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Best evidence topic - Thoracic non-oncologic

Is transcutaneous electrical nerve stimulation effective in relieving postoperative pain after thoracotomy?

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Summary

A best evidence topic was constructed according to a structured protocol. The question addressed was whether the use of transcutaneous electrical nerve stimulation (TENS) is effective in reducing post-thoracotomy pain. Of the 74 papers found with a report search, nine prospective randomized controlled trials (RCT), among which three were double-blind, presented the best evidence to answer the clinical question. All investigated the effect of TENS as an adjunct therapy for relieving acute post-thoracotomy pain in patients undergoing thoracic surgery. The authors, journal, date and country of publication, study type, group studied, relevant outcomes and results of these papers are given. We conclude that a vast majority – seven of the nine retrieved studies – were in favor of TENS as an adjuvant to narcotic analgesics for improving outcome after thoracic surgery. Indeed, the interest and benefit has been shown not only in the treatment of acute post-thoracotomy pain (pain scores and narcotic requirements were consistently lower in the TENS group as opposed to the Placebo-TENS group), but also when used together with narcotic analgesics to reduce the duration of recovery room stay and to increase chest physical tolerance (better coughing attempts during chest physiotherapy) with positive effects on pulmonary ventilator function [forced expiratory volume in 1 s (FEV_1) and/or forced vital capacity (FVC)]. Specifically, the TENS treatment was shown to be ineffective when used alone in severe post-thoracotomy pain (i.e. posterolateral thoracotomy incision), but useful as an adjunct to other medications in moderate post-thoracotomy pain (i.e. muscle sparing thoracotomy incision) and very effective as the sole pain-control treatment in patients experiencing mild post-thoracotomy pain (i.e. video-assisted thoracoscopy incision). Hence, current evidence shows TENS associated with postoperative medications to be safe and effective in alleviating postoperative pain and in improving patient recovery, thus enhancing the choice of available medical care and bettering outcome after thoracic surgery.

Keywords: Thoracic surgery; Thoracotomy; Transcutaneous electrical nerve stimulation; Postoperative pain

1. Introduction

A best evidence topic was constructed according to a structured protocol described in the ICVTS [1].

2. Three-part question

In [patients undergoing thoracotomy for lung surgery] is [transcutaneous electrical nerve stimulation associated with analgesic treatment] superior to [analgesic treatment alone] in [reducing postoperative pain]?

3. Clinical scenario

At day 1 after a left upper lobectomy – done via posterolateral thoracotomy incision – you see a 65-year-old patient for whom postoperative pain cannot be controlled with the usual narcotics. The patient's pain report on the numeric rating scale is 6 at rest and 8 when coughing. The patient has a smoking history of 40 cigarettes a day for 30 years and a chronic obstructive pulmonary disease, both of which justify adequate chest physical therapy. The narcotics used are associated with undesirable side effects (nausea and vomiting). You wonder if transcutaneous electrical nerve stimulation (TENS) might be a relevant adjuvant to narcotics in controlling acute postoperative pain. You propose this therapeutic option to the patient, who argues that it would probably make things worse. You, therefore, decide to look up the evidence in the literature.

4. Search strategy

Medline 1980–May 2009, using the OVID interface, with results limited to human subjects and English language articles: [thoracic surgery] AND [transcutaneous electrical nerve stimulation]. The centre for evidence-based physiotherapy (CEBP), developed to give rapid access to bibliographic details and abstracts of randomized controlled trials (RCT), systematic reviews and evidence-based clinical practice guidelines in physiotherapy; http://www.pedro.

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Table 1

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments/weaknesses
Miller-Jones et al., (1980), Anaesthesia, England [2] Prospective randomized clinical trial (level 1b)	Assessment of the effectiveness of TENS in relieving post-thoracotomy pain Group 1 – TENS ($n=14$) Group 2 – No-TENS ($n=14$) Electrodes: placed on either side of the incision and the drain site (attached immediately after the operation)	Dose of narcotics Pain score (linear analog) FEV_1	TENS < No-TENS but not significantly so ($P>0.05$) TENS > No-TENS but not significantly so ($P>0.05$) No significant differences	Confounding factor: reluctance on the part of the nurse to give opiates to patients already receiving TENS
Stratton and Smith, (1980), Phys Ther, USA [3] Prospective randomized clinical trial (level 1b)	Assessment of TENS on post-thoracotomy pain Group 1 – TENS ($n=11$) Group 2 – No-TENS ($n=10$) Two electrodes: placed at sites of greatest pain. Intensity and rate of the current was controlled by the patient (below a level causing muscular contraction)	FVC recorded as an average of three consecutive trials	TENS > No-TENS $F=6.753$; $P=0.01$	Pain relief was not measured to avoid patient's subjective reports of relief of pain
Rooney et al., (1983), Anesth Analg, USA [4] Prospective randomized double blind clinical trial (level 1b)	Assessment of TENS on post-posterolateral thoracotomy pain Group 1 – TENS ($n=22$) Group 2 – Placebo-TENS ($n=22$) Electrodes: placed 2–2.5 cm above and below the incision line. Stimulation was initiated in the recovery room and given continuously for 24 h. Pulse rate of 120 bpm, pulse width of 0.2 ms and current output of 14–20 mA	Narcotic requirement Frequency of narcotic administration	TENS < Placebo-TENS; $P<0.05$ TENS = Placebo-TENS Every 2–4 h: $P>0.05$ Every 4–12 h: $P>0.05$	The impact of malignancy on TENS was not studied
Warfield et al., (1985), Ann Thorac Surg, USA [5] Prospective randomized double blind clinical trial (level 1b)	Assessment of TENS on post-thoracotomy pain Group 1 – TENS ($n=12$) Group 2 – Placebo-TENS ($n=12$) Electrodes: applied 2 cm from the suture line on both sides of the incision, all units were set at amplitude 7, width 5. Continuous stimulation for 48 h postoperative	Pain score Chest physical therapy Nausea Recovery room stay (h) Narcotic requirement (mg/kg)	TENS < Placebo-TENS Day 1: $P=0.014$ Day 2: $P=0.065$ TENS > Placebo-TENS Day 1: $P=0.018$ Day 2: $P=0.0064$ TENS = Placebo-TENS Day 1: $P=0.175$ Day 2: $P=0.131$ TENS < Placebo-TENS; $P=0.013$ TENS = Placebo-TENS Day 1: $P=0.226$ Day 2: $P=0.535$	
Liu et al., (1985), J Formosan Med Assoc, Taiwan [6]	Assessment of TENS on post-thoracotomy pain (primary outcome) and range of motion of shoulder flexion	Pain score	Group 1: significant alleviation after TENS each day ($P<0.05$) Group 2: no significant	A 'low current' as opposed to a 'no current' method was used to evaluate the placebo effect

(Continued on next page)

Table 1 *(Continued)*

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments/weaknesses
Prospective randomized controlled study (level 1b)	and functional activity (secondary outcomes)		alleviation ($P>0.05$) except on the 4th and 6th postoperative days	
	Group 1 – TENS at the most comfortable intensity of current ($n=15$) Group 2 – TENS at the lowest intensity of current ($n=15$)	ROM of operated shoulder flexion	Group 1: significant increase during the first 5 postoperative days ($P<0.05$) Group 2: no significant increase ($P>0.05$) except on the 1st postoperative day	
	Electrodes: placed postoperative day 1 on the most painful area along the incision wound. Electrical stimulation intensity was set from 0 to 8 (corresponding to values from 1.5 to 150 pps), frequency from 0 to 6 (corresponding to the electrical current of 0–10 mA), and pulse width 0.1 ms	Functional activities	Group 1: significant increase during the first 4 postoperative days ($P<0.05$) Average days for started to walk after operation: 3.2 Group 2: no significant increase ($P>0.05$) except on the 3rd postoperative day Average days for started to walk after operation: 4.5	
Stubbing and Jellicoe (1988), Anaesthesia, England [7] Prospective randomized controlled study (level 1b)	Assessment of TENS on pain and pulmonary function after posterolateral thoracotomy	Analgesic requirement (mg)	TENS = No-TENS Recovery: $P>0.05$ First 24 h: $P>0.05$	A double-blind technique is impossible to use due to the way the study is built (preoperative sensation of tingling). Sham TENS was not used
	Group 1 – TENS ($n=20$) Group 2 – No-TENS ($n=20$)	Time to oral analgesia (h)	TENS = No-TENS $P>0.05$	
	Electrodes: applied to either side of the thoracotomy. Stimulation was started before reversal of the muscle relaxant and applied continuously for 48 h. Fixed pulse rate of 70 pulses/s and pulse width of 180 μs	Satisfactory pain score	TENS = No-TENS 6th h/24th h/48th h: $P>0.05$	
		PEFR	TENS = No-TENS % of preoperative predicted/% reduction on the 1st day postoperative/% reduction on the 2nd day postoperative: $P>0.05$	
		Antiemetic requirement (number of patients)	TENS < No-TENS $P=0.04$	
		Mean length of in-hospital stay (days)	TENS = No-TENS $P>0.05$	
Benedetti et al., (1997), Ann Thorac Surg, Italy [8] Prospective randomized controlled study (level 1b)	Assessment of TENS on pain in different types of thoracic surgical procedures	Pain intensity (numeric rating scale)	TENS = Placebo-TENS = Control; $P>0.05$	
	Group 1 – TENS ($n=103$) Group 2 – Placebo-TENS ($n=106$) Group 3 – Control ($n=115$)	Time to analgesia request (min)	PL: TENS = Placebo-TENS $P=0.344$ MS/CT/ST/VAT: TENS > No-TENS $P<0.001$	
	Two electrodes: placed on either side of the thoracotomy 1 cm from the suture line. Electrical stimulation was set at a frequency of 100	Analgesic intake	PL: TENS = Placebo-TENS = Control; $P>0.05$	

(Continued on next page)

Table 1 *(Continued)*

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments/weaknesses
	pulses/s and a pulse width of 200 μs. Stimulation was started about 1 h after recovery from anesthesia and performed for 1 h. A 1-h rest interval followed to avoid accommodation of nerve fibers before further stimulation for 1 h Five procedures: 1) Posterolateral thoracotomy (PL) 2) Muscle sparing thoracotomy (MS) 3) Costotomy (CT) 4) Sternotomy (ST) 5) Video-assisted thoracoscopy (VAT)		MS/CT/ST/VAT: TENS < Placebo-TENS and Control; $P<0.001$	
Erdogan et al., (2005), W J Surg, Turkey [9] Prospective randomized placebo-controlled double blind study (level 1b)	Assessment of the effectiveness of TENS on postoperative pain and pulmonary function after posterolateral thoracotomy Group 1 – TENS ($n=60$) Group 2 – Placebo TENS ($n=56$) Four electrodes: placed 2 cm below and 2 cm above the thoracotomy. The stimulation operated at 100 Hz frequency, voltage intervals of 100 μs, and an amplitude regulated so as not to disturb the patient	Dose of analgesic VAS levels Pulmonary function Arterial blood gases Side effects	TENS < Placebo-TENS; $P<0.01$ TENS < Placebo-TENS At rest: $P=0.009$ While coughing: $P=0.008$ Significant improvement in the TENS group (FEV_1, $P=0.01$; FVC, $P=0.012$) Significant improvement in the TENS group (PaO_2, $P=0.024$; $PaCO_2$, $P=0.02$) TENS = 0 Placebo-TENS = Vomiting, nausea, pruritis	
Solak et al., (2007), Thorac Cardiovasc Surg, Turkey [10] Prospective randomized controlled study (level 1b)	Assessment of TENS on post-posterolateral thoracotomy pain Group 1 – TENS ($n=20$) Group 2 – No-TENS ($n=20$) Four electrodes: placed 2 cm below and 2 cm above the thoracotomy. The stimulation consisted of 100 ms of 3 Hz frequency and an intensity of 12 mA for 30 min. TENS application began 4 h after operation and was continued for 10 days	VAS levels Prince Henry Scale levels Pulmonary function (FEV_1 and FVC)	Day 0–3 postoperative TENS = No-TENS $P>0.05$ Day 4–60 postoperative TENS < No-TENS $P<0.05$ Day 0–2 postoperative TENS = No-TENS $P>0.05$ Day 3–60 postoperative TENS < No-TENS $P<0.05$ No significant difference between groups; $P>0.05$	Further studies to clarify the effect and elucidate the mechanism of action are warranted

TENS, transcutaneous electrical nerve stimulation; FEV_1, forced expiratory volume in 1s; FVC, forced vital capacity; ROM, range of motion; PEFR, peak expiratory flow rate; VAS, visual analog scale.

fhs.usyd.edu.au/index.html, was also searched. Finally, a hand search was used to follow-up references from the retrieved studies.

5. Search outcome

Nine papers were selected from a total of 74 abstracts (including 3 non-systematic reviews) retrieved to providing the best evidence on the topic. These papers are documented in Table 1.

6. Results

Nine prospective RCT were identified.

Miller-Jones et al. [2] designed a prospective RCT to investigate the effectiveness of TENS in relieving post-

thoracotomy pain. Twenty-eight patients were included: 14 in the TENS group and 14 in the No-TENS group. The results showed that: there was no significant difference in the mean value of forced expiratory volume in 1 s (FEV_1) between those who had TENS and those who did not; the amount of opiates used was lower in the TENS group than in the No-TENS group ($P>0.05$); the No-TENS group had a lower pain score ($P>0.05$).

Stratton and Smith [3] performed a prospective RCT to measure the effects of TENS on patients who had undergone thoracotomies. Twenty-one patients were assigned either to the TENS group ($n=11$) or the No-TENS group (control group, $n=10$). The data indicated a statistically significant increase in forced vital capacity (FVC) during stimulation ($P<0.01$), suggesting that TENS during application improves chest expansion and mobility in patients.

Rooney et al. [4] conducted a prospective randomized double-blind study to evaluate the efficacy of TENS in relief of post-thoracotomy pain by comparing postoperative narcotic requirements in 22 patients having TENS and in 22 patients having sham electrical stimulation (Placebo-TENS group). When TENS was used, 22.7% of the patients required no narcotics in the first 24 postoperative hours ($P<0.05$). All patients having sham stimulation required postoperative narcotics.

Warfield et al. [5] performed a prospective randomized double-blind study to assess the effect of TENS on pain after thoracotomy for pulmonary resection. Twenty-four patients were randomly assigned to an experimental group (TENS group, $n=12$) or a control group treated with sham stimulator setups (Placebo-TENS group, $n=12$). Patients in the TENS group had lower pain scores during the first 24 postoperative hours ($P=0.014$), shorter recovery room stay ($P=0.013$), and better tolerance of chest physical therapy on both day 1 ($P=0.018$) and day 2 ($P=0.0064$).

Liu et al. [6] designed a prospective RCT to examine the effect of TENS on 30 patients who had undergone thoracotomy. Patients were randomly allocated to either an experimental group (group 1: TENS at the most comfortable intensity of current, $n=15$) or a control group (group 2: TENS at the lowest intensity of current, $n=15$). The results showed that TENS had alleviated postoperative pain significantly in group 1. The range of motion (ROM) of shoulder flexion had increased and functional activity had improved. The length between operation and discharge showed no significant difference between the two groups.

Stubbing and Jellicoe [7] performed a prospective RCT to assess the effect of TENS following thoracotomy on 40 patients scheduled to thoracic surgery. Forty patients were randomly assigned to the TENS group ($n=20$) or the No-TENS ($n=20$). The use of TENS did not significantly alter the requirements for analgesia although there was a reduction in postoperative nausea and vomiting in the TENS group ($P=0.04$). There was no difference between the two groups with respect to changes in peak expiratory flow rate (PEFR).

Benedetti et al. [8] designed a prospective RCT to investigate the effect of TENS on postoperative pain in 324 patients having undergone different types of thoracic surgical procedures. The TENS treatment was not effective in posterolateral thoracotomy (severe pain), but was useful as an adjunct to other medications in the muscle-sparing thoracotomy, costotomy, and sternotomy groups (moderate pain). In contrast, it was very effective as the sole pain control treatment in patients having video-assisted thoracoscopy (mild pain).

Erdogan et al. [9] performed a prospective randomized placebo-controlled study of the effect of TENS on post-thoracotomy pain and pulmonary function. One hundred and sixteen patients were randomly assigned to the TENS group ($n=60$) or a control group (Placebo-TENS, $n=56$). The use of TENS reduced the need to administer opioids during the 5-day postoperative period ($P=0.013$). TENS increased the spirometric respiratory function and the arterial blood gases.

Solak et al. [10] examined the effect of TENS on post-thoracotomy pain and pulmonary function of 40 patients scheduled to undergo posterolateral thoracotomy with a prospective RCT. Patients were randomly allocated to either an experimental group (group 1: TENS, $n=20$) or a patient-controlled analgesia (PCA) group (group 2: No-TENS, $n=20$). TENS provided better pain relief and comfort compared to PCA from the fourth postoperative day onwards, and this pain-reducing effect continued for at least two months postoperatively.

7. Clinical bottom line

On the whole, seven of the nine studies presented were clearly in favor of TENS as an adjuvant to narcotic analgesics for improving outcome after thoracic surgery. Indeed, the interest and benefit was shown not only in the treatment of acute post-thoracotomy pain, but also when used together with narcotic analgesics, in reducing the duration of recovery-room stay, increasing chest physical tolerance with positive effects on pulmonary ventilator function. Hence, current evidence shows TENS associated with postoperative medications to be safe and effective in alleviating postoperative pain and in improving patient recovery after thoracic surgery.

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Best Evidence Topic

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