Effect of Transcutaneous Electrical Acupoint Stimulation Combined with Transversus Abdominis Plane Block on Postoperative Recovery in Elderly Patients Undergoing Laparoscopic Gastric Cancer Surgery: A Randomized Controlled Trial

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ABSTRACT

Introduction: This study assessed the influence of transcutaneous electrical acupoint stimulation (TEAS) combined with transversus abdominis plane block (TAPB) on the recovery of elderly patients undergoing laparoscopic gastric cancer surgery.

Methods: Ninety patients (age ≥ 60 years) undergoing laparoscopic gastric cancer surgery were randomly divided into general anesthesia group (group G), TAPB group (group NG), and TEAS combined with TAPB group (group NTG). Patients in the NTG group received TEAS at PC6, LI4, and ST36 acupoints and TAPB. Patients in the NG group received TAPB. The quality of recovery (QoR) was assessed using the QoR-15 questionnaire. The percentages of T lymphocyte subsets were determined. Consumption of anesthetics, extubation time, visual analog scale (VAS) scores, time of first postoperative ambulation and flatus, and postoperative adverse events were also recorded.

Results: QoR-15 scores on postoperative day (POD) 3 and POD 7 were higher in the NTG group than in the G and NG groups (P < 0.05). On POD 1 and POD 3, the percentages of CD3+ and CD4+ T cells and the CD4+/CD8+ ratio were higher and the percentage of CD8+ T cells was lower in the NTG group than in the G and NG groups (P < 0.05). Remifentanil consumption, and the incidence of postoperative nausea and vomiting (PONV) were lower and extubation time and time of first postoperative flatus were shorter in the NTG group than in the G and NG groups (P < 0.05). Compared with the G group, the VAS scores on POD 1 were lower in the NG group and those on POD 2 were lower in the NTG group (P < 0.05).

Conclusion: The combination of TEAS and TAPB ameliorated postoperative pain, improved immune and gastrointestinal function, reduced the incidence of PONV, and effectively promoted postoperative recovery in elderly patients undergoing laparoscopic gastric cancer surgery.

Trial Registration: Chinese Clinical Trial Registry (ChiCTR2100042119).

Keywords: Transcutaneous electrical acupoint stimulation; Laparoscopic surgery; Postoperative pain; Transversus abdominis plane block; Recovery
**Key Summary Points**

Patients with gastric cancer are predominantly elderly patients often associated with poor tolerance and multiple comorbidities.

Laparoscopic surgical resection is currently one of the leading clinical methods for treating gastric cancer.

Preoperative anxiety and postoperative pain-induced stress reactions can suppress gastrointestinal and immune functions, seriously affecting postoperative recovery.

Elderly patients face greater challenges during postoperative recovery.

The aim of this study was to investigate the impact of transcutaneous electrical acupoint stimulation (TEAS) at the acupoints of Neiguan (PC6), Hegu (LI4), and Zusanli (ST36) combined with transversus abdominis plane block (TAPB) on the quality of early recovery after laparoscopic gastric cancer surgery in elderly patients.

The combination of TEAS and TAPB ameliorated postoperative pain, improved immune and gastrointestinal function, reduced the incidence of postoperative nausea and vomiting (PONV), and effectively promoted postoperative recovery in elderly patients undergoing laparoscopic gastric cancer surgery.

**INTRODUCTION**

Laparoscopic surgical resection is currently one of the leading clinical methods for treating gastric cancer. Laparoscopic surgery has the advantages of lower postoperative infection rate, shorter hospital stay, and less associated trauma than traditional open surgery [1, 2]. However, preoperative anxiety, intraoperative pneumoperitoneum, and postoperative pain-induced stress reactions can suppress gastrointestinal and immune functions, seriously affecting postoperative recovery [3, 4]. Additionally, patients with gastric cancer are predominantly elderly patients often associated with poor tolerance and multiple comorbidities. Hence, elderly patients may face greater challenges during postoperative recovery. Opioids are commonly used analgesics in the postoperative period, which can cause common complications such as constipation, respiratory depression, nausea-vomiting, and pruritus [5]. Long-term heavy use of opioids can extensively suppress the immune system, leading to apoptosis of T lymphocytes and inhibiting T lymphocyte proliferation and activation [6, 7]. There are several ways to reduce the use of opioids, such as regional nerve blocks and transcutaneous electrical acupoint stimulation (TEAS).

Transversus abdominis plane block (TAPB) is an essential component of multimodal analgesia to control postoperative pain in various abdominal procedures [8–10]. Subcostal TAPB is a technique currently used primarily for upper abdominal analgesia [11]. TEAS is an acupuncture-related technique that produces effects through non-invasive electrical stimulation through electrodes placed on acupuncture points. It is widely used because of its simplicity and effectiveness [12]. Considerable data have shown that TEAS reduces the incidence of adverse effects associated with general anesthesia and improves the quality of the patient's postoperative recovery [13, 14]. Stimulation of the Zusanli (ST36) acupoint promotes the recovery of gastrointestinal function in patients with colorectal cancer after surgery [15]. The Neiguan (PC6) acupoint has long been targeted for treating vertigo and vomiting in China. In animal studies, electroacupuncture (EA) of the Hegu (LI4) acupoint significantly enhanced immune function in rats with postsurgical gastric cancer [16].

However, the effect of TAPB combined with TEAS for postoperative recovery of elderly patients undergoing laparoscopic gastric cancer surgery was not evaluated. The aim of this study was to investigate the impact of TEAS at the
acupoints of Neiguan (PC6), Hegu (LI4), and Zusanli (ST36) combined with TAPB on the quality of early recovery after laparoscopic gastric cancer surgery in elderly patients.

METHODS

Study Design

This double-blind randomized controlled trial was conducted in accordance with the Declaration of Helsinki and was approved by the local clinical research ethics committee. The trial protocol was approved by the ethics committee of the First Affiliated Hospital of USTC (approval no. KY2019-108). Each participant provided written informed consent before initiating any study-related procedures. This trial was registered with the Chinese registry of clinical trials at http://www.chictr.org.cn (ChiCTR2100042119).

Patient

A total of 90 patients undergoing elective laparoscopic gastric cancer surgery at the First Affiliated Hospital of USTC from January 2021 to December 2021 were randomly assigned in the ratio of 1:1:1 into the general anesthesia group (group G), TAPB group (group NG), and TEAS combined with TAPB group (group NTG). Patients that met the following inclusion criteria were selected for the study: (1) American Society of Anesthesiologists grades I–III; (2) age ≥ 60 years; (3) undergoing elective laparoscopic gastric cancer surgery. Patients that met the following exclusion criteria were not selected: (1) central nervous system and mental diseases; (2) history of an allergic reaction to local anesthetics; (3) swelling, infection, or ulceration at the site of TEAS.

Randomization

We randomized patients with an allocation ratio of 1:1:1:1 using computer-generated random numbers. Randomization codes were kept in a sealed envelope and relayed to an independent nurse. The TEAS stimulator was obscured by an opaque cloth throughout the experiment. In addition, the nurse prepared 0.375% ropivacaine or saline (40 mL) for all patients during the study period. All TAPBs were performed by the same anesthesiologist who was not involved in anesthesia management. The allocation was blinded for all patients, surgeons, the leading anesthesiologist, physician in the post-anesthesia care unit, and follow-up observers until the end of the study.

TEAS Procedure

For all patients, electrode pads were pasted at the acupoints of Hegu (LI4), Neiguan (PC6), and Zusanli (ST36) on both sides 30 min before anesthesia. The G group and NG group received TEAS without actual electric stimuli. The NTG group was provided with a 2/100 Hz density wave and actual electric stimuli. The optimal intensity was set to mild twitching of the surrounding muscle up to the maximum tolerated by the individual. Stopped stimulus and the electrodes were removed at the end of the operation in each group. The electrodes were connected to the TEAS instrument (SDZ-V, Suzhou Medical Technology Co. Ltd., Suzhou, China).

The Hegu (LI4) acupoint is located radial to the midpoint of the second metacarpal in the dorsal hand. The Neiguan (PC6) acupoint is located on the forearm palm side, 2 cun (approx. 40 mm) above the transverse wrist line, between the palmaris longus and the flexor carpi radialis tendon. The Zusanli (ST36) acupoint is located on the lateral aspect of the patella of the lower leg, 3 cun (approx. 60 mm) below the hollow of the patellar ligament lateral (Fig. 1a).

TAPB Procedure

After induction of anesthesia, all patients received bilateral TAPB by the same experienced anesthesiologist. The middle of the axilla near the subcostal margin was scanned with a probe placed vertically between the rib margin and the iliac crest. The injection target was fixed in
the fascial plane between the internal oblique and transversus abdominis muscles using an in-plane puncture technique (Fig. 1b). Patients in the NTG and NG groups were injected with 40 mL of 0.375% ropivacaine (20 mL per side) into the muscle plane after confirming the correct side. An equal volume of saline was injected in the same way in the G group, and diffusion was assessed for all groups.

Anesthesia and Surgical Procedures

Once the patient entered the operating room, vitals such as electrocardiograph (ECG), arterial blood pressure (ABP), pulse oxygen saturation (SpO2), and bispectral index (BIS) were recorded and monitored. Patients were intravenously administered midazolam (0.04 mg/kg), etomidate (0.3 mg/kg), sufentanil (0.3 µg/kg), and rocuronium (1 mg/kg). Anesthesia was maintained with a target-controlled infusion of propofol and remifentanil. The propofol and remifentanil concentrations were adjusted to hemodynamic index and BIS 40–60. Remifentanil and propofol infusion was stopped in each group 5 min before the completion of the surgery.

Prophylactic flurbiprofen axetil (50 mg) and azasetron (10 mg) were administered for postoperative pain and PONV. The same surgeon performed all procedures. Patients were transferred to the post-anesthesia care unit (PACU) after extubation in the operation room. All patients received patient-controlled intravenous analgesia (PCIA) for 2 days and which contained 100 mL of 0.5 µg/mL sufentanil. The PCIA was set as follows: single-dose 2 mL, lock time 15 min, and no background infusion and continuous infusion. If the movement VAS score was greater than 4 points, flurbiprofen axetil 50 mg was intravenously injected as salvage analgesia.

Outcomes

Primary Outcomes
The primary outcome was the early postoperative quality of recovery, assessed via the Quality of Recovery (QoR-15) score. The QoR-15 scale is a self-rating scale widely used to evaluate the quality of early postoperative recovery and which is both effective and reliable [17–19]. This score measures the quality of a patient’s postoperative recovery in terms of changes in physical comfort, mood, physical...
independence, psychological support, and pain [20]. In the present study, QoR-15 evaluation was performed on preoperative day 1 and POD 1, POD 3, and POD 7.

Secondary Outcomes
We collected patients’ peripheral venous blood on preoperative day 1, POD 1, and POD 3. The percentage of T lymphocyte subsets (CD3\(^+\), CD4\(^+\), CD8\(^+\), CD4\(^+\)/CD8\(^-\)) were enumerated by using a BD FACS Canto II flow cytometer. The mean arterial pressure (MAP) and heart rate (HR) were recorded before the onset of TEAS (T\(_1\)), at the establishment of the pneumoperitoneum (T\(_2\)), 1 h after the beginning of the operation (T\(_3\)), at the end of the operation (T\(_4\)), and immediately after extubation (T\(_5\)). Remifentanil and propofol consumption, extubation time, and PCIA press numbers were recorded. VAS scores at rest and movement were recorded at 4, 12, 24, and 48 h after the operation. The postoperative gastrointestinal function was evaluated to first ambulation and first flatus from postoperative time. The occurrence of postoperative adverse events was evaluated on the basis of the incidence of PONV, pruritis, and respiratory depression.

Statistical Analysis
The sample size calculation was based on the results of the primary outcome of QoR-15. A difference of at least 8.0 points in the score is considered clinically significant [21]. Preliminary experimental results indicated that the scores of QoR-15 in the G, NG, and NTG groups were 111.60 ± 10.45, 114.20 ± 8.23, and 125.32 ± 13.11, respectively. The sample size was determined using PASS V.15 with \( \alpha = 0.05 \) (two-sided) and \( (1 - \beta) = 0.9 \) and was found to be 23 patients per group. Considering a dropout rate of 30%, the sample size was increased to 90 patients (30 per group).

All statistical analyses were conducted using SPSS 26.0. Continuous data are presented as the mean ± standard deviation or median ± interquartile range (IQR) according to normal distribution. Repeated measurements were used to analyze differences in the interaction effects between groups and time points. Categorical variables were compared using the chi-squared test and presented as number (proportion). Statistical significance was assessed at \( P < 0.05 \).

RESULTS

Patient Characteristics
The method of operation was changed in one patient in the G group, and one patient each was withdrawn by the end of the trial because of loss of follow-up in both the NG and NTG groups. A total of 87 patients were available for the analysis (Fig. 2). Each group was similar in terms of sex, age, BMI, ASA, and operation time (Table 1).

Primary Outcomes
As shown in Fig. 3, the QoR-15 scores on POD 1 (G group, 77.10 ± 10.16; NG group, 85.97 ± 11.07; NTG group, 90.86 ± 12.36) in the NG and NTG groups were significantly higher than those in the G group (\( P < 0.05 \)). The QoR-15 scores on POD 3 (G group, 96.55 ± 10.51; NG group, 100.55 ± 10.06; NTG group, 116.38 ± 10.82) and POD 7 (G group, 112.62 ± 10.67; NG group, 116.97 ± 11.01; NTG group, 130.66 ± 10.20) were significantly higher in the NTG group than those in the G and NG groups (\( P < 0.05 \)).

Secondary Outcomes

Percentage of T Lymphocyte Subsets
As shown in Table 2, the percentages of CD3\(^+\) and CD4\(^+\) T cells and the CD4\(^+\)/CD8\(^+\) ratio were significantly lower and the percentage of CD8\(^+\) T cells were significantly higher on POD 1 than the baseline values in all three groups (\( P < 0.05 \)). On POD 1 and POD 3, the percentages of CD3\(^+\) and CD4\(^+\) T cells and the CD4\(^+\)/CD8\(^+\) ratio were higher and the percentage of CD8\(^+\) T cells was lower in the NTG group than in the G and NG groups (\( P < 0.05 \)).
MAPs and HRs
As shown in Fig. 4, the MAPs and HRs at $T_1$ and $T_5$ were significantly lower in the NG and NTG groups ($P < 0.05$) than in the G group. The MAPs and HRs at $T_5$ were significantly lower in the NTG group than in the NG group ($P < 0.05$). There was no significant difference in MAPs and HRs among the three groups at $T_1$, $T_3$, and $T_4$.

**Consumption of Anesthetics, Extubation Time, Pain Assessment, Postoperative Recovery of Gastrointestinal Function, and Adverse Events**

Other secondary outcomes are shown in Table 3. Remifentanil consumption was lower in the NG and NTG groups than in the G group ($P < 0.05$) and lower in the NTG group than in the NG group ($P < 0.05$); however, there was no significant difference in propofol consumption among the three groups. The extubation time was significantly shorter in the NTG group than in the G and NG groups ($P < 0.05$). There was
no significant difference in extubation time between the G and the NG groups. The VAS scores at rest and movement were significantly lower in the NG and NTG groups at 4, 12, and 24 h after surgery than in the G group ($P < 0.05$). The VAS scores on POD 1 in the NG group and on POD 1, POD 3, and POD 7 in the NTG group were significantly higher than those in the G group ($P < 0.05$). The QoR-15 scores on POD 3 and POD 7 were significantly higher in the NTG group than in the NG group ($P < 0.05$).

### DISCUSSION

Our study demonstrated that the use of TEAS at the acupoints of bilateral Hegu (LI4), Neiguan (PC6), and Zusanli (ST36) for 30 min before anesthesia to the end of surgery combined with TAPB in elderly patients undergoing laparoscopic gastric cancer surgery improved QoR-15 scores and the extubation quality and reduced VAS scores and the consumption of remifentanil. In addition, TEAS combined with TAPB improved immune and gastrointestinal function and reduced the incidence of PONV. These results suggest that TEAS combined with TAPB could promote the recovery of elderly patients after laparoscopic surgery.

Currently, opioids are the preferred choice for relieving postoperative pain in patients, but their use is associated with adverse effects such as PONV [22]. Ultrasound-guided TAPB as a supplement to abdominal surgical analgesia can reduce opioid use and facilitate patient recovery after surgery [11], but it has relatively limited efficacy. TEAS is a combination of transcutaneous electrical nerve stimulation and acupuncture treatment. The use of electrode pads instead of electric needles is less invasive and provides greater accessibility than traditional acupuncture. Its physiological effects are similar to those of conventional acupuncture [23], with a wide range of applications in relieving nausea and vomiting and improving analgesia and immunity [24–26].

Acupuncture and TEAS are reported to effectively reduce the need for perioperative analgesics and reduce postoperative pain. In a clinical trial, patients undergoing gynecologic laparoscopic surgery who received TEAS had lower VAS scores and higher quality of recovery than patients who did not receive TEAS [27]. Remifentanil consumption was significantly reduced in the TAP group and even more so in the TEAS group. The PCIA press numbers were also significantly lower in the TEAS group than in the TAP group. In addition, compared to the TAP analgesia up to 24 h postoperatively, TEAS combined with TAPB lasted for up to 48 h postoperatively. According to traditional Chinese medicine, Hegu (LI4), Neiguan (PC6), and
Zusanli (ST36) are effective acupoints for analgesia. In a meta-analysis evaluating the efficacy and safety of TEAS for relieving postoperative pain in laparoscopy, it was demonstrated that these three common acupoints used for laparoscopic analgesia synergistically and significantly reduced postoperative pain [28]. TEAS at 2 Hz induces the release of enkephalins and endorphins, and TEAS at 100 Hz induces the release of dynorphins [29, 30]. Therefore, a 2/100 Hz dilatational wave was used in the present study to induce the release of all the relevant endorphins [31].

Immune function plays a crucial role in a patient’s recovery. Anesthesia, surgery, and pain are all risk factors for postoperative immunosuppression [32]. Clinical studies have shown that the level of recovery of immune function affects the prognosis and survival of patients with cancer [33]. T lymphocyte subsets (CD3\(^+\), CD4\(^+\), and CD8\(^+\)) are important indicators of the body’s cellular immunity. CD3\(^+\) T cells are T lymphocytes with anti-tumor activity [34]. CD4\(^+\) T cells are helper T cells. CD8\(^+\) T cells are cytotoxic T cells, and an elevation in their level indicates that the body is immunocompromised [35]. The CD4\(^+\)/CD8\(^+\) ratio reflects the normal immune status of the body. In the present study, the balance of T cell subsets on POD1 was disrupted in all three groups of patients (decreased CD3\(^+\), CD4\(^+\), CD4\(^+\)/CD8\(^+\) and increased CD8\(^+\)). This imbalance may contribute to the postoperative immune damage common in these patients. TEAS is known to have immunomodulatory effects and can enhance cellular immunity in patients with

| Table 2 | Comparison of T lymphocytes subsets |
|---------|------------------------------------|
|         | Group G \((n = 29)\) | Group NG \((n = 29)\) | Group NTG \((n = 29)\) | \(P\) value |
| CD3\(^+\) (%) | | | | |
| Pre- | 68.90 ± 3.98 | 69.05 ± 3.20 | 69.50 ± 4.67 | 0.83 |
| POD1 | 61.97 ± 3.18\(^\ast\) | 62.03 ± 4.41\(^\ast\) | 64.84 ± 4.66\(^{**}\) | < 0.05\(^{**}\) |
| POD3 | 64.50 ± 6.43 | 64.78 ± 5.73 | 68.90 ± 6.87\(^{**}\) | < 0.05\(^{**}\) |
| CD4\(^+\) (%) | | | | |
| Pre- | 37.16 ± 5.53 | 38.23 ± 4.22 | 37.21 ± 4.48 | 0.63 |
| POD1 | 26.92 ± 3.97\(^\ast\) | 27.57 ± 4.57\(^\ast\) | 32.87 ± 5.41\(^{**}\) | < 0.05\(^{**}\) |
| POD3 | 31.95 ± 4.64 | 32.34 ± 3.50 | 37.19 ± 4.53\(^{**}\) | < 0.05\(^{**}\) |
| CD8\(^+\) (%) | | | | |
| Pre- | 27.66 ± 3.90 | 27.21 ± 5.32 | 27.58 ± 4.57 | 0.93 |
| POD1 | 32.23 ± 4.21\(^\ast\) | 33.04 ± 4.26\(^\ast\) | 30.05 ± 4.12\(^{**}\) | < 0.05\(^{**}\) |
| POD3 | 31.19 ± 4.81 | 30.93 ± 4.12 | 27.33 ± 4.49\(^{**}\) | < 0.05\(^{**}\) |
| CD4\(^+\)/CD8\(^+\) | | | | |
| Pre- | 1.38 ± 0.33 | 1.48 ± 0.41 | 1.40 ± 0.38 | 0.60 |
| POD1 | 0.83 ± 0.20\(^\ast\) | 0.85 ± 0.17\(^\ast\) | 1.12 ± 0.29\(^{**}\) | < 0.05\(^{**}\) |
| POD3 | 1.04 ± 0.20 | 1.08 ± 0.23 | 1.38 ± 0.21\(^{**}\) | < 0.05\(^{**}\) |

Data are presented as mean ± SD
Pre- preoperative day, POD postoperative day
Compared with the time of Pre-, \(^\ast P < 0.05\); compared with group G, \(^* P < 0.05\); compared with group NG, \(^{#} P < 0.05\)

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malignant tumors [36]. Wu et al. suggested that TEAS modulates the balance of T lymphocytes and the expression of related cytokines to reduce postoperative immune damage in patients with lung cancer [37]. Our results showed that TEAS treatment increased the levels of CD3\(^+\) and CD4\(^+\) cells and CD4\(^+\)/CD8\(^+\) ratio and decreased the levels of CD8\(^+\) cells. This suggests that TEAS may attenuate the immunosuppression of patients undergoing laparoscopic gastric cancer surgery by partially restoring the immune balance.

Elderly patients have poor vascular elasticity and are prone to experiencing high hemodynamic fluctuations in the perioperative period, leading to cerebrovascular accidents. The MAPs and HRs in the TEAS group were comparable at the time of pneumoperitoneum establishment and immediately after extubation. Our study showed that TEAS effectively suppressed the stress response during pneumoperitoneum establishment and extubation, keeping MAPs and HRs stable. It significantly shortened the extubation time as well. Our findings are consistent with results from previous reports showing that TEAS significantly affects sedation and maintenance of hemodynamic stability [38].

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Postoperative gastrointestinal dysfunction is common after surgical procedures, especially gastrointestinal surgery. Acupuncture protects the gastrointestinal tract by regulating gastrointestinal dynamics to promote venting and allows the patient to quickly resume normal diet [39]. In addition, TEAS can inhibit the release of inflammatory factors [40], thereby reducing damage to the gastrointestinal barrier caused by the inflammatory response. From the results of this study, the time to first flatus was significantly shorter in the TEAS group than in the other two groups. PONV is one of the most common gastrointestinal tract complications after anesthesia. Neiguan (PC6) stimulation can effectively prevent PONV [41]. Our results demonstrated that the incidence of PONV in the TEAS group was the lowest among the three groups. The mechanism by which TEAS prevents PONV is complex. Clinical studies have shown that TEAS reduces plasma concentrations of the emetic molecule 5-hydroxytryptamine (5-HT) [42]. We did not measure the concentration of 5-HT in plasma, and the exact mechanism needs further study.

TEAS is a modification of traditional acupuncture techniques. However, TEAS may also cause some adverse effects such as allergy and ulceration at the acupoint. We have strictly enforced the exclusion of patients with swelling, infection, or ulceration at the site of TEAS, and the stimulation intensity is also chosen to
be the most suitable for the patients and to achieve the optimal therapeutic effect, minimizing the occurrence of complications. TAPB is a superficial technique, with a small risk of complications. We all perform TAPB through a professional under ultrasound guidance, without adverse effects.

There are some limitations in the current study. First, the sample size of 90 may be small. Second, our study only included elderly patients, making it difficult to generalize the findings to patients of other age groups. Third, as we performed TEAS on the patients before induction of anesthesia, there may be a lack of blinding to some extent, leading to biased results of the test. However, the stimulator is covered by an opaque cloth so that the surgeons and anesthesiologists were blinded. The researchers who conducted data collection and performed the outcome assessment were blinded to group allocation. These procedures may minimize bias. Additionally, the long-term effects of TEAS on the quality of recovery and survival rate should be examined.

Table 3 Consumption of anesthetics, extubation time, pain assessment, postoperative recovery of gastrointestinal function, and adverse events

| Variables                                | Group G (n = 29) | Group NG (n = 29) | Group NTG (n = 29) | P value |
|------------------------------------------|------------------|-------------------|-------------------|---------|
| Intraoperative remifentanil usage (µg)   | 1619.13 ± 328.98 | 1415.41 ± 295.67  | 1182.61 ± 253.61* | < 0.05* |
| Intraoperative propofol usage (mg)       | 948.95 ± 146.79  | 915.88 ± 127.33   | 887.49 ± 118.47   | 0.21    |
| Extubation time (min)                    | 17.72 ± 4.67     | 16.10 ± 3.39      | 9.45 ± 3.98*      | < 0.05* |
| Postoperative time to first ambulation (h)| 31.81 ± 7.38     | 28.50 ± 5.38*     | 27.64 ± 5.86*     | < 0.05* |
| Postoperative time to first flatus (h)   | 43.03 ± 8.13     | 36.83 ± 6.19      | 32.57 ± 6.94*     | < 0.05* |
| PONV [n (%)]                             | 13 (44.82)       | 11 (37.93)        | 5 (17.24)*        | < 0.05* |
| Pruritis [n (%)]                         | 1 (3.45)         | 1 (3.45)          | 0 (0.00)          | 1.00    |
| Respiratory depression [n (%)]           | 1 (3.45)         | 0 (0.00)          | 0 (0.00)          | 1.00    |
| PCIA pump press numbers                  | 12.45 ± 4.21     | 9.97 ± 3.80*      | 6.55 ± 3.19*      | < 0.05* |
| VAS scores at rest                       |                  |                   |                   |         |
| 4 h                                      | 3.44 ± 0.62      | 2.90 ± 0.82*      | 2.62 ± 0.73*      | < 0.05* |
| 12 h                                     | 2.68 ± 0.55      | 1.92 ± 0.67*      | 1.73 ± 0.60*      | < 0.05* |
| 24 h                                     | 1.83 ± 0.55      | 1.40 ± 0.52*      | 1.18 ± 0.42*      | < 0.05* |
| 48 h                                     | 1.24 ± 0.40      | 1.10 ± 0.49       | 0.72 ± 0.36*#     | < 0.05* |
| VAS scores at movement                   |                  |                   |                   |         |
| 4 h                                      | 4.42 ± 0.67      | 3.68 ± 0.73*      | 3.50 ± 0.64*      | < 0.05* |
| 12 h                                     | 3.60 ± 0.57      | 2.85 ± 0.53*      | 2.67 ± 0.55*      | < 0.05* |
| 24 h                                     | 2.84 ± 0.56      | 2.15 ± 0.50*      | 1.89 ± 0.52*      | < 0.05* |
| 48 h                                     | 2.03 ± 0.52      | 1.74 ± 0.56       | 1.19 ± 0.42*#     | < 0.05* |

Data are presented as mean ± SD or n (%)
PCLIA patient-controlled intravenous analgesia, VAS visual analog scale, PONV postoperative nausea and vomiting
Compared with group G, *P < 0.05; compared with group NG, #P < 0.05

\[\text{△Adis}\]
CONCLUSION

Our study showed that TEAS combined with TAPB ameliorated postoperative pain, improved immune function, maintained hemodynamic stability, and achieved shorter extubation time. TEAS combined with TAPB also improved gastrointestinal function and reduced the incidence of PONV. It significantly promoted the quality of recovery after general anesthesia in elderly patients undergoing laparoscopic gastric cancer surgery.

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Author Contributions. Ruyi Xing and Yang Yang designed the study and wrote the first draft of the manuscript. Min Zhang, Hanyu Wang and Mengyuan Tan performed data collection and analysis. Chen Gao and Chao Yang contributed to the material preparation and technical operation, Mingyu Zhai and Yanhu Xie designed the study and revised the manuscript. All authors read and approved the final manuscript.

Disclosures. Ruyi Xing, Yang Yang, Min Zhang, Hanyu Wang, Mengyuan Tan, Chen Gao, Chao Yang, Mingyu Zhai, Yanhu Xie declare that they have no conflict of interest.

Compliance with Ethics Guidelines. The trial protocol was approved by the ethics committee of the First Affiliated Hospital of USTC (Approval no. KY2019-108) and registered in the Chinese clinical trial registry (ChiCTR2100042119). Each participant provided written informed consent before initiating any study-related procedures. This study was conducted in accordance with the Declaration of Helsinki.

Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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