

The effect of transcutaneous electric nerve stimulation on chronic postoperative pain and long-term quality of life

Transkütanöz elektrikli sinir uyarımının kronik ameliyat sonrası kronik ağrı ve uzun dönem yaşam kalitesine etkisi

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ABSTRACT

Background: This study aims to investigate the effects of transcutaneous electrical nerve stimulation on early-stage postoperative pain and long-term quality of life in patients undergoing thoracotomy.

Methods: Between January 2019 and September 2019, a total of 100 patients (76 males, 24 females; mean age: 57.9±11.9 years; range, 51 to 79 years) who underwent thoracotomy due to benign or malignant lesions were included. The patients were divided into two groups: 50 patients who received transcutaneous electrical nerve stimulation (Group 1) and a control group of 50 patients who did not receive transcutaneous electrical nerve stimulation (Group 2). The Short Form-36 life quality scale was used to evaluate patients' quality of life at one month before and after surgery.

Results: The mean length of hospital stay was 4.9±3.1 days in Group 1 and 6.2±4.6 days in Group 2 (p=0.008). There were no statistically significant differences in early-stage postoperative pain scores between the groups (p>0.05). Compared to Group 2, Group 1 had significantly lower pain scores and higher life quality scores pre- and postoperatively (p<0.05).

Conclusion: Transcutaneous electrical nerve stimulation is an effective method to manage chronic pain in the postoperative period. On the other hand, it does not effectively reduce early-stage postoperative pain or affect complication rates. The prevention of chronic postoperative pain by transcutaneous electrical nerve stimulation improves long-term quality of life of patients.

Keywords: Postoperative pain, quality of life, surgery, thoracic surgery, transcutaneous electrical nerve stimulation.

ÖZ

Amaç: Bu çalışmada torakotomi yapılan hastalarda transkütanöz elektrikli sinir uyarımının erken dönem ameliyat sonrası ağrı ve uzun dönem yaşam kalitesi üzerine etkileri incelendi.

Çalışma planı: Ocak 2019 - Eylül 2019 tarihleri arasında benign veya malign lezyonlar nedeniyle torakotomi yapılan toplam 100 hasta (76 erkek, 24 kadın; ort. yaş: 57.9±11.9 yıl; dağılım, 51-79 yıl) çalışmaya dahil edildi. Hastalar iki gruba ayrıldı: 50 hastaya transkütanöz elektrikli sinir uyarımı uygulandı (Grup 1) ve 50 hastadan oluşan kontrol grubuna (Grup 2) transkütanöz elektrikli sinir uyarımı uygulanmadı. Ameliyat öncesi ve ameliyat sonrası birinci aylarda hastaların yaşam kalitesini değerlendirmek için Kısa Form-36 yaşam kalitesi ölçeği kullanıldı.

Bulgular: Ortalama hastanede kalış süresi Grup 1'de 4.9±3.1 gün ve Grup 2'de 6.2±4.6 gün idi (p=0.008). İki grup arasında erken dönem ameliyat sonrası ağrı skorları açısından istatistiksel olarak anlamlı bir fark yoktu (p>0.05). Ameliyat öncesi ve sonrasında Grup 2'ye kıyasla, Grup 1'in ağrı skorları anlamlı düzeyde daha düşük ve yaşam kalitesi skorları daha yüksek idi (p<0.05).

Sonuç: Transkütanöz elektrikli sinir uyarımı ameliyat sonrası dönemde kronik ağrıyı yönetmede etkili bir yöntemdir. Ancak, erken dönem ameliyat ağrısını etkili düzeyde azaltmaz veya komplikasyon oranlarını etkilemez. Transkütanöz elektrikli sinir uyarımı ile ameliyat sonrası kronik ağrının engellenmesi, hastaların uzun dönemde yaşam kalitesini artırmaktadır.

Anahtar sözcükler: Ameliyat sonrası ağrı, yaşam kalitesi, cerrahi, göğüs cerrahi, transkütanöz elektrikli sinir uyarımı.

Received: April 06, 2020 Accepted: June 10, 2020 Published online: October 20, 2021

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Cite this article as:

Cansever L, Sezen CB, Yaran OV, Duman S, Seyrek Y, Hatipoğlu M, et al. The effect of transcutaneous electric nerve stimulation on chronic postoperative pain and long-term quality of life. Turk Gogus Kalp Dama 2021;29(4):496-502

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Despite advanced invasive surgical techniques and anesthetic equipment, the pain remains one of the most important complications in the postoperative period following thoracotomy.^[1] Postoperative pain increases hospitalization time and decreases the quality of life and, thus, is a significant source of concern for thoracic surgery patients.^[2] Intercostal nerve traction is thought to be the most important factor in pain development.^[1-4] To mitigate pain, several surgical techniques such as intercostal sutures, double-edge closure, video thoroscopic approaches, and neural block techniques are performed.^[5-8] Transcutaneous electrical nerve stimulation (TENS) is an effective non-invasive method for reducing pain, particularly in the early postoperative period;^[9,10] however, there are scarce data regarding the patients' long-term quality of life and chronic pain.

In the present study, we aimed to investigate the effects of TENS on early and chronic postoperative neuropathic pain and long-term quality of life in thoracotomy patients.

PATIENTS AND METHODS

This single-centered, prospective study was conducted at Yedikule Chest Disease and Thoracic Surgery Training and Research Center, Department of Thoracic Surgery between January 2019 and September 2019. A total of 100 patients (76 males, 24 females; mean age: 57.9±11.9 years; range, 51 to 79 years) who underwent thoracotomy due to benign or malignant lesions were included. The patients were divided into two groups: 50 patients who received TENS (Group 1) and a control group (Group 2) of 50 patients who did not receive TENS. Cancer patients who received neoadjuvant therapy (i.e., chemotherapy, chemoradiotherapy or radiotherapy), patients with chest wall invasion, those with a history of rib fracture, and those who had multiple rib fractures intraoperatively were excluded from the study. Comorbidity scores were calculated according to the modified Charlson Comorbidity Index (CCI).^[11] A written informed consent was obtained from each patient. The study protocol was approved by the Istanbul Training and Research Hospital Institutional Review Board (9/11/2018-1487). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

Thoracotomy was performed in all patients included in the study. Thoracotomy was performed in

wedge resections, when thoracoscopy was unfavorable. No epidural catheter was inserted preoperatively.

Following double-lumen selective intubation, the patients were placed in the lateral decubitus position for surgery. A 12 to 20-cm posterolateral thoracotomy incision was made. The chest wall was entered through the fifth intercostal space, while preserving the musculus serratus anterior. After completing the pulmonary resection, the intercostal space was closed with two polyglactin sutures. Surgery was completed after inserting a 32-Fr thoracic drainage tube via the eighth or ninth intercostal space.

The patients who underwent postoperative TENS were treated with high-frequency stimulation using the Braun TENS device (B. Braun Taiwan Co., Ltd. New Tapei City, Songshan District, Taiwan). The TENS setting was calibrated as a biphasic waveform at 100 pulse/s, and a pulse width of 200 Ms. Four sterile 5×5 cm electrodes were placed 2 to 4 cm distant and parallel to the thoracotomy incision. The patients received TENS postoperatively with 8-h intervals. Both groups had intramuscular diclofenac sodium 75 mg twice a day and intravenous tramadol hydrochloride 100 mg three times per day. Paracetamol was used for additional pain control, as needed.

Postoperative follow-up

Patients' pain levels were evaluated routinely in every 6 h starting on the first postoperative day. The Visual Analog Scale (VAS) was used to evaluate pain scores, where 0 indicates no pain and 10 indicates the worst pain of the patient.^[12] Patients' pain scores were calculated for postoperative three consecutive days.

The pain scoring scale modulated by Jensen *et al.*^[13] was used at the end of the first postoperative week. While evaluating the pain score, 0 indicates no pain, 10 indicates the worst pain. In addition, the Short Form-36 (SF-36) life quality scoring was used to evaluate the patients' quality of life in the pre- and postoperative first and sixth months.^[14]

Postoperative morbidity included complications that occurred during the first postoperative month. Atrial fibrillation that necessitated medical treatment, postoperative pneumonia, prolonged air leak (longer than six days), and surgical wound infections were considered morbidities.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software

(IBM Corp., Armonk, NY, USA). Continuous variables were presented in mean ± standard deviation (SD) or median (min-max), while categorical variables were presented in number and frequency. Demographics and clinical characteristics of the patients, such as age and hospital stay duration, were tested for normal distribution using the Kolmogorov-Smirnov test. The t-test was used to compare the group means for these variables, and the chi-square test was used to compare morbidity between the two groups. A *p* value of <0.05 was considered statistically significant.

RESULTS

The study included 50 patients who received TENS in Group 1 and 50 patients who did not receive TENS in Group 2. Sixty patients underwent right-sided pulmonary resection, while 40 patients underwent left-sided pulmonary resection. Eighteen patients underwent thoracotomy due to possible malignancies.

After the frozen section reported benign lesions, further resection was not performed. Baseline demographic and clinical characteristics of the patients are shown in Table 1.

The mean length of hospital stay was 4.9±3.1 days in Group 1 and 6.2±4.6 days in Group 2 (*p*=0.008). There was no statistically significant difference between the groups in terms of early postoperative pain scores (Table 2).

The patients who received TENS had significantly better results according to Jensen et al.'s^[13] pain and life quality scale and also better pain perception in the first week of the postoperative period. This pain quality scores of Group 1 were lower than Group 2, indicating a statistical significance (*p*<0.05) (Table 3). At the end of the first week, Group 1 had significantly lower pain scores compared to Group 2.

Table 1. Baseline characteristics of patients

Variables	Group 1			Group 2			<i>p</i>
	n	%	Mean±SD	n	%	Mean±SD	
Age (year)			58.8±12.7			57.1±11.1	
Sex							} >0.05
Male	34	68		42	84		
Female	16	32		8	16		
ECOG							
0	22	44		22	44		
1	28	56		28	56		
CCI							
<2	16	32		9	18		
>3	34	68		41	82		
Resection type							
Wedge resection	11	22		7	14		
Lobectomy	33	66		30	60		
Pneumonectomy	6	12		13	26		
Preoperative life quality							
Physical function			67.4±26.7			63.1±29.0	>0.05
Physical role play			55.6±41.4			34.5±43.1	<0.05
Emotional role play			59.5±41.6			40.7±45.8	
Energy viability vitality			55.5±22.4			51.0±22.8	
Spiritual health			59.8±20.6			63.8±19.6	
Social function			65.6±26.3			60.0±27.4	>0.05
Pain			63.6±32.1			64.3±29.0	
General health perception			58.5±18.5			56.9±19.8	

SD: Standard deviation; ECOG: Eastern Cooperative Oncology Group; CCI: Charlson Comorbidity Index.

Table 2. Early-stage postoperative pain scores of patients

Variables	Group 1	Group 2	<i>p</i>	
	Mean±SD	Mean±SD		
VAS scores				
Postoperative Day 1				
Rest	4.3±1.9	4.7±1.7	} >0.05	
Cough	6.3±2.1	6.4±1.5		
Postoperative Day 2				
Rest	3.4±1.8	3.6±1.3		
Cough	5.1±1.8	5.1±1.3		
Postoperative Day 3				
Rest	3.2±1.7	3.2±1.3		
Cough	4.5±1.8	4.3±1.5		

SD: Standard deviation; VAS: Visual Analog Scale.

There were nine complications (9%): four patients (8%) in Group 1 and five patients (10%) in Group 2. In Group 1, one patient had a wound infection which was medically treated, two patients

had pneumonia and one patient had atrial fibrillation which was also medically treated. In Group 2, one patient had atrial fibrillation, two patients had pneumonia, one patient had wound infection, and

Table 3. Evaluation of early-stage postoperative pain

Variables	Group 1	Group 2	<i>p</i>
	Mean±SD	Mean±SD	
Pain	2.5±1.3	6.1±2.4	} <0.05
Sting	1.9±1.2	6.1±2.7	
Burning	2.0±0.9	5.5±2.9	
Distress	2.1±1.4	6.5±2.4	
Coldness	1.8±0.7	5.2±3.2	
Sensitivity	1.8±1.0	5.6±2.9	
Crushing feeling	2.0±0.9	5.4±3.1	
Itching	1.6±0.7	5.5±3.0	
Hitting feeling	2.0±1.2	6.1±2.8	
Numbness	1.8±1.1	5.1±3.1	
Electrification	1.8±1.2	5.1±3.2	
Tingling	1.8±0.7	5.6±3.1	
Cramp	1.6±0.7	5.1±3.2	
Spread	1.6±0.8	5.4±3.0	
Throbbing	1.7±1.1	5.1±3.2	
Ache	1.9±1.1	5.5±2.9	
Feeling of heaviness	1.4±0.61	5.4±3.1	
Discontentment	1.9±1.2	5.6±2.9	
Deep pain	1.9±1.2	5.6±2.6	
Superficial pain	1.9±1.2	5.6±2.6	

SD: Standard deviation.

Table 4. Evaluation of postoperative life quality

Variables	Group 1	Group 2	<i>p</i>
	Mean±SD	Mean±SD	
Life quality in postoperative month 1			
Physical function	83.0±19.0	39.7±26.8	} <0.05
Physical role play difficulty	81.2±28.6	23.0±33.8	
Emotional role play difficulty	92.0±20.8	26.1±37.6	
Energy viability and vitality	60.0±16.9	42.7±15.0	
Spiritual health	59.0±17.1	48.3±16.9	
Social function	74.1±16.4	38.0±23.8	
Ache	75.6±15.9	39.3±21.1	
General perception of health	62.6±19.4	41.3±20.5	
Life quality in postoperative month 6			
Physical function	91.8±18.0	27.4±27.9	} <0.05
Physical role play difficulty	94.5±20.4	17.0±28.3	
Emotional role play difficulty	95.3±17.8	28.66±40.4	
Energy viability and vitality	81.8±22.4	48.90±16.2	
Spiritual health	79.3±21.7	64.56±23.4	
Social function	78.1±19.4	29.25±29.7	
Ache	88.5±17.4	39.0±21.9	
General perception of health	80.7±26.6	34.98±31.0	

SD: Standard deviation.

one patient had prolonged air leakage. Prolonged air leak spontaneously resolved on postoperative Day 10. The patients who received TENS had better life quality compared to those who did not in the first and sixth month postoperatively. Furthermore, these patients had also better pre- and postoperative life quality scores compared to the patients who did not receive TENS (Table 4).

DISCUSSION

Postoperative pain is commonly treated ineffectively. Although non-invasive thoracic surgery techniques have advanced recently, patients with high-grade lung cancer, central lung lesions, or concurrent pleural adhesions often require thoracotomy. In the postoperative period, pain can lead to complications such as pulmonary function disorders, secretion retention, atelectasis, and hypoxia. Although several studies have shown that TENS reduces early-stage postoperative pain, its exact mechanism of action remains speculative. Long-term TENS treatment prevents pain perception by increasing cerebral cortex

activity, endorphin release, and causing spinal nerve blockade.^[15-17] One study reported that TENS reduced pain during hospitalization, but did not have an effect in the long-term. Erdogan et al.^[18] reported that TENS reduced early-stage postoperative pain and analgesic usage. Sezen et al.^[10] reported that TENS reduced pain, while it did not affect the complication rates, patient vitals, or hospitalization duration. In another study, Freynet and Falcoz^[19] reported that TENS decreased hospitalization duration and reduced pain levels significantly, when combined with analgesics; however, TENS alone was not sufficient for pain management. Fiorelli et al.^[20] also reported that TENS decreased cytokine release after posterior thoracotomy and that patients who received TENS had a better pulmonary capacity and required fewer narcotics. Sbruzzi et al.^[9] found that TENS led to significantly less pain after posterolateral thoracotomy. Similarly, Stubbing and Jellicoe^[21] showed that TENS did not provide any significant benefit in patients who received analgesic treatment. In our study, we used the Jensen et al.^[13] pain scale to evaluate pain

levels and revealed that while TENS was ineffective for early-stage postoperative pain, it effectively reduced patients' pain levels in the first and sixth postoperative months. Although pain is presumptively associated with postoperative complications in TENS studies, few studies have demonstrated a significant relationship between TENS usage and complication rates. Stubbing and Jellicoe^[21] reported less nausea and vomiting in patients who received TENS. On the contrary, Sezen *et al.*^[10] and Fiorelli *et al.*^[20] did not report any significant association between TENS usage and postoperative complications. Of note, pulmonary rehabilitation in the early postoperative period is assumed to be the most important factor in the absence of complications.

In their study, Esteban González *et al.*^[22] reported that the physical functions of thoracotomy patients increased by early-stage TENS treatment. Freynet and Falcoz^[19] found that TENS not only improved pulmonary function, but also increased the shoulder joint activity. In our previous study using video-assisted thoracoscopy, lowering early-stage postoperative pain significantly increased the quality of life.^[23] These findings indicate that inhibiting early-stage pain prevents chronic neuropathic pain, which is the most important factor in improving quality of life. In our study, we used Jensen *et al.*'s^[13] pain and life quality scale to evaluate patients in the first week postoperatively. The patients who received TENS had better life quality and lower pain scores compared to those who did not ($p < 0.05$). Based on these results, we can speculate that reduction of pain due to TENS in the early postoperative period improves quality of life of patients in the long-term.

In our study, we placed the TENS electrodes parallel to the surgical field as described previously.^[10,17,19,22] Fiorelli *et al.*^[20] reported that TENS reduced pain-stimulating cytokine release originating from the surgical field's muscles, when its electrodes were placed parallel to the surgical field.

In our study, although there was no relationship between TENS and early-stage postoperative pain, chronic pain statistically significantly reduced in patients who received TENS treatment. Furthermore, the TENS group had a better quality of life than the control group in the first and sixth postoperative months. Finally, physical, spiritual, emotional, and social functions were significantly better in the TENS group during the first postoperative month.

Although the study has a prospective design, the sample size of the study is relatively small. In addition,

the study cohort was heterogeneous and included patients of a wide age range. Besides, the VAS scores are subjective methods to evaluate pain.

In conclusion, transcutaneous electrical nerve stimulation is an effective method to manage chronic pain in the postoperative period. On the other hand, it does not effectively reduce early-stage postoperative pain or affect complication rates. Based on our study results, prevention of chronic postoperative pain by transcutaneous electrical nerve stimulation application improves long-term quality of life of patients.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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