The effect of intraoperative transcutaneous electrical nerve stimulation (TENS) on postoperative neck pain following thyroidectomy

Cholhee Park

Department of Medicine

The Graduate School, Yonsei University

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Directed by Professor Cheung Soo Shin

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ABSTRACT

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Cholhee Park

Department of Medicine
The Graduate School, Yonsei University

(Directed by Professor Cheung Soo Shin)

Posterior neck pain following thyroidectomy is common because full neck extension is required during the procedure. We evaluated the effect of intraoperative transcutaneous electrical nerve stimulation (TENS) on postoperative neck pain in patients undergoing total thyroidectomy under general anaesthesia. One hundred patients were randomised to one of two groups; fifty patients received TENS applied to the trapezius muscle and fifty patients acted as controls. Postoperative posterior neck pain and anterior wound pain were evaluated using an 11-point numerical rating scale (NRS) at 30 min, 6, 24, and 48 hours following surgery. The numerical rating scale for posterior neck pain was significantly lower in the TENS group compared with the control group at all time points ($p < 0.05$). There were no significant differences in the numerical rating scale for anterior wound pain at any time point. No adverse effects related to TENS were observed. We conclude that intraoperative TENS applied to the trapezius muscle safely and effectively reduced posterior neck pain following thyroidectomy.

Key words : transcutaneous electrical nerve stimulation; thyroidectomy; pain, postoperative

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I. INTRODUCTION

Thyroidectomy is performed in the supine position with the neck fully extended in order to improve access to the thyroid gland and adjacent structures.[1] According to a previous study, more than 80 per cent of patients complain of posterior neck pain following thyroidectomy,[2] probably due to prolonged hyperextension. Indeed, the degree of neck extension has been found to correlate with pain intensity.[3] Most clinicians are primarily concerned with incisional pain after thyroid surgery, paying less attention to posterior neck pain and there is little published research evaluating the treatment of posterior neck pain after thyroid surgery. It remains unclear whether analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs) and opioids administered for postoperative pain effectively treat posterior neck pain after thyroidectomy and their use is sometimes limited by undesirable side effects.[4]

Transcutaneous electrical nerve stimulation (TENS) is a form of non-invasive electrical stimulation that produces a perceptible sensation via electrodes attached to the skin and has been used extensively to treat acute and chronic pain.[5] TENS has been shown to reduce postoperative pain following cardiac surgery,[6] cholecystectomy,[7] caesarean section,[8] and thoracotomy.[9] TENS is sometimes used as an adjunct to reduce postoperative systemic analgesic requirements.[10] We decided to perform a randomised, double-blind study to evaluate the effect of intraoperative TENS on postoperative neck pain in patients undergoing total thyroidectomy.

II. MATERIALS AND METHODS

Following approval from the local research ethics committee and written informed consent, female patients aged between 20 and 60 of ASA physical status I or II who were scheduled to undergo total thyroidectomy under general anaesthesia were considered eligible for inclusion in the study. Exclusion criteria were a history of headache or neck pain in the previous six months, a history of herniated cervical disc, cervical foraminal stenosis, ossification of the posterior longitudinal ligament, chronic use of opioids or antidepressants, or cardiorespiratory disease.

Patients were assigned to one of two groups using computer-based non-stratified randomisation to the TENS or control group. Patients, surgeons, and physicians involved in postoperative care were blinded as to the group allocations. An independent researcher who evaluated the outcomes was blinded as to group allocations.

Prior to anaesthesia induction, 2 electrodes (4.8 × 4.8 cm) were attached between the midpoint of the acromion and spinous process of the seventh cervical vertebra in the upper trapezius muscles on both the left and right side (Figure 1.). The location of electrodes was selected in order to avoid the wrinkles created by neck extension, assuring secure attachment, as well as the fact that previous reports had shown that pain after neck extension is often localized to the back of the neck and shoulder area. Electrodes were firmly affixed to the skin with adhesive. The portable TENS unit LT1061 (Shenzhen Dongdixin Technology, Shenzhen, China) used in this study generated a 2-channel symmetrical biphasic square wave form. The unit was set at a frequency of 100 Hz and pulse duration of 200 μs. Stimulation intensity was determined in all patients prior to anaesthesia induction as the level at which each patient felt strong, but not painful, paraesthesia in the upper trapezius muscle for 30 seconds. After noting the stimulation intensity, the TENS unit was disconnected.

All patients received intravenous midazolam 0.02 $mg.kg^{-1}$ and glycopyrrolate 0.1 mg in the anaesthetic room. Monitoring, according to AAGBI recommendations was commenced (ECG, non-invasive blood pressure and pulse

oximetry) and general anaesthesia induced with intravenous propofol 1.5-2.0 $mg.kg^{-1}$ and remifentanil 0.3-1.0 $\mu g.kg^{-1}$ followed by rocuronium bromide 0.6 $mg.kg^{-1}$. The patients trachea was intubated and anaesthesia maintained with 1.0 MAC end-tidal concentration desflurane in a 50:50 oxygen:air mixture and 0.05-0.25 $\mu g.kg^{-1}.min^{-1}$ remifentanil infusion which was titrated to maintain mean blood pressure and heart rate within 30% of baseline values.

A TENS unit was connected to each patient after a roll pad was placed underneath the shoulders to extend the neck. For patients in the TENS group, stimulation was applied at the intensity level previously chosen by the patient. Electrical stimulation continued until the end of surgery. For patients in the control group, the TENS unit was connected but not switched on.

A low transverse curvilinear skin incision was made on the front of the neck along a natural skin crease and thyroidectomy was performed by one of two surgeons. All patients received intravenous nefopam 20 mg and ondansetron 4 mg prior to skin closure and fentanyl 50 μg upon arrival in the recovery room. All patients received intravenous ramosetron 0.3 mg and dex-ketoprofen 50 mg at 4 hours postoperatively and dex-ketoprofen 50 mg 12 hours postoperatively. Patients received intravenous boluses of fentanyl 50 μg or dex-ketoprofen 50mg as rescue analgesia if required.

The primary outcome measure was posterior neck pain using a numerical rating scale (NRS) from 0-10, where 0 indicates no pain and 10 indicates the worst pain imaginable, at 30 min, 6, 24, and 48 hours after surgery. The secondary outcome measures were NRS for anterior wound pain at 30 min, 6, 24, and 48 hours after surgery and the need for rescue analgesia.

The sample size required was based on previous research.[2] where the standard deviation of NRS in the control group was 2.8 at 12 hours after surgery. To detect a 2 point difference in NRS in the TENS group (2-sided α value of 0.05 with 90% power), 45 subjects were required for each group. We included 50 patients per group in order to allow for a 10% dropout rate.

The normality of distribution was assessed using the Shapiro-Wilk test. The difference in NRS of posterior neck and anterior wound pain between groups

was analysed using the Mann-Whitney U-test with Bonferroni correction. The number of patients who required additional analgesics was analysed using the chi-square test. SPSS version 20.0 (SPSS Inc., Chicago, IL) software was used for statistical analysis and a p value < 0.05 was considered statistically significant.

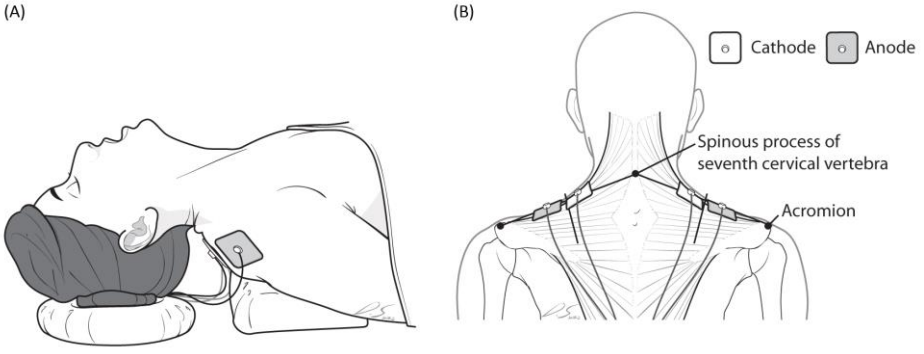

Figure 1. (A) The extended neck position for thyroidectomy and (B) the location of electrodes used for transcutaneous electrical nerve stimulation (TENS).

III. RESULTS

The Consolidated Standards of Reporting Trials (CONSORT) flow diagram is shown in Fig. 2. A total of 116 patients were assessed as eligible for inclusion in the study, 16 patients were excluded and 100 patients were enrolled and randomly assigned to one of two groups. Two patients in the TENS group were withdrawn from the study. In one patient contraction of the trapezius muscle occurred at 28 mA intensity and disturbed the procedure. The muscle contraction stopped after reducing the stimulation intensity and surgery was resumed without complication. The other patient who was withdrawn had an ECG artifact which resolved after turning off the unit. The data from 98 patients were analysed.

The baseline patient characteristics and neck extension times are shown in

Table 1. The mean (SD) TENS intensity was 17 (6) mA. The median NRS for posterior neck pain was significantly lower in the TENS group compared with the control group at all time points (Table 2). The median NRS for wound pain was not significantly different between groups at any time point. The number (proportion) of patients who required rescue analgesia was 20 (42%) in the TENS group and 22 (44%) in the control group and was not significant. No adverse reactions related to TENS were observed.

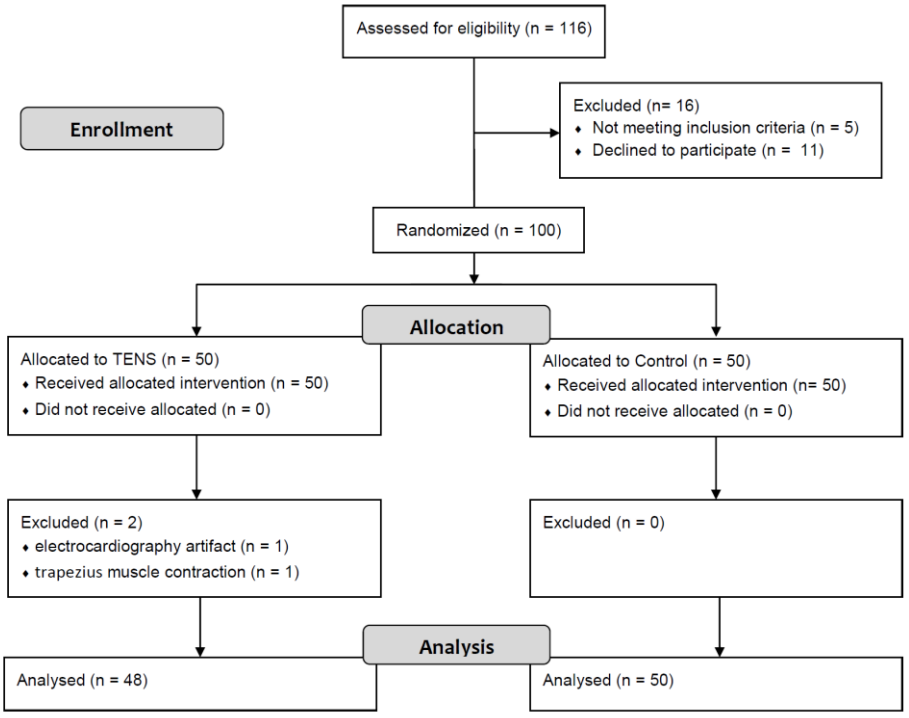

Figure 2. Consort flow diagram showing eligibility, randomisation, and follow-up.

Table 1. Baseline characteristics and neck extension times for patients included in the study. Values are mean (SD).

	TENS group n=48	**Control group n= 50**
Age; yr	44 (9)	44 (9)
Height; cm	159 (5)	159 (5)
Weight; kg	59 (8)	58 (9)
Body mass index; $kg.m^{-2}$	23 (3)	23 (3)
Neck extension time; min	80 (32)	80 (25)

Table 2. The numerical rating scale for posterior neck pain and anterior wound pain at 30 min, 6, 24, and 48 hours following thyroidectomy. Values are median (IQR [range]).

	TENS group n=48	**Control group n= 50**	**p value**
Posterior neck pain			
30 min	0 (0 - 2 [0-6])	4 (1 - 5 [0-10])	< 0.001
6 hours	2 (0 - 4 [0-8])	4 (3 - 5 [0-8])	0.001
24 hours	1 (0 - 3 [0-5])	3 (2 - 4 [0-6])	< 0.001
48 hours	0 (0 - 2 [0-5])	2 (0 - 4 [0-6])	0.001
Anterior wound pain			
30 min	6 (5 - 6 [0-8])	6 (4 - 7 [3-9])	ns
6 hours	5 (4 - 6 [3-7])	5 (4 - 6 [1-7])	ns
24 hours	3 (3 - 4 [2-7])	3 (3 - 4 [2-6])	ns
48 hours	2 (2 -3 [0-6])	2 (2 -3 [0-5])	ns

IV. DISCUSSION

We have demonstrated that intraoperative TENS is effective in reducing posterior neck pain following thyroidectomy. Although a number of studies have demonstrated the efficacy of TENS in the management of postoperative pain, this is the first study to evaluate the efficacy of intraoperative TENS in reducing postoperative pain related to prolonged neck extension. The potential causes of posterior neck pain after thyroidectomy include muscular sprain, muscle ischaemia, anterior longitudinal ligament injury or hyperextension of the cervical zygapophyseal joint. Prolonged neck extension probably generates nociceptive stimuli and neural transmission intraoperatively resulting in posterior neck pain following surgery. Non-painful electrical counter-stimulation via the large diameter Aβ fibres evoked by TENS may interfere with neural transmission of nociceptive stimuli, a mechanism dubbed "gate control".[5] In addition, intraoperative TENS may act as pre-emptive analgesia by reducing sensitization of peripheral and central pain pathways. The concept of pre-emptive analgesia has been supported by studies that suggest the timing of analgesia administration influences their efficacy by reducing nervous system sensitization by nociceptive inputs.[11]

A disadvantage of TENS is that its effect is rapidly lost when stimulation is stopped,[12] making it necessary for frequent, or continuous, stimulation in order to treat persistent pain. However, in our study, patients in the TENS group experienced adequate analgesia for up to 48 hours following thyroidectomy. This prolonged effect may be due to a pre-emptive analgesic effect of TENS on the nociceptive system and we hypothesize that intraoperative TENS is more effective than postoperative TENS, an area of research that we believe requires further study.

In contrast to our results, some studies have reported no major benefit of TENS over regular opioid analgesics following surgery.[13, 14] These disparate results may be due to differences in surgical procedures and severity of postoperative pain. Benedetti and colleagues found that TENS was effective for mild and moderate postoperative pain, but not for severe pain.[15] Posterior neck pain in our

control group could be regarded as mild to moderate; the median NRS in the control group was between 3 and 4 on the first postoperative day and 2 on postoperative day 2, although several patients reported a score of 10 at 30 min postoperatively. The number (proportion) of patients reporting severe posterior neck pain (NRS $\geq$ 7) at any time point was 2 (4.2%) in the TENS group and 6 (12.0%) in the control group but this did not reach statistical significance. Our results support the findings of other studies that TENS is useful to treat mild to moderate postoperative pain.[16]

Some studies have reported that TENS has a placebo effect, contributing to a 20 – 30% reduction in pain, although this has been disputed.[17, 18] It is difficult to distinguish the effects of TENS from those of placebo due to methodological problems associated with the blinding of patients. In this study, we compared TENS with sham TENS during general anaesthesia and removed the unit before the patient recovered consciousness in order to blind patients as to their treatment group allocation, thereby eliminating any possible placebo effect of TENS.

A variety of non-pharmacological measures have been used to manage posterior neck pain following thyroidectomy. Han and colleagues showed that bilateral greater occipital nerve blocks effectively reduced posterior neck pain and occipital headache after surgery.[2] However, nerve blocks are time-consuming, invasive and often painful procedures with a range of possible complications. Ultrasound-guided, or nerve stimulation, placement of the nerve blocks are necessary in order to increase the success rate, whereas TENS is non-invasive, easily applied, has few side effects, and appears to have a high success rate.

TENS may be used in three ways: conventional (high frequency, low intensity), acupuncture-like (low frequency, high intensity) and intense (high frequency, high intensity).[5] We used conventional TENS because acupuncture-like TENS causes muscle contractions that may disturb the procedure and intense TENS is recommended for a maximum period of 15 minutes only. Although one patient had unacceptable intraoperative trapezius muscle contraction, this stopped after

the stimulation intensity was reduced. Muscle contraction is a minor limitation to the use of conventional intraoperative TENS.

One patient exhibited disruptive ECG artifact during TENS, probably due to interference by the electromyography signal or the electric field generated by the TENS. The ECG can usually be filtered and artefacts eliminated by changing the ECG option from 'monitoring' to 'moderate' mode.[19] However, in our patient, the artifact was not resolved by changing the ECG option or reducing the stimulation intensity. When the TENS unit was switched off, the ECG artifact disappeared, and when it was switched on, the artifact reappeared without any haemodynamic changes, indicating that the artifact was not caused by altered electrical activity of the heart. Although TENS has few contraindications, it is not recommended in patients with cardiac pacemakers, as it may interfere with pacemaker performance. We are not aware of any reports describing the interaction between ECG and TENS.

A limitation of our study is that we could not confirm with each patient whether the electrical stimulation was appropriately delivered because they were anaesthetized.

V. CONCLUSION

Intraoperative TENS is effective in reducing posterior neck pain following thyroidectomy. It appears to be a safe and reliable intraoperative therapeutic option and should be considered for other surgical procedures that require neck extension.

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ABSTRACT(IN KOREAN)

갑상선 절제술 후 목 통증에 수술 중 경피적 전기 신경 자극의 효과

<지도교수 신증수>

연세대학교 대학원 의학과

박 철 희

갑상선 절제술은 목을 뒤로 젖힌 상태에서 시행하기 때문에 수술 후 뒷목 통증이 흔하게 발생된다. 본 연구는 전신 마취 후 갑상선 전 절제술을 받는 환자를 대상으로 수술 중 경피적 전기 신경 자극을 시행하고 그 효과를 평가하였다. 100명의 환자를 대상으로 무작위 이중맹검을 통해 실험군 50명은 승모근에 수술 중 경피적 전기 신경 자극을 시행하였고, 대조군 50명은 시행하지 않았다. 수술 후 30분, 6시간, 24시간, 48시간 경과 후의 뒷목 통증과 수술 부위 통증을 11점 만점의 점수식 평정척도를 이용하여 평가하였다. 뒷목 통증은 실험군이 대조군에 비해 모든 측정 시점에서 통증이 감소하였으며, 수술 부위 통증은 차이가 없었다. 경피적 전기 신경 자극에 대한 부작용은 나타나지 않았다. 수술 중 승모근 경피적 전기 신경 자극은 안전하고 효과적으로 갑상선 절제술 후 뒷목 통증을 줄이는 결과를 보여주었다.

핵심되는 말 :경피적 전기 신경 자극; 갑상선 절제술; 수술 후 통증