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<*Original Article*>

Efficacy of Acupoint Stimulation at ST9 (Renying) for Postoperative Sore Throat and Hoarseness: A Prospective Double-blinded Randomized Clinical Trial

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ABSTRACT

Background: In this study, we aimed to determine the efficacy of acupoint stimulation at ST9 (Renying) in treating postoperative sore throat (POST) and hoarseness.
Methods: This randomized clinical trial included 70 adult patients scheduled for elective surgery under tracheal intubation. Patients were randomly assigned to either the acupoint stimulation group (ACP group, $n = 35$) or the control group ($n = 35$). The incidence of POST and hoarseness were evaluated immediately after anesthesia recovery and the following morning. The patients and the evaluator were blinded to the treatment status.
Results: The incidence of POST was significantly lower in the ACP group than in the control group immediately after anesthesia recovery and the following morning ($P < 0.001$ and $P = 0.002$, respectively). Similarly, the incidence of hoarseness was also significantly lower in the ACP group than in the control group at both time points ($P < 0.001$ and $P = 0.006$, respectively).
Conclusions: The ACP group showed significantly lower incidence of POST and hoarseness than the control group. Perioperative acupoint stimulation at ST9 may have the potential to reduce postoperative complications associated with tracheal intubation.

INTRODUCTION

Postoperative sore throat (POST) is one of the most common complications in patients undergoing general anesthesia with tracheal intubation, with an incidence ranging from 21 % to 65 % [1, 2]. POST is primarily caused by mechanical and inflammatory injuries to the pharyngeal and laryngeal mucosa. During intubation, friction and pressure from the tracheal tube and cuff can induce epithelial damage, mucosal edema, and ischemia. These injuries lead to the release of inflammatory mediators, such as prostaglandins, bradykinin, and substance P, which sensitize the nociceptors, leading to pain and discomfort. Excessive cuff pressure, a large tube diameter, prolonged intubation time, repeated laryngoscopy, and mucosal dryness during anesthesia are also contributing factors [3]. Therefore, POST is considered a multifactorial complication resulting from mechanical trauma and subsequent secondary inflammatory response of the upper airway [4]. Despite numerous studies investigating preventive strategies, an effective and defini-

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tive method to prevent POST has yet to be established.

Postoperative hoarseness is another common complication after endotracheal intubation under general anesthesia, with a reported incidence ranging from 22 % to 55 % [5, 6]. Post-intubation hoarseness mainly results from mechanical trauma and ischemic inflammation of the glottic and vocal cord mucosa caused by intubation and extubation maneuvers or cuff pressure [7]. Even short-term intubation can lead to transient voice changes due to erythema or edema of the vocal cords. Subluxation of the cricoarytenoid joint or recurrent laryngeal nerve injury may occur, leading to vocal cord immobility, ulceration, granuloma formation, and prolonged symptoms. However, this complication is rare. Reported risk factors include tube size, duration of surgery, reintubation, and head and neck positioning [5–7].

Recently, accumulating evidence from clinical trials and systematic reviews has suggested that acupoint stimulation plays a broader role in perioperative care than previously recognized [8, 9]. Reportedly, perioperative acupoint stimulation reduces anesthetic and analgesic requirements and attenuates anesthesia-related complications, thereby providing potential organ-protective effects during and after surgery [10]. These potential benefits have drawn increasing attention to acupoint stimulation as a promising perioperative management strategy for enhancing postoperative recovery.

The traditional acupuncture literature describes the stimulation of acupoint ST9 (Renying) as effective for alleviating throat and neck pain [11]. Modern acupuncture textbooks also list sore throat and hoarseness as indications for ST9 stimulation [12].

Therefore, we hypothesized that ST9 stimulation would reduce the incidence of POST and postoperative hoarseness. To test this hypothesis, we conducted a randomized clinical trial to evaluate the incidence of POST and hoarseness (the primary outcomes) following ST9 stimulation.

MATERIALS AND METHODS

The Institutional Review Board of Osaka Medical College approved this study (RIN364) and this trial was registered in the University Hospital Medical Information Network (UMIN) clinical trial registry (UMIN000023936). Between September and November 2016, we recruited adult patients scheduled to undergo general anesthesia with tracheal intubation. We excluded patients using analgesics (including opioids) and/or anti-inflammatory drugs and those in whom difficult airway management was anticipated. Surgical procedures with a high likelihood of direct manipulation of the recurrent laryngeal nerve, such as cervical, intracranial, or thoracic surgeries, were excluded, and the study population mainly comprised patients undergoing breast or abdominal surgeries. Written informed consent was obtained from each participant after a document explaining the study objectives, procedures, and risks was provided. The exclusion criteria included an anticipated difficult airway, pre-existing hoarseness and/or sore throat, and current acupoint stimulation therapy.

In total, 78 patients were screened for eligibility; five were excluded, and three declined participation. Of the five excluded patients, three were taking non-steroidal anti-inflammatory drugs (NSAIDs), one had a pre-existing sore throat, and one had pre-existing hoarseness. Ultimately, 70 patients were enrolled. Randomization was performed using the sealed-envelope method, and patients were allocated to the acupoint stimulation group (ACP, n = 35) or the control group (n = 35). Allocation concealment was ensured, as the clinician opening the envelope was blinded to group assignment until allocation.

For the acupoint stimulation device, we used the Kori-spot® (Seirin Co., Ltd., Shizuoka, Japan), a plastic protrusion mounted on an adhesive seal (**Figure 1**). The device incorporates a central micro-projection (approximately 0.5 mm in diameter) designed to apply localized pressure to the acupoint. The projection is plastic (non-conductive) and does not penetrate the skin, posing minimal risks of burns or electrical interference during electrosurgery, and preventing the risks of bleeding or infection inherent to needle insertion.

The acupoint used was ST9. According to the World Health Organization (WHO) Standard Acupuncture Point Locations, ST9 is located on the anterior border of the sternocleidomastoid muscle at the level of the laryngeal prominence, where the pulsation of the common carotid artery can be palpated [13] (**Figure 1**). In the ACP group, Kori-spot® devices were applied bilaterally to ST9 and covered with adhesive seals. In the Control group, only adhesive seals were applied bilaterally at ST9 to blind the patients and outcome assessors. In both groups, adhesive seals were applied after the patients had fallen asleep and when tracheal intubation had been completed. The seals

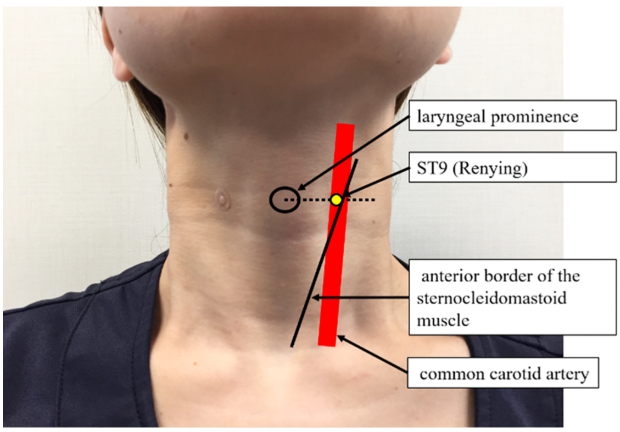

Figure 1 **Representative image of acupoint stimulation in ST9 (Renying)**

were removed before awakening. As such, even if the assessors observed the removal of the seals, they could not identify the group assignments.

No premedications were administered. Standard monitoring included peripheral oxygen saturation, non-invasive blood pressure, heart rate, electrocardiography, and end-tidal carbon dioxide concentration. Anesthesia was induced with propofol (1–2 mg/kg) and remifentanil (0.3–0.5 µg/kg/min). Rocuronium (0.8–1.0 mg/kg) was administered to facilitate neuromuscular blockade. Tracheal intubation was performed by anesthesiologists with over 10 years of clinical experience. The size of the ETT (Portex® Soft Seal™, Smiths Medical, Minneapolis, MN, USA) was determined by dividing the height by 20 to minimize the influence of tube size. A stylet was used in all the cases. The cuff pressure was adjusted to 20 cmH_2O. The ETT cuff was lubricated with a medical gel free of local anesthetics.

Anesthesia was maintained with sevoflurane or desflurane and remifentanil (0.1–0.3 µg/kg/min). At the end of surgery, remifentanil and sevoflurane/desflurane were tapered. Postoperative analgesia with fentanyl was provided at the discretion of the anesthesiologist. NSAIDs were not used. Neuromuscular reversal was achieved with sugammadex (2 mg/kg). After confirming recovery of consciousness, extubation was performed, and the patients were monitored for POST and hoarseness. The presence or absence of POST and hoarseness was determined based on patient self-report. No objective evaluation of vocal cord function was performed. Assessments were conducted by blinded evaluators, other than those who applied the device, and the incidences of POST and hoarseness were recorded.

Sample size calculation

In a preliminary study, the incidence of POST was 45 % and 10 % in the control and ACP groups, respectively. Assuming 80 % power to detect a significant difference, the required sample size was calculated to be 32 patients per group. After adjusting for missing data, 35 patients were recruited per group.

Statistical analysis

The incidences of POST and hoarseness were compared between the two groups using Fisher's exact test. Continuous variables are expressed as mean ± standard deviation and were compared using Welch's t-test. Statistical analysis was performed using R (version 4.5.1; R Foundation for Statistical Computing, Vienna, Austria). All tests were two-tailed, and P values < 0.05 were considered statistically significant.

RESULTS

A CONSORT flow diagram of patient enrollment is shown in **Figure 2**. No patient was lost to follow-up during the assessment period, and all participants completed the study. **Table 1** presents the demographic data for patients in the ACP and Control groups. No significant between-group differences were observed in height, weight, body mass index, age, duration of surgery, or duration of anesthesia. Intraoperative fentanyl was administered to significantly fewer patients in the ACP group than in the Control group (18 of 35 patients vs. 32 of 35 patients, P < 0.001), whereas the total fentanyl dose did not differ significantly between groups.

Condition of the stimulation sites

All Kori-spot® devices and adhesive seals remained in place throughout anesthesia without detachment or displacement. No patient in either group exhibited erythema, swelling, or any other local adverse reactions at the stimula-

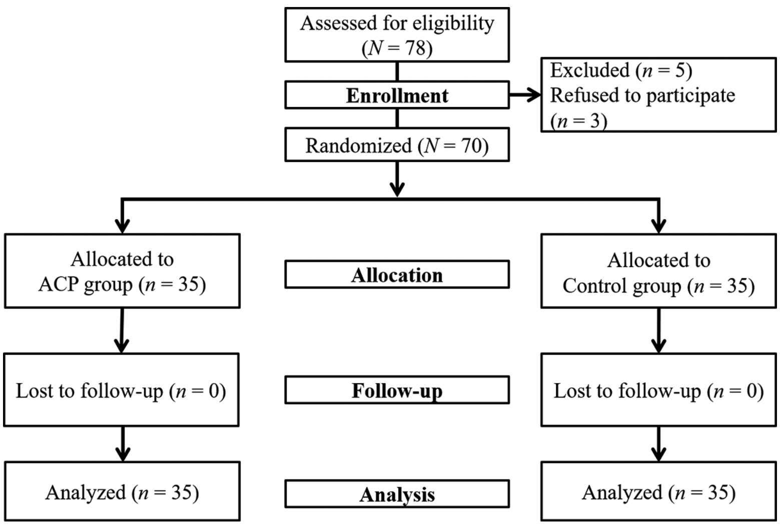

Figure 2 CONSORT flowchart for patient recruitment

Table 1 Patient background

	Control group n = 35	ACP group n = 35
Sex (M/F)	14/21	12/23
Age (years)	58 ± 15	64 ± 14
Weight (kg)	61 ± 12	61 ± 13
Height (cm)	160 ± 9	160 ± 10
BMI ($kg \cdot m^{-2}$)	23 ± 4	23 ± 4
Mallampati classification 1/2/3/4	16/18/1/0	21/14/0/0
Cormack-Lehane classification 1/2/3/4	23/11/1/0	23/12/0/0
Duration of surgery (min)	105 ± 52	130 ± 65
Duration of anesthesia (min)	163 ± 58	181 ± 74
Fentanyl use, n	32*	18*
Total fentanyl dose (μg)	198 ± 100	151 ± 208

Data are presented as mean ± SD or number of patients
*P < 0.05 between groups (Fisher's exact test).

Table 2 Comparison of incidences of postoperative sore throat between Control and ACP groups

	Control group n = 35	ACP group n = 35	P-value
Number of patients with sore throat immediately after anesthesia recovery	20	5	< 0.001*
Number of patients with sore throat on the next morning	15	3	0.002*

Data are presented as number of patients
Data were analyzed utilizing Fisher's exact test; *P < 0.05.

Table 3 Comparison of incidences of postoperative hoarseness between Control and ACP groups

	Control group n = 35	ACP group n = 35	P-value
Number of patients with hoarseness immediately after anesthesia recovery	21	5	< 0.001*
Number of patients with hoarseness on the next morning	10	1	0.006*

Data are presented as number of patients
Data were analyzed utilizing Fisher's exact test, *P < 0.05.

tion sites (ST9). After recovery from anesthesia, no patient reported discomfort or tenderness at the stimulation sites.

Comparison of POST after general anesthesia

Table 2 presents the incidence rates of POST. Immediately after recovery from anesthesia, the incidence of POST was significantly lower in the ACP group than in the control group (ACP, 5 patients; control, 20 patients; P < 0.001). The following morning, the incidence remained significantly lower in the ACP group (ACP, 3 patients; control, 15 patients; P = 0.002).

Comparison of postoperative hoarseness after general anesthesia

Table 3 presents the incidence of postoperative hoarseness. Immediately after anesthesia recovery, the ACP group had a significantly lower incidence of hoarseness than the control group (ACP, 5 patients; Control, 21 patients; P <

0.001). The following morning, the incidence of hoarseness remained significantly lower in the ACP group (ACP, 1 patient; Control, 10 patients; $P = 0.006$).

DISCUSSION

Principal Findings

This randomized controlled trial demonstrated that ST9 stimulation significantly reduced the incidence of POST and hoarseness following tracheal intubation under general anesthesia. Our findings suggest that perioperative stimulation of ST9 effectively prevents postoperative pharyngolaryngeal symptoms and may serve as a simple, non-invasive, and feasible adjunctive intervention. POST and hoarseness are often regarded as minor complications; however, they are among the most frequent adverse events associated with tracheal intubation and can substantially affect patient comfort, satisfaction, and the overall perception of anesthesia quality. Therefore, effectively preventing these symptoms is an important component of patient-centered perioperative care. Given that most patients underwent breast surgery or laparoscopic cholecystectomy, procedures not typically associated with severe postoperative wound pain, substantial masking of POST by pain at other surgical sites is unlikely. In the present study, fewer patients in the ACP group received intraoperative fentanyl, yet the incidence of POST was lower in this group. In the study by Tsukamoto *et al*. (2022), intraoperative fentanyl administration was not significantly associated with POST in univariate analysis and was not identified as an independent risk factor in multivariable analysis [14]. Accordingly, the influence of fentanyl administration on the outcomes of the present study is considered to be limited.

Comparison with previous studies

Notably, several studies have reported beneficial effects of acupoint stimulation in reducing the incidence of POST. A systematic review and meta-analysis by Jau *et al.* (2022) demonstrated that true acupoint stimulation, such as manual acupuncture, transcutaneous electrical acupoint stimulation, or acupoint application at LI4 (Hegu), PC6 (Neiguan), RN22 (Tiantu), RN23 (Lianquan), BL10 (Tianzhu), DU14 (Dazhui), and K-A20, significantly decreased the incidence of POST compared with sham or no stimulation [15]. Yue *et al*. showed that preoperative acupuncture at LU11 (Shaoshang) combined with intraoperative electroacupuncture at LU5 (Chize) and LI4 (Hegu) reduced POST and postoperative nausea [16]. In contrast, evidence regarding the effect of acupoint stimulation on postoperative hoarseness remains limited. Liu *et al*. reported in a randomized, double-blind, placebo-controlled trial that acupoint application at RN22 (Tiantu), PC6 (Neiguan), ST36 (Zusanli), and KI1 (Yongquan) reduced the incidence of POST and hoarseness [17]. However, most previous studies involved stimulation at multiple acupoints, making it difficult to identify the specific contributions of individual acupoints.

The present study is novel in showing that stimulation of a single acupoint (ST9) significantly reduced POST and hoarseness, supporting a simple, clinically applicable, and reproducible approach.

Rationale for selecting ST9

ST9 lies lateral to the laryngeal prominence and anterior to the sternocleidomastoid muscle. According to WHO standards, ST9 can be readily identified by palpating the common carotid artery pulse, enabling accurate and reproducible application [13]. ST9 can be located using stable anatomical landmarks without repositioning the patient; therefore, it is readily applicable in the operating room.

Traditionally, ST9 has been used to treat throat pain, hoarseness, and cough [11, 12]. Its stimulation may improve local blood circulation, relax muscle tension, and alleviate inflammation-related symptoms in the mucosa [12]. Clinical reports incorporating ST9 into treatment protocols for chronic pharyngolaryngitis or vocal cord disorders have shown improvements in throat discomfort and phonatory function [18].

Compared with multi-acupoint methods, single-point ST9 stimulation is simpler, more consistent, and more time-efficient.

Possible mechanisms

The precise mechanism underlying the observed effects remains unclear; however, two complementary pathways are likely involved: (1) modulation of nociceptive transmission and (2) regulation of inflammatory and edematous responses.

(1) Inhibition of nociceptive transmission (primarily relevant to POST)

Mechanical irritation during intubation activates nociceptive afferent fibers in the pharyngeal and laryngeal mucosa, which project via the glossopharyngeal and vagus nerves to the nucleus tractus solitarius (NTS) and the spinal trigeminal nucleus complex (Sp5) [19, 20]. ST9 lies adjacent to the carotid sinus, and stimulation in this region can activate the carotid sinus (Hering's) nerve, which projects to the NTS. Case reports and animal studies have shown that stimulation near ST9 can induce transient hypotension and bradycardia by activating the carotid sinus–NTS reflex arc [21, 22], indicating enhanced NTS activity. The NTS further interacts with the locus coeruleus and raphe nuclei, which are key components of the descending pain modulatory system [23, 24]. Activation of this pathway may suppress nociceptive transmission at the spinal dorsal horn and at the Sp5 level, thereby alleviating pharyngeal pain (**Figure 3**).

(2) Modulation of inflammatory and edematous responses (relevant to POST and hoarseness)

POST and hoarseness are caused by mucosal injury,

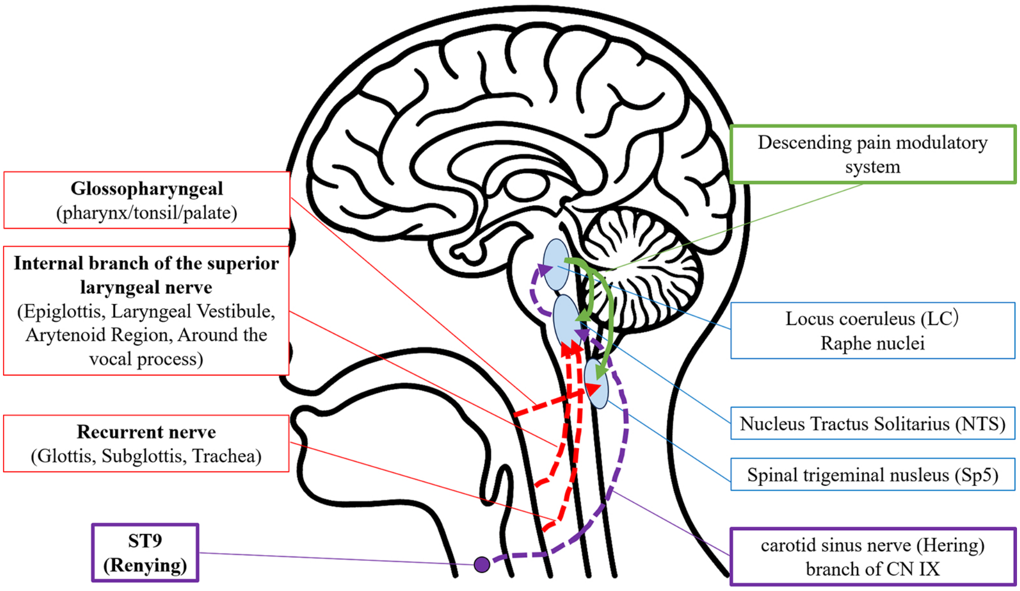

Figure 3 Schematic Diagram of the Descending Inhibitory via ST9 Stimulation
Mechanical irritation during intubation activates nociceptive afferent fibers in different regions of the pharyngolaryngeal area: pharyngeal pain is transmitted via the glossopharyngeal nerve to Sp5, pain around the epiglottis is conveyed via the internal branch of the superior laryngeal nerve, and pain below the glottis is transmitted via the recurrent laryngeal nerve to NTS (red dashed arrows). ST9 stimulation activates the carotid sinus (Hering's) nerve and enhances NTS activity, with subsequent interactions between the NTS and the locus coeruleus and raphe nuclei (purple dashed arrows). Consequently, the descending pain modulatory system is activated, which suppresses nociceptive transmission at the spinal dorsal horn and Sp5, thereby reducing pharyngeal pain (green solid arrow). Afferent pathways are indicated by dashed lines, whereas efferent (descending) pathways are indicated by solid lines.

ischemic inflammation, and laryngopharyngeal edema following intubation. Anatomically, ST9 lies adjacent to the carotid sinus and can elicit baroreceptor reflexes [25]. Experimental studies have shown that activation of baroreceptor reflexes or the carotid sinus nerve exerts anti-inflammatory effects through central and neuroendocrine pathways. Centrally, it suppresses expression of proinflammatory cytokines such as tumor necrosis factor, interleukin (IL)-1β, and IL-6 in the hypothalamus [26]; peripherally, it activates the hypothalamic–pituitary–adrenal axis, promoting endogenous glucocorticoid release [27]. These effects may reduce vascular permeability, mucosal edema, and inflammatory cell infiltration, thereby facilitating the recovery of vocal cord vibrations and reducing pharyngeal discomfort.

The mechanistic considerations presented in this study are based on existing anatomical and physiological knowledge and should be regarded as hypothetical. These proposed pathways were not directly examined in the present study. Accordingly, the involvement of specific neural mechanisms underlying the effects of ST9 stimulation remains speculative, and the proposed model should be interpreted as one possible explanation for the observed findings.

Methodological advantages of ST9 stimulation

With respect to stimulation modalities, needle acupuncture and transcutaneous electrical nerve stimulation (TENS) are commonly used; however, their use is limited by intraoperative constraints. Theoretically, metal needles carry risks of burns or stray currents during electrosurgery, and strict control of metallic attachments is recommended [28]. Systematic reviews have reported acupuncture-related adverse events such as bleeding, subcutaneous hematoma, and infection [29], calling for caution in patients receiving anticoagulation therapy. TENS is non-invasive; however, it involves the use of an external electrical device. Potential interference with electrosurgical units and the possibility of malfunction in environments with multiple active devices can limit its intraoperative use [30].

Mechanical acupoint stimulation can be considered as a non-invasive alternative to needles or TENS. In this study, we used an adhesive device (Kori-spot®) to stimulate ST9. This device stimulates the skin with a plastic, nonconductive projection; therefore, it does not interfere with electrosurgical equipment and carries no risk of bleeding or infection. These characteristics support a favorable intraoperative safety profile.

Clinical implications

POST and hoarseness are usually mild, but are bothersome complications that diminish patient satisfaction and the perceived quality of anesthesia. Pharmacologic prophylaxis, such as lidocaine, corticosteroids, and NSAIDs, has been reported to mitigate POST and hoarseness [1, 2, 4–7]; however, these agents may be limited by allergy or underlying conditions such as diabetes mellitus or chronic kidney disease, and therefore may not be universally applicable. Conventional preventive measures, including optimizing tube size, maintaining optimal cuff pressure, and lubricating the endotracheal tube, can reduce these symptoms to some extent but do not eliminate them completely. Combining such approaches with a non-invasive adjunct, such as ST9 stimulation may further enhance patient comfort without adding risk. Given its simplicity, safety, and high reproducibility, ST9 stimulation may be particularly useful in inpatient surgical settings where rapid recovery and patient comfort are required.

Limitations

This study has some limitations. First, the proposed mechanisms are hypothetical and based on physiological reasoning and animal data; therefore, further research incorporating neuroimaging, electrophysiological, or biochemical assessments is needed to validate these findings. Second, the optimal timing and duration of ST9 stimulation remain unclear. Future studies should explore whether preoperative, intraoperative, or postoperative application yields the greatest benefit. Third, as this was a single-center trial, multicenter randomized studies are required to confirm the reproducibility and safety of the proposed mechanisms across different populations and settings. Fourth, vocal cord paralysis was not systematically assessed, as postoperative hoarseness was evaluated solely based on patient self-report without laryngeal examination. Fifth, although the present findings suggest a potential involvement of descending pain modulation, various factors that may influence this system, such as migraine, irritable bowel syndrome, and medications affecting central pain modulation, were not systematically assessed. Future studies incorporating these factors will be required to further clarify the mechanisms underlying the effects of ST9 stimulation.

CONCLUSIONS

Non-invasive stimulation of acupoint ST9 significantly reduced the incidence of POST and hoarseness following tracheal intubation under general anesthesia. These effects may be mediated through neuromodulatory and anti-inflammatory mechanisms, bridging traditional acupoint theory with modern neurophysiology. Compared with conventional acupuncture or multi-site stimulation, single-point ST9 stimulation is simpler, highly reproducible, and safe for intraoperative use. It represents a promising, evidence-based adjunctive therapy for improving patient comfort and satisfaction in perioperative care.

AUTHOR DISCLOSURE STATEMENT

The authors have no conflicts of interest directly relevant to the content of this article.

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