[16 17] and peduncular cells in the posterior horn of spinal cord[17–19] stimulation is of about 2 and 3 Hz. This blocks the nociceptive afferents from the site of injury by release of enkephalins in substantia gelatinosa cells[20] and stimulates the descending control of pain involving serotonin release in the periaqueductal grey. Low-frequency EA can generate long-standing analgesia.[3] An increase in the messenger RNA for pro-enkephalin in brain (pituitary) is observed for 24–48 h following acupuncture.[3] General analgesic action is seen with the use of low frequencies and local analgesic action by the use of high frequencies.[21] Higher frequencies were not used as they release dynorphin, which has rapid starting effect but much leakage,[3 14] and may reduce mesencephalic production of encephalin.[22]

There are still doubts about the best acupuncture technique to provide discharge of long standing opioids. Analgesic effects of acupuncture may be maximised by repetitive sessions.[23] Therefore, low frequency and high intensity EA sessions lasting at least 20 min in the days before major surgeries could improve postoperative pain control. The optimal timing of sessions has not been established, but we note that β endorphin follows the adrenocorticotropic hormone circadian rhythm (ACTH)[24] and that both molecules originate from proopiomelanocortin (POMC),[25] what could justify morning sessions.

In a study conducted with patients undergoing gynaecological surgery where preoperative EA was used immediately before the procedure (2 and 100 Hz), the consumption of opioids during the operation was lower in the treatment group (release of A dynorphin is possibly implicated), the infusion of PCA morphine was similar to control group in the first 6 h (demonstrating the physiological decrease of A dynorphin concentration) and the infusion of morphine was reduced after this period, and remained at low levels until the end of 24 h protocol (demonstrating the high physiological increase in enkephalin).[12]

One possibility for the negative findings of a recent study[26] on the use of EA during surgery was the use of a single frequency of higher stimulation (10 Hz). The use of a single frequency favours neuronal accommodation, reducing its therapeutic effect. Thus, two alternating frequencies should be used.[14] Different frequencies of stimulation (2 and 100 Hz) release different opioid peptides. Low frequency increases enkephalin release by 367% (stimulating δ receptors) and dynorphin by 29% (stimulating κ receptors). On the other hand, high frequency slightly reduces enkephalin release and increases dynorphin by 49%.[22 27] The use of high frequencies increases the concentration of cholecystokinin octapeptide (CCK-8)—a potent antiopioid agent.[7 27] Another problem that must be avoided is the administration of very high powers (particularly during surgery) and prolonged administration both of which can also increase CCK-8 production.[7 28 29]

The choice of 15 Hz frequency was based on studies that suggested that this is often useful for the treatment of postoperative nausea, after chemotherapy sessions and during pregnancy care (though we did not measure nausea here). Studies by Dundee *et al*[8] of 500 women undergoing gynaecological surgery showed better effects if EA was applied at PC6 with frequencies between 10 and 15 Hz and that this effect disappeared by injecting anaesthetic at the same point.[9] Studies conducted during surgery showed that acupuncture in PC6 point failed to reduce vomiting after surgery.[10 11] A study with 90 patients undergoing cardiac surgery showed that a single preoperative session of acupuncture significantly reduced postoperative emesis.[30]

CONCLUSION

The use of preoperative EA (12–18 h before surgical procedure) in conventional heart surgery may significantly reduce postoperative fentanyl dosage as well as undesirable opioid side effects. Further studies should be conducted in order to establish the optimum preoperative EA method and number of sessions for pain control.

Summary points

- Acupuncture can reduce the need for postoperative opioid analgesics.
- Acupuncture may not be feasible in the immediate preoperative period.
- We gave acupuncture one day before surgery, compared with sham TENS.
- Use of opioids was lower after acupuncture than after sham TENS.

Competing interests None.

Patient consent Obtained.

Ethics approval This study was conducted with the approval of the Ethics Committee of Hospital Municipal Sao Jose de Joinville – 08042.

Provenance and peer review Not commissioned; externally peer reviewed.

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