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Original Article

Does transcutaneous electric acupoint stimulation improve the quality of recovery after thyroidectomy? A prospective randomized controlled trial

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Abstract: Background: We evaluated the effects of transcutaneous electric acupoint stimulation (TEAS) on the postoperative quality of recovery after thyroidectomy with general anesthesia in this prospective, randomized, double-blind, placebo-controlled study. Methods: Eight-four American Society of Anesthesiologists physical status (ASA) I or II patients undergoing thyroidectomy were randomly allocated to TEAS or control groups. The primary outcome was the quality of recovery, which was assessed on the day before surgery and 24 h after surgery using the Quality of Recovery 40 questionnaire (QoR-40). Secondary outcomes included the incidence of postoperative nausea and vomiting (PONV), postoperative pain intensity, duration of post anesthesia care unit (PACU) stay and patient's satisfaction. Results: Global QoR-40 score at 24 h after surgery was higher in the TEAS group (median [interquartile range], 183 [172-190]) compared with the control group (168 [154-183]) ($P < 0.001$). Compared with the control group, postoperative pain intensity and the cumulative number of opioids administered was lower in the TEAS group patients ($P < 0.001$). TEAS reduced the incidence of PONV and dizziness ($P = 0.001$), as well as the duration of PACU stay ($P < 0.001$). Simultaneously, the patient's satisfaction scores were higher in the TEAS group ($P = 0.002$). Conclusion: Preoperative TEAS enhances the quality of recovery, postoperative analgesia and patient's satisfaction, alleviates postoperative side effects and accelerates discharge after general anesthesia for thyroidectomy.

Keywords: Transcutaneous electric acupoint stimulation, quality of recovery, postoperative nausea and vomiting, postoperative pain, thyroidectomy

Introduction

Thyroid tumor is a common cancer in women, requiring surgical treatment. Although thyroidectomy is performed extensively as day surgery [1], postoperative pain, nausea and vomiting remain problematic despite use of analgesics and antiemetics [2]. These complications delay patient's resuscitation, hospital discharge and increase overall healthcare costs [3, 4]. Thus, various complementary and alternative analgesic techniques have been encouraged to combine with pharmacological therapy, such as acupuncture, electroacupuncture and psychotherapy.

Transcutaneous electric acupoint stimulation (TEAS) is a noninvasive technique, which can potentially be applied by medical personnel with minimal training. Considerable evidences have demonstrated that TEAS can reduce the consumption of intra-operative anesthetics and general anesthesia related side-effects, such as nausea and vomiting [5-7]. Although these parameters are important and should be evaluated, the effects of TEAS on the quality of recovery from patient's perspective were not well characterized. Therefore, we conducted this prospective, randomized study to verify the hypothesis that pre-operative TEAS could improve the quality of recovery after thyroidectomy surgery.

Materials and methods

After obtaining ethical approval from Fujian Provincial Hospital (Ref: K2014-12-003), this prospective randomized, double-blind, placebo-controlled trial was conducted at Fujian Provincial Hospital from January 2015 to May

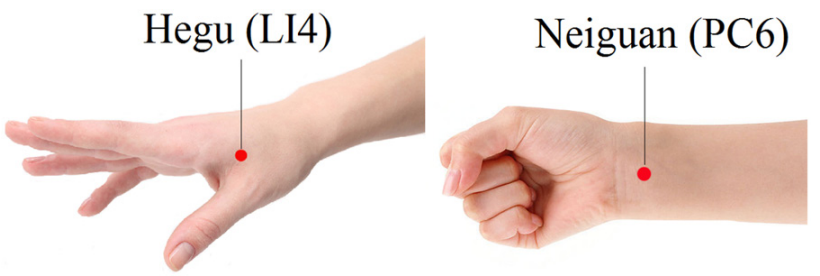

Figure 1. Location of Hegu (LI4) and Neiguan (PC6) acupoints.

2015. Our study protocol was registered at www.clinicaltrials.gov (ID: NCT02333747), which was in line with the principles of the Declaration of Helsinki. Eighty-four female patients aged 18 to 60 with ASA physical status I or II, undergoing elective thyroidectomy with general anesthesia were recruited in our study. The exclusion criteria included potentially difficult airway, a history of chronic pain, drug or alcohol abuse, mental disorder, intake of any analgesic drug within 48 h before surgery, and previous experience with acupuncture treatment.

Written informed consent was obtained from all subjects before randomization. Patients were assigned to either the TEAS group or the control group by a table of computer-generated random numbers. The allocation ratio was 1:1 for the two groups. Group assignments were sealed in sequentially numbered opaque envelopes. Patients in the TEAS group received preoperative TEAS at bilateral Hegu (LI4) and Neiguan (PC6) according to the traditional anatomical locations (**Figure 1**) before the induction of anesthesia in the holding area. TEAS was performed with a disperse-dense frequency of 2/10 Hz and an intensity of 6-9 mA for 30 min using the Hans electronic acupuncture apparatus (HANS-100A, Nanjing Jisheng Medical Technology Company, Nanjing, China). According to individual maximum tolerance, the optimal intensity was adjusted to maintain a slight twitching of the regional muscle. In the control group, the patients were applied to the apparatus, while electronic stimulation was not applied. The patients, attending anesthesiologist, surgeons and data collector were blinded to group assignment.

All patients received standard monitoring, including electrocardiogram, noninvasive blood pressure, pulse oximetry, and temperature. General anesthesia was induced with intravenous sufentanil 0.5 μg/kg and propofol 2.0 mg/kg. Tracheal intubation was facilitated with intravenous cisatracurium 0.15 mg/kg. After intubation, mechanical ventilation was used to maintain $P_{ET}CO_2$ at 35-45 mmHg. Anesthesia maintenance was achieved using sevoflurane titrated to keep the hemodynamic changes within 20% of baseline and bispectral index (BIS) of 40-60. Perioperative normothermia (36°C to 37°C) was maintained by a warming device (Bair Hugger; Augustine Medical Inc., Eden Praire, USA). All patients received intravenous tropisetron 5 mg 30 min before the end of procedure. Neuromuscular blockade was antagonized by neostigmine 0.02 mg/kg plus atropine 0.01 mg/kg.

The primary outcome was the quality of recovery, which was assessed on the day before surgery and 24 h after surgery using QoR-40. The QoR-40 incorporates five dimensions of recovery: emotional state (9 items), physical comfort (12 items), psychological support (7 items), physical independence (5 items), and pain (7 items). Each item is graded on a five-point score. The global QoR-40 score ranges from 40 to 200, representing extremely poor to excellent quality of recovery, respectively. Secondary outcomes were the incidence of PONV, postoperative pain intensity, duration of PACU stay and patient's satisfaction. A patient will be considered to suffer from PONV if nausea or vomiting is documented in 24 h after surgery. Postoperative pain intensity was rated at postoperative hours 1, 2, 4, 8 and 24 with Visual Analogue Scale (VAS) ranging from 0 to 10, where 0 means no pain and 10 is the worst pain imaginable. The patient received intravenous morphine 2 mg as rescue analgesia to maintain a VAS score < 4. Patient's satisfaction was evaluated on postoperative 24 h using a 10-point numerical rating scale: 10 = excellent, 1 = bad.

Our sample size calculation for the two-tailed testing of the TEAS superiority hypothesis was based on the global QoR-40 scores. We accepted a 10-point difference represents a clinically relevant difference in quality of recovery

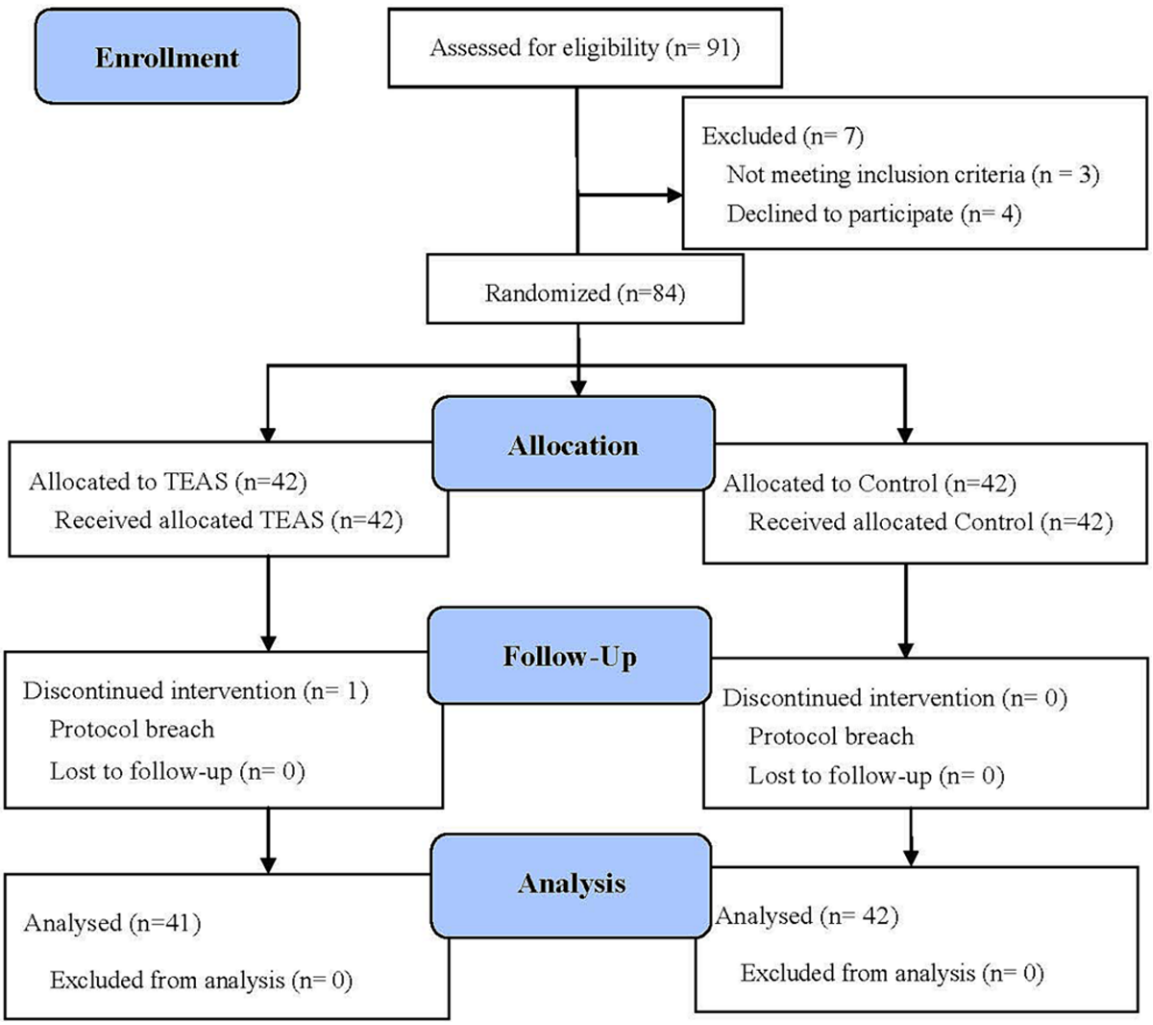

Figure 2. Consolidated Standards of Reporting Trials (CONSORT) flow diagram TEAS, transcutaneous electric acupoint stimulation.

according to a previous study [8]. The QoR-40 scores at 24 h postoperative equivalent to 168 (15.2) were estimated based on our pilot study in patients undergoing general anesthesia for thyroidectomy. A power analysis using a type I error estimate of 5% ($\alpha = 0.05$) and a power (1-β) of 80% indicated that a sample of 38 subjects per group would be required. Allowing for an approximately 10% incomplete follow-up or dropout, a total of 84 subjects were enrolled in this study.

Statistical analysis was calculated by SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). The normality of distribution was assessed by the Kolmogorov-Smirnov test. Parametric data were analyzed with the independent *t*-test and were reported as mean [standard deviation (SD)]. Nonparametric data were reported as median [interquartile range (IQR)] and analyzed using the Mann-Whitney test. Categorical variables were reported as the number of patients (%) and evaluated by the x^2 or Fisher's exact test when appropriate. All reported *P*-values are two-tailed, and a *P*-value of < 0.05 was considered to be of statistical significance.

Results

The details of the conduct of this study are shown in **Figure 2**. We initially assessed 91 patients for eligibility to participate in this study. Of these, 3 patients did not meet the inclusion criteria, 4 declined to participate, and the remaining 84 patients enrolled to the study. One patient from the TEAS group was later

Table 1. Patient demographic and clinical characteristics

	Group TEAS (n = 41)	Group C (n = 42)	*P*-value
Age (year)	37.5 (8.5)	40.2 (7.8)	0.262
ASA (I/II)	38/3	37/5	0.713
Height (cm)	159.1 (6.5)	158.7 (4.7)	0.695
Weight (kg)	55.2 (6.4)	54.1 (5.4)	0.209
Preoperative QoR-40	190 (186-193)	189 (185-192)	0.421
Duration of surgery (min)	56.1 (6.6)	54.4 (7.6)	0.275
Duration of anesthesia (min)	70.1 (7.6)	68.8 (8.5)	0.251

Values are mean (SD), median (IQR) or number (%). TEAS, transcutaneous electric acupoint stimulation; C, Control; QoR, quality of recovery.

Table 2. QoR-40 dimensions and global scores

	Group TEAS (n = 41)	Group C (n = 42)	*P*-value
QoR-40 dimensions			
Emotional state	41 (36-45)	38 (33-42)	0.023
Physical comfort	50 (45-54)	43 (40-47)	< 0.001
Psychological support	34 (33-35)	34 (33-35)	0.174
Physical Independence	24 (23-25)	24 (23-25)	0.252
Pain	30 (25-36)	25 (22-30)	< 0.001
Global QoR-40	183 (172-190)	168 (154-183)	< 0.001

Values are median (IQR), QoR, quality of recovery; TEAS, transcutaneous electric acupoint stimulation; C, control.

Table 3. Patient characteristics in 24 h after surgery

	Group TEAS (n = 41)	Group C (n = 42)	*P*-value
Average pain score	2.6 (0.7)	3.9 (0.9)	0.013
Maximum pain score	5 (4-6)	6 (5-7)	0.021
Time to first rescue analgesia (min)	69 (8)	37 (9)	< 0.001
Cumulative number of rescue analgesia	1 (1-3)	3.5 (2-7)	0.004
PONV [n (%)]	10 (24.4)	26 (61.9)	0.001
Dizziness [n (%)]	12 (29.3)	27 (64.2)	0.001
Duration of PACU stay (min)	26 (6)	37 (7)	< 0.001
Patient's satisfaction	8 (6-8)	6 (5-7)	0.002

Values are mean (SD), median (IQR), or number (%). TEAS, transcutaneous electric acupoint stimulation; C, control; PONV, postoperative nausea and vomiting; PACU, post anesthesia care unit.

excluded due to protocol breach. A total of 83 patients completed the study and their data were included in the analysis. Patients' demographic and clinical characteristics were similar between the two groups (**Table 1**).

The QoR-40 score at 24 h after surgery are shown in **Table 2**. The median global QoR-40 score (IQR) was 183 (172-190) in the TEAS group, which was greater than the score of 168 (154-186) for the control group (P < 0.001). Compared with the control group, the TEAS group demonstrated higher scores are most apparent in the dimensions of emotional status, physical comfort and pain (P < 0.05).

As is shown in **Table 3**, compared with the control group, postoperative average and maximum VAS scores were lower in the TEAS group (P = 0.013 and P = 0.021, respectively). Simultaneously, the time to first request of rescue analgesia was longer (P < 0.001) and the cumulative number of opioids administered was less in the TEAS group (P = 0.004). In addition, the incidence of PONV and dizziness were alleviated in the TEAS group (P = 0.001, PONV; P = 0.001, dizziness). Compared with the control group, the duration of PACU stay was shorter (P < 0.001) and the patient's satisfaction scores were higher (P = 0.002) in the TEAS group than in the control group.

Discussion

In this prospective randomized study, we have demonstrated that the preoperative utility of TEAS at LI4 and PC6 improves the quality of recovery in patients undergoing thyroidectomy. Furthermore, the postoperative analgesic time was prolonged, the amount of postoperative analgesic and general anesthesia related side effects were reduced by TEAS.

Although the exact mechanism by which TEAS exerts its antiemetic activity is not well understood, many studies have supported the efficacy of Neiguan (PC6) acupoint stimulation for preventing PONV. Our data further confirmed

that preoperative TEAS can attenuate the incidence of PONV. Generally, PONV not only reduces patient comfort but can also lead to serious postsurgical complications, such as the aspiration of the gastric contents, suture dehiscence and bleeding, which may delay discharge or result in a hospital admission. The potential benefits for patients, especially in outpatient thyroidectomy, are faster recovery and rapid discharge after procedure.

Judging from pain intensity and supplemental analgesic requirement, preoperative utility of TEAS has been proven to be appropriate complementary and alternative therapy for acute postoperative analgesia. The TEAS is a combination of transcutaneous electrical nerve stimulation and traditional Chinese acupoints. Compared with the electro-acupuncture, TEAS has no risk of broken needles, low incidence of procedural pain and contamination. In addition, TEAS can be applied widely with minimal training [9]. Moreover, the reduced incidence of PONV and the decreased amount of analgesic support the notions that different dense-disperse frequency (2/10 HZ) of stimulation can alleviate pain and PONV. Since 2 Hz of stimulation could prompt the release of β-endorphin and metenkephalin [10-12], and 10 Hz of stimulation on acupoint LI4 and PC6 can reduce the incidence of PONV [7, 13, 14].

Furthermore, the higher scores of QoR-40, especially the scores of emotional state, physical comfort and pain support the notions mentioned above and indicated that TEAS can improve the quality of recovery, which is potential psychological stress and influence the patients' satisfaction directly [15]. Previous studies of anesthesia services emphasize on the PONV and pain after thyroidectomy [16-19], for PONV and pain are important risk for postoperative complications, which potentially delays the hospital discharge and lower the patients' satisfaction indeed. However, these indicators can't evaluate the patients' integral state directly. QoR-40 is a multidimensional instrument that was specifically developed and validated to evaluate the health status of patients after anesthesia and surgery from patients' perspective [8]. It can be particularly beneficial when an intervention affects various aspects of patient recovery, as is the case for TEAS.

There are some limitations in this study. First, we limited our study to a single type of surgery-thyroidectomy. Hence, our results may not be generalizable to more extensive surgeries. Second, we merely recruited the female patients in this study, therefore, whether our result is applicable to male patients remains further studied. In addition, due to different culture and education, the changes in validity and reliability of chinesized QoR-40 should take into consideration when interpreting the results [20].

Overall, our findings have identified that preoperative TEAS is an effective intervention in improving the quality of recovery, and accelerating discharge from PACU after general anesthesia for thyroidectomy.

Acknowledgements

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Disclosure of conflict of interest

None.

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