

Transcutaneous nerve stimulation for pain relief during chest tube removal following cardiac surgery

Vishwas Malik, Usha Kiran, Sandeep Chauhan, Neeti Makhija

Department of Cardiac Anaesthesia, Cardiothoracic Centre, All India Institute of Medical Sciences, New Delhi, India

Abstract

Background and Aims: In patients undergoing open heart surgery, chest tubes are removed postoperatively when patients are well awake and stable. Pain during chest tube removal can be moderate to severe and can be the worst experience of hospitalization. Various modalities of pain relief during chest tube removal have been tried with variable results. We sought to examine the effect of transcutaneous electrical nerve stimulation (TENS) as an intervention for pain relief during chest tube removal after cardiac surgery.

Material and Methods: In a tertiary care center, fifty patients undergoing open heart surgery were randomized into two groups. Group TENS ($n = 25$) received TENS from 30 min before and continued up to 30 min after chest tube removal. Control Group ($n = 25$) did not receive TENS. In both the groups, additional analgesic medication was provided on demand, besides the standard analgesic regime which was injection ketorolac 30 mg intramuscularly every 8 h. Patients were studied for pain during chest drain removal and pain related nausea, vomiting, and sense of well-being.

Results: Mean visual analog pain score assessed for chest tube removal was significantly less 4.1 ± 1.2 ($P < 0.05$) in TENS Group as compared to 6.1 ± 0.8 in Control Group. Significantly greater number of patients ($n = 14$) ($P < 0.05$) in Control Group demanded additional analgesia as compared to TENS Group ($n = 5$). Feeling of well-being, improvement in appetite, and sleep was better in TENS Group as compared to Control Group.

Conclusion: We conclude that TENS might not replace the conventional analgesics but has definite adjuvant role in decreasing pain scores and improves sense of well-being during chest tube removal after cardiac surgery.

Keywords: Cardiac surgery, chest tube removal, pain relief, transcutaneous nerve stimulation

Introduction

Cardiac surgical patients have their chest tubes removed within 36–48 h postoperatively unless there is some complication/contraindication.^[1] Chest tube removal is associated with varying degrees of pain ranging from mild, moderate to sharp pain.^[2] Controversy still exists regarding pain management during chest tube removal.^[3]

Attempts to reduce pain during chest tube removal have been made using nitrous oxide in O_2 , isoflurane, or propofol to provide analgesia during these procedures.^[1,4,5] Recently, there have also been attempts to address this pain by topical analgesia, music, and relaxation therapy with variable results.^[6-8]

Within the last two-three decades, there have been increasing numbers of reports concerning the use of transcutaneous electrical nerve stimulation (TENS) for postoperative pain relief.^[9] TENS has been found effective for postoperative pain relief after various surgeries such as gynecological and thoracic operations.^[10,11]

Address for correspondence: Dr. Neeti Makhija,
Department of Cardiac Anaesthesia, Room No. 9, 7th Floor,
Cardiothoracic Centre, All India Institute of Medical Sciences,
Ansari Nagar, New Delhi - 110 029, India.
E-mail: neetimakhija@hotmail.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Malik V, Kiran U, Chauhan S, Makhija N. Transcutaneous nerve stimulation for pain relief during chest tube removal following cardiac surgery. *J Anaesthesiol Clin Pharmacol* 2018;34:216-20.

Access this article online

Quick Response Code:



Website:

www.joacp.org

DOI:

10.4103/joacp.JOACP_336_15

Klin *et al.*^[12] have reported the use of TENS following cardiac surgery for postoperative pain relief, but no special comments have been made regarding its use for relief of pain during removal of chest tubes. With this background, we sought to combine TENS with routine analgesics to investigate whether it is beneficial as an adjuvant in addressing the pain associated with chest tube removal. To our knowledge, no studies have been conducted on the use of TENS for chest tube removal after cardiac surgery.

The present study was conducted to evaluate the efficacy of TENS for pain relief during chest tube removal in adult patients following cardiac surgery when used in addition to routine analgesics. We further evaluated its additional benefit for pain associated nausea, vomiting, and feeling of well-being.

Material and Methods

This prospective randomized study was carried out in the 30 bedded cardiac surgical postoperative Intensive Care Unit of a tertiary care center, following approval from Institute Ethical Committee and written informed consent. Fifty adult patients who underwent elective open heart surgery requiring two mediastinal chest tubes were enrolled in the study. Patients with history of epilepsy, redo or emergency procedures, associated with complicated/unstable postoperative course, requiring pacemakers, and those who received analgesic medication within 1 h before chest tube removal were excluded from the study.

Before beginning of the study, all the concerned staffs were educated on each aspect of the study to ensure consistent application and to reduce bias. Patients were randomly assigned to one of two treatment groups, Group TENS ($n = 25$) and Group Control ($n = 25$). Standard chest tubes were inserted after completion of surgical procedure, size of which was determined according to the weight of the patient. Postoperative analgesic protocol, i.e., injection ketorolac 30 mg every 8 hourly was used for all the patients.

On day 2, after chest tube drainage had stopped, chest tube removal was planned. Group TENS patients received TENS from 30 min before chest tube removal and continued up to 30 min after chest tube removal. Two electrodes were placed one on each side of the chest tube site over the area of anticipated maximum pain by the investigator. An Elpha 2000 dual channel TENS device was applied with a pulse width of 50–60 μ s. The intensity (output in mA) was adjusted according to the comfort of the patient from 5 to 15 mA by the attending clinician who was not

the investigator. Control Group patients did not receive application of TENS. On-demand analgesia was provided in both the groups in the form of additional dose of injection ketorolac 10 mg intramuscularly, and data were recorded by the caregiver nurse.

Patients reported the level of pain experienced during chest tube removal using a visual analog score, which was shown to them 5 min after chest tube removal. A vertical scale was used because it is recommended for clinical phenomenon requiring increased sensitivity.^[13] The scale was 10 cm in length but was shown to the patient as a large solid line on which patient was asked to mark his level of pain. The scale was described to the patient as “0” (no pain whatsoever) to “10” (the worst imaginable pain). Each patient was questioned with the same statement verbatim. Pain was measured in cm from the bottom of the scale to the subject mark.

The patients were also administered a questionnaire:^[14]

- i. Would you say that your pain during chest tube removal was adequately treated?
- ii. Did you feel a sense of well-being after the treatment?
- iii. Did you feel nausea because of the pain induced by chest tube removal?
- iv. Did you feel any improvement in appetite after the treatment?
- v. Did you feel any improvement in sleep after the treatment?

Visual analog scale score, questionnaire, and responses were recorded by the caregiver nurse.

Assuming an alpha probability level of 0.05, a desired detectable effect size of 0.4 of the population standard deviation, and a desired statistical power of 0.85, the minimum number of patients in each group was determined to be 25. An effect size index of 0.4 is considered large and was selected because a wide range of pain intensity scores were anticipated within each group.

Proportions were compared with Chi-square test or Fisher exact test as appropriate. Continuous parametric data were compared with a Student's *t*-test, and nonparametric data were compared with a Mann–Whitney U-test. $P \leq 0.05$ was considered as significant.

Results

All the fifty patients wenrolled completed the study. There was no significant difference between the two groups with regard to age, weight, proportion of males and females, type of surgery, and duration of surgery [Table 1].

Mean visual analog pain scores were significantly less in TENS Group as compared to Control Group. Fewer patients in the TENS Group demanded additional analgesia as compared to the Control Group [Table 2].

Significantly higher proportion of patients in the TENS Group expressed satisfaction over adequacy of the treatment of pain during chest tube removal compared to Control Group. Feeling of well-being was reported by more patients in TENS Group as compared to Control Group. Proportion of patient who complained of nausea those who had improvement in appetite were not different in the two groups. More patients in TENS Group reported better sleep as compared to Control Group [Table 3].

Discussion

Chest drains are essential part of postoperative management after cardiac surgery, and their removal is an unpleasant aspect of a patient's hospital experience.^[2,15,16] The choice of analgesic modalities currently described to alleviate pain during chest drain removal includes propofol,^[1] isoflurane,^[5] opiates,^[17,18] local anesthetic infiltration or instillation,^[4] and topical analgesics.^[6]

Propofol and isoflurane when used in subanesthetic concentration have been found useful in relieving the pain following chest tube removal. However, their administration requires the presence of an anesthesiologist, and fasting status of the patients is always a concern. Moreover, patients have to be cooperative as they are asked to perform a valsalva maneuver at the time of chest tube removal. Opioids are effective in relieving acute pain but are not without disadvantages because of respiratory depression. Local anesthetics have a rapid onset of action and help in decreasing the pain by reducing the pain stimuli coming from sensory nerve endings, but can cause toxicity by rapid absorption from the instillation/injection site.

Given the inherent side effects associated with traditional techniques such as propofol, isoflurane, and opioids, there seems to be a biological plausibility of nonpharmacological approach in addition to routine analgesics to manage acute pain associated with chest tube removal. To explore this plausibility, various nonpharmacological agents such as cold application,^[19,20] relaxation therapy,^[7] and music^[8] have been investigated as adjuvant for pain relief during chest tube removal. TENS is also a nonpharmacological method which has been used extensively for postoperative pain relief following thoracic operations.^[21] However, its use specifically for pain relief during chest tube removal after cardiac surgery has not been described. While the precise action of TENS

Table 1: Demographic data and perioperative data

	TENS (n=25)	Control (n=25)	P
Age (mean±SD)	42.4±14	37.6±15	0.272
Male:female (ratio)	17:8	17:8	1.0
Weight (kg), mean±SD	60.5±9.3	60.2±5.7	0.884
Height (cm), mean±SD	161.6±5.7	160±4.2	0.282
CABG	7	6	NS
Valvular surgery	12	13	NS
Congenital surgery	6	6	NS
CPB time (min), mean±SD	74.5±30.4	77.3±30.3	0.742
Clamp time (min), mean±SD	42.9±19.4	45.4±19.7	0.65

NS=Not significant, SD=Standard deviation, CABG=Coronary artery bypass graft, CPB=Cardiopulmonary bypass, TENS=Transcutaneous electrical nerve stimulation

Table 2: Pain scores, demand for analgesia

	TENS	Control	P
Pain during chest tube removal (VAS)	4.1±1.2	6.1±0.8	0.001*
Additional demand for analgesia (number of patients)	5	14	0.009**

*Mann-Whitney U-test, **Fischer's exact test. P≤0.05 - statistically significant. VAS=Visual analog scale, TENS=Transcutaneous electrical nerve stimulation

Table 3: Responses to the posttherapy global assessment questionnaire in each of the two treatment groups

	TENS (n=25)	Control (n=25)	P
Adequacy of treatment	15	5	0.004*
Sense of well-being	15	5	0.004*
Nausea during chest tube removal	0	5	0.05**
Improvement in appetite	5	0	0.05**
Improvement in sleep	10	0	0.001*

*Chi-square test, ** Fischer's exact test. P≤0.05 - statistically significant. TENS=Transcutaneous electrical nerve stimulation

is not understood, it appears to exert its beneficial effects through several different modes of action. The classical gate control theory of pain control suggests that stimulation of large diameter, myelinated A-β nerve fibers which have a low threshold for stimulation by electrical current can alter pain recognition in the substantia gelatinosa, thus “closing the gate”, and thereby decreasing the transmission of painful stimuli through the smaller diameter A-δ and C fibers.^[22]

There is also evidence that TENS can directly decrease the conduction and amplitude of painful stimuli through the A- fibers. Finally, an endogenous opioid-dependent mechanism involving the release of endorphins, enkephalins, and dynorphins in CNS has been proposed.^[23]

Most TENS units are capable of delivering a range of stimuli from 10 to 100 Hz. There appears to be a strong patient preference for pulse frequencies > 50 Hz. Most investigators feel that high-frequency (80–100 Hz), low-intensity stimulation gives the best results in the treatment of postoperative pain.

The current amplitude is initially set by the patient who finds a point, which is just below the threshold of discomfort or motor stimulation (approximately 2–20 mA), by a trial and error method. The sensation produced is described as tingling, vibrating, or soothing and is usually effective within a few minutes after the stimulation has begun.^[9]

In the present study, the results demonstrated that TENS as an adjuvant to analgesics was more effective than analgesics alone in reducing the pain scores associated with chest drain removal. We considered it unethical to discontinue the routine analgesics necessary to ensure patient comfort during their stay in the ICU; rather, in addition, patients were allowed “on-demand” analgesia in both TENS and Control groups which was recorded.

Subjective content analysis revealed a significant difference in improving patient perception of chest tube removal when TENS was used before, during, and after the chest tube removal. Patient’s comments indicated a more favorable experience with TENS than in patients not given TENS. Duncan *et al.* confirmed that although both visual analog and verbal descriptor techniques successfully quantify sensory intensity and affective aspects of pain, respectively, verbal descriptors may provide a more sensitive tool for separating intensity and unpleasantness.^[14] We tried to incorporate the affective component of pain by putting up the global questionnaire to participants in both the groups.

The short intense nature of sensations during chest tube removal may not be prevented with the use of analgesia alone. Traditional analgesic method used for this procedure may be less successful than previously thought. This study demonstrates that TENS can be another pain relief option during removal of chest drains after cardiac surgery, especially in the presence of background analgesics. This technique is simple to use and does not require supervision by a medical staff.

Limitations

The study had its limitations that although it was randomized, it was not blinded. Inclusion of another group which included patients with sham TENS might have consolidated the findings that pain relief was not just a placebo effect. However, even a placebo effect of pain relief justifies its use during chest tube removal. Another limitation of the study was that we did not record the interval between the routine analgesic administration and timing of chest tube removal individually that might have resulted in variable pain intensity because of the variable level of analgesic in circulation. However, this confounding factor was present in both the groups possibly eliminating the confounding.

Conclusion

We conclude that TENS has a definite adjuvant role in decreasing the pain scores with reduction in demand analgesia during chest tube removal. Furthermore, with the use of TENS, there was a better sense of well-being manifested as decreased nausea, improvement in appetite, and sleep. However, it does not replace the routine analgesic requirements.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

- McMurray TJ, Bhanumurthy S, Groogan F. Low dose propofol for chest tube removal. *Anaesthesia* 1995;50:566.
- Gift AG, Bolgiano CS, Cunningham J. Sensations during chest tube removal. *Heart Lung* 1991;20:131-7.
- Bruce EA, Howard RE, Franck LS. Chest drain removal pain and its management: A literature review. *J Clin Nurs* 2006;15:145-54.
- Akrofi M, Miller S, Colfar S, Corry PR, Fabri BM, Pullan MD, *et al.* A randomized comparison of three methods of analgesia for chest drain removal in postcardiac surgical patients. *Anesth Analg* 2005;100:205-9.
- Bryden FM, McFarlane H, Tunstall ME, Ross JA. Isoflurane for removal of chest drains after cardiac surgery. *Anaesthesia* 1997;52:173-5.
- Singh M, Gopinath R. Topical analgesia for chest tube removal in cardiac patients. *J Cardiothorac Vasc Anesth* 2005;19:719-22.
- Gorji HM, Nesami BM, Ayyasi M, Ghafari R, Yazdani J. Comparison of ice packs application and relaxation therapy in pain reduction during chest tube removal following cardiac surgery. *N Am J Med Sci* 2014;6:19-24.
- Broscious SK. Music: An intervention for pain during chest tube removal after open heart surgery. *Am J Crit Care* 1999;8:410-5.
- Tyler E, Caldwell C, Ghia JN. Transcutaneous electrical nerve stimulation: An alternative approach to the management of postoperative pain. *Anesth Analg* 1982;61:449-56.
- Hamza MA, White PF, Ahmed HE, Ghoname EA. Effect of the frequency of transcutaneous electrical nerve stimulation on the postoperative opioid analgesic requirement and recovery profile. *Anesthesiology* 1999;91:1232-8.
- Benedetti F, Amanzio M, Casadio C, Cavallo A, Cianci R, Giobbe R, *et al.* Control of postoperative pain by transcutaneous electrical nerve stimulation after thoracic operations. *Ann Thorac Surg* 1997;63:773-6.
- Klin B, Uretzky G, Magora F. Transcutaneous electrical nerve stimulation (TENS) after open heart surgery. *J Cardiovasc Surg (Torino)* 1984;25:445-8.
- Gift AG. Visual analogue scales: Measurement of subjective phenomena. *Nurs Res* 1989;38:286-8.
- Duncan GH, Bushnell MC, Lavigne GJ. Comparison of verbal and visual analogue scales for measuring the intensity and unpleasantness of experimental pain. *Pain* 1989;37:295-303.
- Carson MM, Barton DM, Morrison CC, Tribble CG. Managing pain during mediastinal chest tube removal. *Heart Lung* 1994;23:500-5.

16. Paiement B, Boulanger M, Jones CW, Roy M. Intubation and other experiences in cardiac surgery: The consumer's views. *Can Anaesth Soc J* 1979;26:173-80.
17. Puntillo KA. Dimensions of procedural pain and its analgesic management in critically ill surgical patients. *Am J Crit Care* 1994;3:116-22.
18. Joshi VS, Chauhan S, Kiran U, Bisoi AK, Kapoor PM. Comparison of analgesic efficacy of fentanyl and sufentanil for chest tube removal after cardiac surgery. *Ann Card Anaesth* 2007;10:42-5.
19. Ertug N, Ulker S. The effect of cold application on pain due to chest tube removal. *J Clin Nurs* 2012;21:784-90.
20. Payami MB, Daryei N, Mousavinasab N, Nourizade E. Effect of cold application in combination with Indomethacin suppository on chest tube removal pain in patients undergoing open heart surgery. *Iran J Nurs Midwifery Res* 2014;19:77-81.
21. Warfield CA, Stein JM, Frank HA. The effect of transcutaneous electrical nerve stimulation on pain after thoracotomy. *Ann Thorac Surg* 1985;39:462-5.
22. Melzack R, Wall PD. Pain mechanisms: A new theory. *Science* 1965;150:971-9.
23. Mannheimer JS, Lampe GN, editors. *Clinical Transcutaneous Electrical Nerve Stimulation*. Philadelphia: FA Davis Company; 1988. p. 331-495.

Staying in touch with the journal

1) Table of Contents (TOC) email alert

Receive an email alert containing the TOC when a new complete issue of the journal is made available online. To register for TOC alerts go to www.joacp.org/signup.asp.

2) RSS feeds

Really Simple Syndication (RSS) helps you to get alerts on new publication right on your desktop without going to the journal's website. You need a software (e.g. RSSReader, Feed Demon, FeedReader, My Yahoo!, NewsGator and NewzCrawler) to get advantage of this tool. RSS feeds can also be read through FireFox or Microsoft Outlook 2007. Once any of these small (and mostly free) software is installed, add www.joacp.org/rssfeed.asp as one of the feeds.