Original Article

Effect of Transcutaneous Electrical Nerve Stimulation on Pain, Inspiratory Capacity, and Cough in Patients Undergone Median Sternotomy

Apurva Pardeshi[1], Prajakta Sahasrabudhe[1], Ashok Shyam[2], Parag Sancheti[2]

[1]Department of Cardiovascular and Respiratory Physiotherapy, Sancheti Institute College of Physiotherapy, [2]Department of Academic Research, Sancheti Institute of Orthopedics and Rehabilitation, Pune, Maharashtra, India

Abstract

Background: Occurrence of postpulmonary complications (PPCs) is common after thoracic incisions. Significant reduction in pulmonary functions reported in patients after median sternotomy is known to be associated with postoperative pain which potentiates risks for PPCs. Transcutaneous electrical nerve stimulation (TENS) is a low-frequency electrical current used for efficient pain modulation in managing various types of pain, including that after thoracic surgery. **Aim:** The aim of this study was to study the effect of TENS on Pain, Inspiratory Capacity, and Cough (PIC Score) in patients who have undergone median sternotomy. **Materials and Methods:** Thirty patients who underwent median sternotomy were randomly divided into control and experimental groups on the postoperative 1st day. Participants of the experimental group received TENS, and the control group received placebo TENS for 5 days. PIC Score was used as an outcome tool and was assessed at baseline (before commencement) and the endpoint (on the 5th day after the intervention). **Results:** Although both the groups showed improvements in PIC Scores, the experimental group showed superior results than the placebo group ($P = 0.02$). **Conclusion:** Conventional TENS effectively reduces pain and improves inspiratory capacity and coughing (PIC Score) in patients who have undergone median sternotomy.

Keywords: Low-frequency current, pain gate theory, physiotherapy, postpulmonary complications, thoracotomy

Introduction

Postpulmonary complications (PPCs) are common but avoidable occurrences after heart surgeries through median sternotomy. Although general anesthesia used during the surgery is thought to increase the incidence of PPCs by depression of respiratory drive during the perioperative period, postoperative pain also contributes to it.[1-3] Pain at the sternotomy site alters normal breathing patterns, affects alveolar ventilation, and is associated with reduced pulmonary function, including the efficiency of the cough reflex.[4] Ineffective bronchial clearance (bronchial secretions) increases the likelihood of PPCs.[5] Prompt and effective pain modulation has a role in preserving pulmonary function reducing complications.[3] Given the numerous side effects of pharmacological options for pain management, nonpharmacological modalities such as transcutaneous electrical nerve stimulation (TENS) might prove beneficial in reducing pulmonary impairments.[6] TENS provides an analgesic effect on pain and reduces the need for analgesics when applied directly on the sternotomy site, helps improve pulmonary functions with very few associated complications and very few contraindications that can be seen due to the use of any other pain-relieving strategies. Thus, TENS can be an adjunctive option with multimodal analgesia poststernotomy.[7]

The study aimed to see the effect of TENS on pain, inspiratory capacity, and cough in poststernotomy patients. Hence, the present study was designed to evaluate the effect of TENS on Pain, Inspiratory capacity, and Cough Score.

Materials and Methods

It was a randomized control trial. After obtaining approval from the Institutional Review Board and registration in Clinical

Address for correspondence: Dr. Prajakta Sahasrabudhe, 11/12, Thubepark, Shivaji Nagar, Pune - 411 005, Maharashtra, India.
E-mail: prajakta.sahasrabudhe2@gmail.com

How to cite this article: Pardeshi A, Sahasrabudhe P, Shyam A, Sancheti P. Effect of transcutaneous electrical nerve stimulation on pain, inspiratory capacity, and cough in patients undergone median sternotomy. Indian J Respir Care 2022;11:215-8.

Received: 29-12-2021 **Revised:** 14-03-2022
Accepted: 18-03-2022 **Published:** 28-07-2022

Access this article online

Quick Response Code:

Website: www.ijrc.in

DOI: 10.4103/ijrc.ijrc_168_21

Trial Registry India (CTRI/2021/09/03639279), thirty patients within the age group of 18–65 years, who have undergone cardiac surgery through median sternotomy approach, are hemodynamically stable and without ventilatory support at postoperative 1st day were recruited from cardiac recovery unit of a tertiary health-care setup of a metropolitan city of India. Patients who had any signs of systemic or surgical site infection or inflammation and were put on permanent pacemakers were excluded from the study.

After taking informed consent from the patients, they were divided into two groups equally, namely experimental group (Group A) and control group (Group B), using computer-generated charts of random numbers [Figure 1]. Pain, Inspiratory capacity, and Cough Score (PIC Score) were assessed at the time of recruitment in the study (1st postoperative day) and the end of the intervention period (5th postoperative day). PIC Score is a comprehensive outcome tool assessing pain level with visual analog scale, inspiratory capacity with an inspiratory spirometer, and subjective assessment of cough efficiency.[8]

Intervention

Group A received conventional TENS (frequency as 50HZ and intensity as tolerated by patients) for 20 min once a day for 5 days with two pairs of electrodes placed 2–2.5 cm lateral to the incision starting from the 1st postoperative day.[9]

In Group B (control group), the electrode placement was the same as Group A, but the intensity was zero, and the patients were informed that the stimulation was silent.[10] Cardiac rehabilitation protocol initiation and progression norms were kept identical in both the groups, which started on postoperative day 1. It included diaphragmatic breathing exercises with an incentive spirometer, free active exercises for plantar flexors, knee extensors, hip abductors, and extensors. Shoulder-free exercises were also done within pain-free limit done twice daily with 5–10 repetitions for each exercise. Ambulation within the cardiac care unit was added on postoperative day 2. A physiotherapist monitored and supervised the entire exercise session.[11]

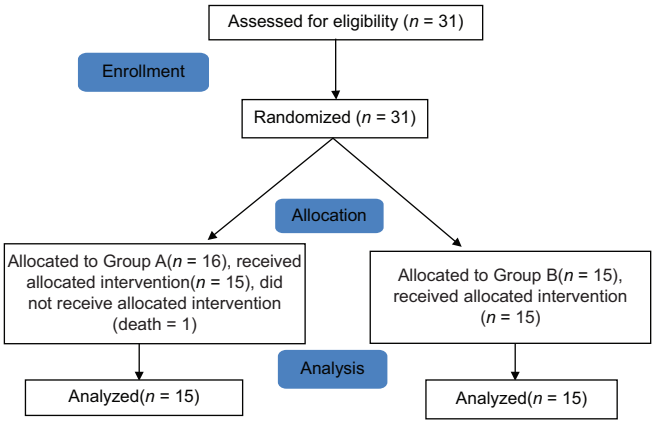

Figure 1: Consort chart

Data analysis

Data were analyzed using SPSS (Statistical Package for The Social Sciences) software version 26(IBM, Chicago IL USA). Wilcoxon signed-rank test was used for within-group comparison, and Mann–Whitney *U*-test was used for between-groups comparison for PIC Score. The level of significance was set at 0.05.

Results

The population demographics are presented in Table 1. Although both the groups had statistically significant improvement in PIC Scores at the end of the intervention period, Group A was observed to have superior scores than Group B (*P* value 0.02) [Tables 2,3 and 4].

In comparison, improvement was recorded in pain for individual components of the score (*P* value 0.02).

Discussion

Median sternotomy is the most used approach for cardiac surgeries. Pain is a widespread occurrence associated with complications and morbidities in the perioperative period. After a major surgery is done under general anesthesia, the alveolar-to-arterial oxygen difference may take some

Table 1: Demographics of Group A and Group B

	Age (mean±SD)	CABG patients	Valve replacement patients
Group A	58.13 ± 8.48	13	2
Group B	57.13 ± 8.96	13	2

SD: Standard deviation, CABG: Coronary artery bypass graft

Table 2: Within-group analysis for Group A

Parameter	Mean		*P*
	Preintervention Group A	Postintervention Group A	
PIC Score	4.9333 ± 0.88372	8.6000 ± 0.98561	0.01

PIC: Pain, inspiratory capacity, and cough

Table 3: Within-group analysis for Group B

Parameter	Mean		*P*
	Preintervention Group B	Postintervention Group B	
PIC Score	4.9333 ± 1.03	7.2000 ± 0.8619	0.01

PIC: Pain, inspiratory capacity, and cough

Table 4: Between-group analysis for Group A and B

Parameter	Mean		*P*
	Group A	Group B	
PIC Score	3.666667 ± 1.17	2.266667 ± 1.77	0.02

PIC: Pain, inspiratory capacity, and cough

days to normal.[2] Incision-related pain is associated with shallow and altered breathing patterns adding to ineffective alveolar ventilation and microatelectasis. Changes are seen in thoracic cage mobility, and abdominal motion due to pain postmedian sternotomy also contributes to reduced lung volumes.[12] Ineffective cough mechanism was secondary to reduced lung volumes and painful forced exhalation increases tendency toward retained secretions in the lungs threatening lung infections. Hence, managing pain in the perioperative period is vital to prevent PPCs. Pharmacological agents are a mainstay in pain modulation postcardiac surgery. Opioids or anti-inflammatory medicines, local or spinal analgesia, and nerve block can be given intravenously or orally to treat postsurgical pain, but in cardiac patients, there are concerns about side effects such as purists, nausea, and vomiting, effect on renal tubular function, inhibition of platelet aggregation due to which other modalities are used in treating pain.[3] TENS-a routinely used electrotherapeutic modality in the physiotherapy department is a cost-effective option to manage pain with fewer adverse reactions.

Conventional TENS has a high stimulation frequency (40–150 HZ), short pulse duration (<50 microseconds), and tolerable intensities. It selectively activates large diameter nonnoxious afferents (A-beta fibers) to reduce nociceptor cell activity and sensitization at a segmental level in the spinal cord, blocking the pain being carried simultaneously.[13] Many studies have documented that TENS helps reduce pain, improve pulmonary functions, and helps in improvement of respiratory muscle strength in patients undergoing CABG through median sternotomy. Most research uses TENS as an intervention for experimental groups without using a true placebo in the control group.[14-16]

Psychological factors that influence the experience of pain include attention, behavioral responses, and interaction of a person with the environment. Use of the placebo effect in managing pain has shown a beneficial impact. Placebo does not have any direct therapeutic effect on the body but affects brain–mind responses. It reduces pain by directly or indirectly acting on spinal nociceptive pathways. Placebo also affects the central nervous system by belief or expectation of pain relief, which inhibits pain transmission and thus reduces pain.[17]

The outcome measure used in the present study, PIC Score is a 10-point grading system evaluating pain severity, inspiratory capacity, and cough efficiency. It was developed and validated for use in patients admitted in intensive care units with rib fractures. Muscle and bone injury in rib fracture is associated with severe pain and hence reduction in pulmonary function which potentiates risk for respiratory complications similar to that seen in postthoracic surgery. Therefore, the score was used in the present study to assess the effectiveness of the intervention.[8]

In the present study, improvement in PIC Score in patients undergoing median sternotomy was seen in the TENS group compared to the placebo group, proving the effectiveness of TENS in managing postoperative impairments. On comparison of individual components, greater benefits in pain reduction were observed in the TENS group possibly through pain gate mechanism. Still, no statistically significant difference was observed in inspiratory capacity and cough efficiency changes.

Use of an incentive spirometer and breathing exercises effectively improve pulmonary functions and functional capacity of the patients who have undergone CABG.[18,19] In the present study, both the groups received breathing exercises as a part of routine physiotherapy justifying similar improvements in lung parameters in both the groups.

Limitations

Use of pain medications, breathing exercises, and activity prescription was continued in both the groups during the intervention on the ethical grounds which might have interfered with change independent variable. Incidence of postsurgical pulmonary complications and hospital stay could have been evaluated to measure the actual impact of TENS in preventing PPCs.

Conclusion

From the present study, it can be concluded that conventional TENS effectively reduces pain and improves inspiratory capacity and coughing (PIC Score) in patients who have undergone median sternotomy.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Baumgarten MD, Garcia GK, Frantzeski MH, Giacomazzi CM, Lagni VB, Dias AS, *et al.* Pain and pulmonary function inpatients submitted to heart surgery via sternotomy. Rev Bras Cir Cardiovasc 2009;21:386-92.
2. Miskovic A, Lumb AB. Postoperative pulmonary complications. Br J Anesth 2017;118:317-34.
3. Huang AP, Sakata RK. Pain after sternotomy – Review. Rev Bras Anestesiol 2016;66:395-401.
4. Denu ZA, Yasin MO, Melekie TB, Berhe A. Postoperative pulmonary complications and associated risk factors among surgical patients. Anesth Clin Res 2015;6:5.
5. Johnson MI. Post-surgical pain: The status of evidence for the use of Transcutaneous Electrical Nerve Stimulation (TENS). Analg Resusc Curr Res 2016;7:1-4.
6. Bjordal JM, Johnson MI, Ljunggreen AE. Transcutaneous electrical nerve stimulation (TENS) can reduce postoperative analgesic consumption. A meta-analysis with assessment of optimal treatment parameters for postoperative pain. Eur J Pain 2003;7:181-8.
7. Cardinali A, Celini D, Chaplik M, Grasso E, Nemec EC. Efficacy of transcutaneous electrical nerve stimulation for postoperative pain, pulmonary function, and opioid consumption following cardiothoracic procedures: A systematic review. Neuromodulation 2021;24:1439-50.
8. Witt CE, Bulger EM. Comprehensive approach to the management of the patient with multiple rib fractures: A review and introduction of a bundled rib fracture management protocol. Trauma Surg Acute Care Open 2017;2:e000064.
9. Jaisinghani S, Jiandani M, Mehta A. Effect of transcutaneous electrical

nerve stimulation on postoperative pain following cardiac surgery-pilot study. Int J Physiother 2015;2:341-6.
10. Kiran V, Thirupathi A. The effect of transcutaneous electrical nerve stimulation on forced vital capacity and pain in patients with median sternotomy. J Med Sci Res 2016;4:10926-33.
11. Borzou SR, Amiri S, Salavati M, Soltanian AR, Safarpoo G. Effects of the first phase of cardiac rehabilitation training on self-efficacy among patients undergoing coronary artery bypass graft surgery. J Tehran Uni Heart Cent 2018;13:126-31.
12. Ragnarsdottir M, Ánsdóttir ÁK, Ingvarsdóttir I, Hannesson P, Torfason B, Cahalin L. Short term changes in pulmonary functions and respiratory movements after cardiac surgery via median sternotomy. Scand Cardiovasc J 2004;38:46-52.
13. Rajaei S, Dabbagh A. Risk factors for postoperative respiratory mortality and morbidity in patients undergoing coronary artery bypass grafting. Anesth Pain Med 2012;2:60-5.
14. Jahangiri Fard A, Razavi M, Ahmadi ZH, Forouzesh Fard M. Effect of TENS on postoperative pain and pulmonary function in patients undergoing coronary artery bypass surgery. Pain Manag Nurs 2018;19:408-14.
15. Lima PM, Farias RT, Carvalho AC, Da Silva PN, Ferraz Filho NA, De Brito RF. Transcutaneous electrical nerve stimulation after coronary artery bypass graft surgery. Rev Bras Cir Cardiovasc 2011;26:591-6.
16. Monisha R, Aparna K. Efficacy of TENS & respiratory physiotherapy to improve functional capacity in post CABG. J Physiother Res 2017;1:8.
17. Wager TD, Atlas LY. The neuroscience of placebo effects: Connecting context, learning and health. Nat Rev Neurosci 2015;16:403-18.
18. Julia Alencar R, Costa-Val R, Rosseti MB, Neto MH. Comparison between deep breathing exercises and incentive spirometry after CABG surgery. Braz J Cardiovasc Surg 2009;24:165-72.
19. Amin R, Alaparthi GK, Samuel SR, Bairapareddy KC, Raghavan H, Vaishali K. Effects of three pulmonary ventilation regimes in patients undergoing coronary artery bypass graft surgery: A randomized clinical trial. Sci Rep 2021;11:6730.