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ORIGINAL RESEARCH

Effect of Stellate Ganglion Block on Preventing Atrial Fibrillation After Esophagectomy: A Double-Blind Randomized Controlled Trial

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Background: Postoperative atrial fibrillation (POAF) is a common complication after esophagectomy and is associated with adverse outcomes. This study investigated whether preoperative stellate ganglion block (SGB) could reduce the incidence of POAF and improve postoperative recovery.

Methods: In this single-center, randomized, double-blind, placebo-controlled trial, 100 patients undergoing esophagectomy were randomly assigned to receive ultrasound-guided right-sided SGB with 7 mL of either 0.5% ropivacaine (SGB group) or normal saline (control group). The primary outcome was the incidence of POAF within 72 hours postoperatively. Secondary outcomes included the timing and duration of POAF, heart rate variability, other arrhythmias, sufentanil consumption, pain scores, vital signs, sleep quality, gastrointestinal recovery, length of hospital stay, complications and mortality.

Results: The incidence of POAF was 10% in both groups (OR = 1.0, 95% CI: 0.27–3.69, $p > 0.99$). However, patients in the SGB group experienced significantly fewer premature atrial contractions (97 vs 347; $p = 0.038$), lower pain scores (VAS at rest: B = –0.60, $p < 0.001$; during movement: B = –0.67, $p < 0.001$) and lower heart rate on postoperative day 1 (B = –4.29, $p = 0.026$). Regarding gastrointestinal recovery, the SGB group showed significantly shorter times to first flatus ($p = 0.001$) and first semi-liquid intake ($p = 0.027$). Sleep disturbances were also less frequent in the SGB group (4% vs 21%, OR = 0.08, $p = 0.039$). No significant differences were observed between the groups in terms of length of hospital stay, incidence of postoperative complications or mortality.

Conclusion: Although SGB did not reduce the incidence of POAF, it was associated with improved postoperative recovery. These findings suggest that SGB may serve as a beneficial adjunct to optimize recovery following esophagectomy.

Keywords: postoperative atrial fibrillation, stellate ganglion block, esophagectomy, autonomic nervous system, sleep quality

Introduction

Esophageal cancer is the seventh most common malignancy and the sixth leading cause of cancer-related mortality worldwide.[1] Thoraco-laparoscopic esophagectomy remains the primary treatment approach. Despite surgical advances, postoperative complications are still frequent,[2] with postoperative atrial fibrillation (POAF) being one of the most common, occurring in 20% to 40% of patients.[3–6] POAF is of considerable clinical significance, as it increases the risk of stroke, heart failure, prolonged hospitalization, bleeding due to anticoagulation and all-cause mortality.[7–10]

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Autonomic nervous system (ANS) imbalance is considered a key contributor to the pathogenesis of POAF.[11,12] During the perioperative period, factors such as surgical trauma, pharmacologic interventions and systemic inflammatory responses can disrupt ANS regulation, thereby increasing the susceptibility to atrial arrhythmias. In the context of major surgery, autonomic imbalance becomes more severe, contributing directly to the elevated incidence of POAF observed in the early postoperative phase.[13] Although antiarrhythmic drugs are commonly used to prevent POAF,[14–17] their application is often limited by systemic side effects and potential toxicity, particularly in patients with multiple comorbidities.[18,19] These limitations highlight the need for alternative prophylactic strategies that are both effective and well-tolerated.

Ultrasound-guided stellate ganglion block (SGB) has emerged as an effective and minimally invasive intervention that potentially lowering the risk of POAF. By directly modulating ANS activity, SGB prolongs the atrial effective refractory period and reduces both the inducibility and duration of atrial fibrillation.[20] Previous studies have demonstrated that SGB decreased the incidence of POAF following coronary artery bypass grafting[21,22] and reduced postoperative supraventricular tachycardia in thoracic surgery patients.[23] However, high-quality clinical trials evaluating the efficacy of SGB in preventing POAF among esophagectomy patients remain lacking. This study aims to assess the effectiveness of SGB in reducing the incidence of POAF after esophagectomy and to explore its potential as a therapeutic strategy to improve postoperative outcomes.

Patients and Methods

Ethics

This prospective, single-center, double-blind, randomized controlled trial was conducted after obtaining approval from the Ethics Committee of Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, Hangzhou, Zhejiang Province, China, on October 28, 2022 (approval No. 20220385). The trial was registered in the China Clinical Trial Registry on February 24, 2023 (registration No. ChiCTR2300068592). Both verbal and written informed consent were obtained from all participants. This study has been reported in compliance with the Consolidated Standards of Reporting Trials (CONSORT) Guidelines.[24]

Patients

In this study, patients with esophageal cancer who were admitted to our center and scheduled to undergo thoraco-laparoscopic McKeown esophagectomy were enrolled. Inclusion criteria were as follows: (1) age between 20 and 85 years; (2) American Society of Anaesthesiologists (ASA) physical status I–III; (3) elective surgery using the thoraco-laparoscopic McKeown approach. Exclusion criteria included: (1) previous diagnosis of atrial fibrillation; (2) history of thoracic surgery; (3) heart failure; (4) sleep disorders or sleep apnea syndrome; (5) hepatic or renal dysfunction; (6) active infection or sepsis; (7) use of antiarrhythmic medications, including β-blockers, digitalis, or calcium channel blockers; (8) known allergy to ropivacaine; (9) inability to undergo SGB; (10) coagulopathy or current anticoagulant therapy; (11) vulnerable individuals, including those with psychiatric disorders, cognitive impairment, or pregnancy.

Randomization and Blinding

The randomization list was generated using software and assigned participants to either the SGB group or the control group in a 1:1 ratio. The randomization results were sealed in sequentially numbered, opaque envelopes to ensure allocation concealment. After obtaining informed consent, the envelopes were opened by study personnel, who then prepared the study medications accordingly: 7 mL of 0.5% ropivacaine for the SGB group or 7 mL of normal saline for the control group as a placebo.

The study employed a double-blind design. Both the patients and the study team—including those administering the interventions, as well as those assessing and analyzing the data—were blinded to the group assignments throughout the study.

Interventions

All participants underwent routine monitoring of electrocardiography (ECG), blood pressure, and oxygen saturation before the procedure. Ultrasound-guided right-sided SGB was performed by the same experienced anesthetist. A high-frequency ultrasound probe was placed in the transverse plane at the level of the seventh cervical vertebra (C7). The C7 level was confirmed by ultrasound visualization of cervical anatomy, typically identifying the C7 transverse process by the presence of only a posterior tubercle and absence of an anterior tubercle. The internal jugular vein, common carotid artery, vertebral vein, vertebral artery, and longus colli muscle were identified in the transverse scan (Figure 1). Color Doppler imaging was used to avoid vascular structures. A 25-gauge needle (B. Braun Stimuplex D, Germany) was inserted into the fascial plane at approximately the C6/C7 level, with the tip positioned at the site where the sympathetic chain extends, located posterolateral to the carotid sheath, deep to the prevertebral fascia, and superficial to the fascia overlying the longus colli muscle.[25,26] Finally, in the SGB group, 7 mL of 0.5% ropivacaine was administered around the stellate ganglion under ultrasound guidance. In the control group, an equal volume of normal saline was injected at the same anatomical location using the same ultrasound-guided technique.

The effectiveness of the block was assessed in an unblinded manner over a 20-minute period following the SGB procedure. Successful SGB was defined by the presence of Horner's syndrome, characterized by miosis, ptosis, enophthalmos, conjunctival and nasal congestion, a sensation of nasal obstruction, reduced facial sweating, and variable temperature changes in the region innervated by the stellate ganglion. Participants in the SGB group with unsuccessful blocks were excluded after unblinding.

All patients received a standardized anesthesia protocol. Monitoring included electrocardiography, pulse oximetry, entropy, invasive arterial pressure, and temperature. Pre-oxygenation was performed with 6 L/min of oxygen for 3 minutes, followed by induction with propofol, sufentanil, and rocuronium. After mask ventilation, endotracheal intubation was performed. Patients were positioned in the left lateral decubitus position for the thoracic phase and supine for the abdominal and cervical phases. During the thoracic phase, artificial pneumothorax was induced at 7 cmH_2O, double-lung ventilation was applied, and esophagectomy with lymph node dissection was performed. In the abdominal phase, pneumoperitoneum was established at 15 cmH_2O, and the stomach was mobilized and prepared for reconstruction, followed by cervical anastomosis with the esophagus. Ventilation parameters included a tidal volume of 6–8 mL/kg, a respiratory rate of 12–16 breaths/min, FiO_2 of 50%–80%, and positive end-expiratory pressure of 5 cmH_2

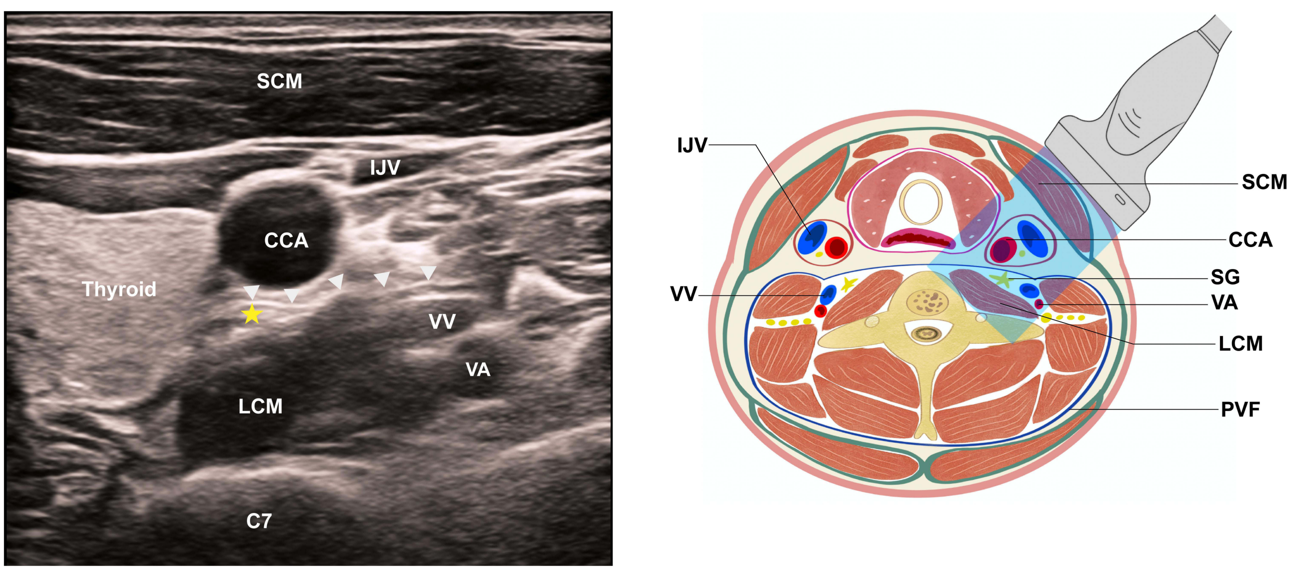

Figure 1 Schematic illustration of right-sided stellate ganglion block under ultrasound guidance. The ultrasound image and corresponding anatomical diagram are shown. White arrowheads indicate the prevertebral fascia, and the yellow star marks the target injection zone.

Abbreviations: SCM, sternocleidomastoid muscle; SG, stellate ganglion; LCM, longus colli muscle; PVF, prevertebral fascia; IJV, internal jugular vein; CCA, common carotid artery; VV, vertebral vein; VA, vertebral artery.

O. Anesthesia was maintained with sevoflurane, propofol, remifentanil, rocuronium. Blood pressure was kept within ±20% of the baseline. Ventilation was adjusted to maintain $PETCO_2$ between 35 and 45 mmHg, and entropy value was kept between 40 and 60.

A standardized postoperative pain management protocol was implemented. Fifteen minutes before the end of surgery, 3 mg of granisetron was administered prophylactically to prevent nausea, and 50 mg of flurbiprofen was given for analgesia. Following skin closure, 20 mL of 0.5% ropivacaine was administered for local infiltration at the chest and abdominal incision sites. A patient-controlled intravenous analgesia (PCIA) pump was set up with sufentanil 250 µg diluted in 250 mL of normal saline. The pump was programmed with a background infusion rate of 1 mL/h, a bolus dose of 2 mL, a lockout interval of 5 minutes, and a maximum limit of 12 mL per hour. All study participants received supervised postoperative rehabilitation, including a structured early mobilization protocol to encourage prompt ambulation.

Outcomes

The primary outcome was the incidence of POAF within 72 hours after esophagectomy. Secondary outcomes included the timing and duration of POAF, heart rate variability, and other arrhythmias (including premature ventricular and atrial contractions) within 72 hours postoperatively. Clinical atrial fibrillation was defined as episodes lasting at least 30 seconds.[27] To ensure comprehensive detection of POAF events, three monitoring methods were employed: (1) a 72-hour ECG Holter monitor with automatic algorithms for detecting the occurrence and duration of POAF and other arrhythmias (Baihui Smart Dynamic ECG, Hangzhou, China); (2) conventional 12-lead ECG; and (3) continuous ECG monitoring with a 3-channel bedside monitor in the wards. All POAF events were diagnosed by physicians who were blinded to the group assignments. Amiodarone was administered if atrial fibrillation persisted for more than 30 minutes or resulted in hemodynamic instability. Electrical cardioversion was performed when a rapid ventricular rate caused hemodynamic compromise or myocardial ischemia, typically in conjunction with amiodarone therapy.

Other secondary outcomes included cumulative postoperative sufentanil consumption via PCIA, pain intensity after surgery, vital signs, sleep quality and additional recovery-related outcomes. Pain intensity was assessed at 4, 12, 24, 48 hours after surgery, using a visual analog scale (VAS), where 0 indicated no pain and 10 indicated the worst pain imaginable. Vital signs—specifically blood pressure and heart rate—were recorded preoperatively, at the end of operation, and at 8 a.m. on postoperative days 1 and 2. Sleep quality was evaluated using a VAS, where 0 indicated the best and 10 the worst, with a score ≥6 considered indicative of sleep disturbance. Additional recovery-related outcomes included time to first flatus, time to first semi-liquid intake, time to first bowel movement, postoperative complications, intensive care unit admission, length of hospital stay, and mortality.

Sample Size

The sample size was determined based on a previous study that reported a 40% incidence of POAF in the control group.[6] Given that SGB has been shown to reduce the incidence of supraventricular arrhythmia after thoracic surgery by 65%,[23] the expected incidence in the SGB group was estimated to be 14%. Using a two-sided test with $\alpha = 0.05$ and power $(1 - \beta) = 0.8$, the required sample size was calculated to be 92 using G*Power software (version 3.1.9.7). To account for potential loss to follow-up, a total of 100 participants were recruited, with 50 in each group.

Statistical Methods

All statistical analyses were conducted using IBM SPSS Statistics Version 22. Continuous variables were initially assessed for normality. Normally distributed data were presented as mean ± standard deviation (SD) and compared using the independent *t*-test. Non-normally distributed data were described by median and interquartile range (IQR). Independent data were analyzed using the Mann–Whitney *U*-test, while repeated measures were analyzed using generalized estimating equations (GEE). Categorical variables were presented as frequencies (n) and percentages (%) and analyzed using the χ^2-test. A two-sided *p*-value of less than 0.05 was considered statistically significant.

A GEE model was employed to evaluate the effects of SGB on repeated measures for secondary outcomes, including mean arterial pressure, heart rate, cumulative sufentanil consumption, VAS pain scores, and sleep quality. The model included an interaction term between time (preoperative and various postoperative time points) and group (SGB group vs control group) to assess differential changes in these outcomes between groups from baseline through postoperative follow-up.

If the interaction effect between time and group was significant, the interaction term was retained, and subsequent analyses were conducted to examine and interpret the differences between groups at each time point. If the interaction effect was not significant, the interaction term was removed, and the main effect of the group was evaluated independently. In this case, the main effect of the group was analyzed to determine whether a consistent difference existed between the groups across all time points, regardless of time.

Specifically, the GEE model was employed to calculate regression coefficients (B) along with their 95% confidence intervals (CIs), or odds ratios (ORs), median difference with corresponding 95% CIs, to quantify the between-group differences at each time point. These measures were used to evaluate the clinical significance of the differences between groups and to interpret the practical implications of the SGB intervention. The 95% CIs for medians differences were computed using the Hodges-Lehmann estimator.

Results

From March 10, 2023, to November 20, 2023, a total of 100 patients were enrolled in the study, with 50 assigned to the SGB group and 50 to the control group. Two patients, one from each group, were excluded. One patient withdrew midway due to refusal to wear the Holter monitor, and the other was excluded because of block failure (Figure 2). As a result, 98 patients completed the follow-up assessment and were included in the final analyses. There were no significant differences in demographic or surgical characteristics between the two groups (Table 1).

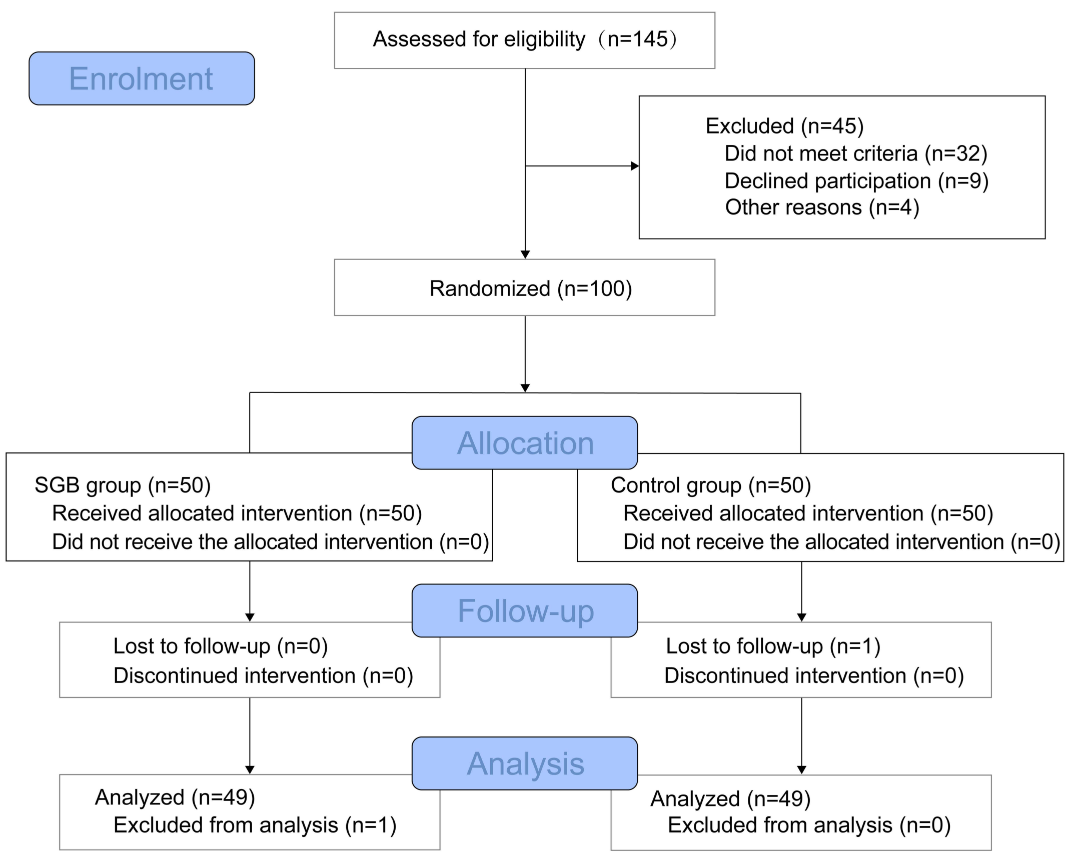

Figure 2 CONSORT flow diagram of participant enrollment and allocation.
Abbreviations: SGB, stellate ganglion block.

Table 1 Baseline Characteristics of the Randomised Patients

Parameters	SGB Group (n=49)	Control Group (n=49)	*p*-value
Age, years	65 (59–70)	68 (64–72)	0.102
Male sex, n (%)	47 (96)	43 (88)	0.268
Body mass index (kg/m²)	21 (21–24)	22 (20–24)	0.629
ASA physical status, n (%)			0.487
II	46 (94)	43 (88)	
III	3 (6)	6 (12)	
NYHA, n (%)			>0.999
I	39 (80)	39 (80)	
II	10 (20)	10 (20)	
Coronary artery disease, n (%)	2 (4)	3 (6)	>0.999
Hypertension, n (%)	22 (45)	19 (39)	0.682
Diabetes, n (%)	6 (12)	3 (6)	0.487
COPD, n (%)	4 (8)	5 (10)	>0.999
Emphysema, n (%)	4 (8)	4 (8)	>0.999
Smoking history, n (%)	11 (22)	7 (14)	0.435
Preoperative chemotherapy, n (%)	25 (51)	22 (45)	0.686
FEV_1 predicted (%)	92 (80–101)	95 (78–102)	0.779
Missing	4	2	
Operation duration (min)	248 (212–305)	250 (210–310)	0.845
Postoperative ventilation duration (min)	90 (60–124)	95 (73–135)	0.428
Crystalloid infusion volume (mL)	1500 (1200–2000)	1500 (1500–2000)	0.313
Blood transfusion volume, n (%)	0	2 (4)	0.495
Urine volume (mL)	600 (400–800)	600 (500–1000)	0.296

Notes: All data is presented as median (IQR) or n (%).
Abbreviations: ASA, American Society of Anaesthesiologists; NYHA, New York Heart Association; COPD, chronic obstructive pulmonary disease; SGB, stellate ganglion block; FEV_1, forced expiratory volume in one second.

The postoperative Holter monitor results within 72 hours are detailed in Table 2 and Table S1. Among the 98 patients, 10 (10%) developed POAF. The median onset time was 31 (range 24–45) hours, and the median duration was 7 (range 5–15) hours. The incidence of POAF within 72 hours waFigure ss similar between two groups (10% in both), with OR of 1.0 (95% CI: 0.27–3.69, $p > 0.99$). Premature atrial contractions were recorded as 97 (range 23–1604) in the SGB group and 347 (range 79–1253) in the control group ($p = 0.038$).

In the SGB group, the postoperative VAS pain scores were significantly lower than those in the control group following esophagectomy, both at rest (B = –0.60, 95% CI: –0.86 to –0.33, $p < 0.001$) and during movement (B = –0.67, 95% CI: –0.93 to –0.41, $p < 0.001$),as shown in Table 3 and Figure 3.

As summarized in Table 3, The SGB group also demonstrated a lower postoperative heart rate (B = –4.29, 95% CI: –8.07 to –0.52, $p = 0.026$), a shorter time to first flatus (median difference = –1, 95% CI: –2 to 0 days, $p = 0.001$), and a shorter time to first semi-liquid intake (median difference = –1, 95% CI: –2 to 0 days, $p = 0.027$). Sleep quality on postoperative day 1 was better in the SGB group, with only 4% reporting sleep disturbances compared to 21% in the

Table 2 Primary Outcome and Postoperative Holter Monitor Within 72 hours

Parameters	SGB Group (n=49)	Control Group (n=49)	*p*-value
Monitoring duration (h)	69 (66–72)	69 (64–72)	0.946
POAF, n (%)	5 (10)	5 (10)	>0.99
Cumulative time (h)	39	72	N/A
Minimum heart rate (bpm)	58 (54–64)	58 (53–64)	0.641
Maximum heart rate (bpm)	130 (112–160)	134 (115–151)	0.907
Average heart rate (bpm)	80 (74–86)	81 (74–87)	0.614
PVC (beats)	11 (4–82)	17 (3–275)	0.735
PAC (beats)	97 (23–1604)	347 (79–1253)	0.038

Notes: All data is presented as median (IQR) or n (%).
Abbreviations: SGB, stellate ganglion block; POAF, postoperative atrial fibrillation; PVC, premature ventricular contractions; PAC, premature atrial contractions; N/A, not applicable.

Table 3 Secondary Outcomes and Postoperative Quality of Recovery

Parameters	SGB Group (n=49)	Control Group (n=49)	Treatment Effect (95% CI)	*p*-value
Mean arterial pressure, mmHg				
Pre-operation (baseline)	92 (87–99)	88 (83–97)		
End of operation	102 (89–114)	101 (87–111)	2.21 (–1.06 to 5.48)	0.185
POD1	96 (87–108)	97 (89–101)		
POD2	99 (88–108)	95 (87–104)		
Heart rate, bpm				
Pre-operation (baseline)	74 (64–81)	71 (66–82)		
End of operation	69 (62–78)	70 (63–80)	–4.29 (–8.07 to –0.52)	0.026
POD1[a]	76 (70–88)	82 (70–89)		
POD2[a]	77 (74–84)	87 (79–98)		
Cumulative sufentanil consumption, μg	(n=46)	(n=45)		
4 h	6 (4–10)	6 (4–10)		
12 h	15 (9–24)	18 (12–25)	–0.12 (–1.81 to 1.58)	0.328
24 h	34 (22–45)	34 (23–53)		
48 h	65 (41–106)	65 (55–102)		
Postoperative pain at rest (VAS)	(n=48)	(n=48)	–0.60 (–0.86 to –0.33)	<0.001
4 h	1 (0–2)	1 (1–3)	–0.81 (–1.36 to –0.26)	0.004
12 h	2 (2–3)	3 (2–4)	–1.08 (–1.60 to –0.57)	<0.001
24 h	2 (2–3)	3 (3–4)	–0.85 (–1.26 to –0.45)	<0.001
48 h	2 (1–2)	2 (2–3)	–0.75 (–1.15 to 0.35)	<0.001
Postoperative pain during movement (VAS)	(n=48)	(n=48)	–0.67 (–0.93 to –0.41)	<0.001
4 h	2 (1–3)	3 (2–4)	–0.83 (–1.45 to –0.22)	0.008
12 h	4 (3–4)	5 (4–5)	–1.08 (–1.55 to –0.62)	<0.001
24 h	4 (3–4)	5 (4–5)	–1.04 (–1.42 to –0.67)	<0.001
48 h	3 (2–4)	4 (3–4)	–0.90 (–1.24 to 0.55)	<0.001

(*Continued*)

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Table 3 (Continued).

Parameters	SGB Group (n=49)	Control Group (n=49)	Treatment Effect (95% CI)	*p*-value
VAS for sleep quality ≥ 6[b], n (%)	(n=47)	(n=48)	2.09 (0.18 to 23.85)	0.553
Pre-operation (baseline)	2 (4)	1 (2)	N/A	N/A
POD 1	2 (4)	10 (21)	0.08 (0.01 to 0.88)	0.039
POD 2	7 (15)	5 (10)	0.72 (0.05 to 10.43)	0.810
POD 3	7 (15)	4 (8)	0.92 (0.06 to 13.81)	0.953
Time to first flatus, day	5 (4–6)	6 (5–7)	−1 (−2 to 0)	0.001
Missing	2	4		
Time to first semi-liquid intake, day	9 (8–10)	10 (8–12)	−1 (−2 to 0)	0.027
Time to first bowel movement, day	4 (4–5)	4 (4–6)	0 (−1 to 0)	0.634
ICU admission, n (%)	2 (4)	1 (2)	2.04 (0.18 to 23.29)	0.558
Complications, n (%)				
Need for pleural drainage	9 (18)	7 (14)	1.35 (0.46 to 3.97)	0.790
Pulmonary embolism	0 (0)	2 (4)	N/A	0.495
Anastomotic leakage	1 (2)	1 (2)	1.00 (0.06 to 16.45)	>0.99
Anastomotic stricture	4 (8)	9 (18)	0.40 (0.12 to 1.42)	0.136
Length of hospital stay, day	10 (9–13)	11 (10–12)	0 (−1 to 0)	0.296
Mortality, n (%)	0 (0)	1 (2)	N/A	0.315

Notes: All data presented as n (%); median (IQR).[a]At 8 a.m. on postoperative days 1 and 2.[b]Sleep quality was assessed using a visual analog scale (VAS), where 0 represented the best sleep quality and 10 the worst. A VAS score of 6 or higher was defined as sleep disturbance.
Abbreviations: SGB, stellate ganglion block; POD, postoperative day; ICU, intensive care unit; VAS, visual analog scale; N/A, not applicable.

control group (OR = 0.08, 95% CI: 0.01 to 0.88, p = 0.039). No significant differences were observed in cumulative sufentanil consumption, mean arterial pressure, intensive care unit admission rates, time to first bowel movement, complications, length of hospital stay and mortality.

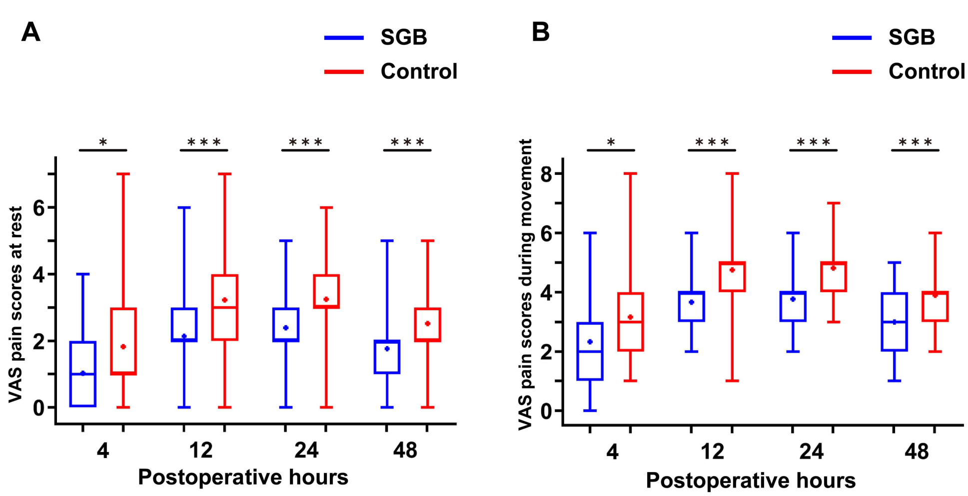

Figure 3 VAS pain scores at rest and during movement at 4, 12, 24 and 48 hours after esophagectomy. (**A**) VAS pain scores at rest. (**B**) VAS pain scores during movement. Data are presented as median (horizontal bars), interquartile range (box), minimum and maximum (whiskers), and mean (cross). *p <0.05, ***p <0.001.
Abbreviations: VAS, visual analog scale.

Discussion

To the best of our knowledge, this is the first large-scale, randomized, double-blind trial evaluating the efficacy of SGB in preventing POAF after esophagectomy. Although the incidence of POAF was similar between groups, SGB was associated with lower heart rate postoperatively, fewer premature atrial contractions, reduced VAS pain scores, improved sleep quality on postoperative day one and faster recovery of gastrointestinal function. These findings suggest that although SGB may not reduce the incidence of POAF, it appears to provide perioperative benefits by promoting autonomic stability, enhancing postoperative comfort and facilitating early recovery after esophagectomy.

In terms of POAF timing and duration, our findings are consistent with those of previous studies.[6,17] However, contrary to prior reports demonstrating a protective effect of SGB against arrhythmias, we did not observe a reduction in POAF incidence in the SGB group.[20,21,23] One potential explanation is the unexpectedly low baseline POAF incidence observed in both groups, which may have obscured the potential efficacy of SGB. Previous studies have reported POAF rates ranging from 20% to 40% following esophagectomy.[3–6] For instance, a randomized clinical trial of landiolol hydrochloride reported a POAF rate of 30% (15/50) in the control group and 10% (5/50) in the landiolol group.[5] Similarly, another trial showed that amiodarone reduce POAF from 40% (16/40) in the control group to 15% (6/40) in the amiodarone group.[6]

Several perioperative factors may have contributed to the low POAF incidence in our cohort. Firstly, all patients underwent McKeown minimally invasive esophagectomy with bilateral lung ventilation and artificial pneumothorax, thereby avoiding thoracotomy.[2] Additionally, perioperative management followed an Enhanced Recovery After Surgery (ERAS) protocol,[28,29] which included preoperative chemotherapy in 48% of patients, multi-modal analgesia, early correction of electrolyte imbalances, early ambulation, and supervised rehabilitation. Furthermore, the observation window for POAF was limited to the first 72 hours postoperatively. While previous studies have shown that the incidence of POAF is highest on the second day after esophagectomy, and more than 90% of cases occurring within the first 72 hours.[6,30] Nonetheless, it is undeniable that a small proportion of cases may still develop beyond 3 days postoperatively. Thus, the relatively short observation period may have underestimated the true incidence of POAF in the control group.

Despite the lack of effect on POAF prevention, the SGB group exhibited lower postoperative heart rates and fewer premature atrial contractions compared to controls. Given the established link between early postoperative tachycardia and POAF development—particularly on postoperative days 1 and 2[31] —these findings suggest that SGB still holds potential for POAF prevention. SGB may contribute to autonomic stabilization in the early postoperative period, potentially attenuating sympathetic overactivation.

This study also demonstrated that SGB significantly reduced VAS pain scores at rest and during movement at 4, 12, 24, and 48 hours postoperatively. These results align with previous evidence suggesting that autonomic modulation by SGB can alleviate acute postoperative pain.[32–34] Furthermore, the SGB group experienced shorter times to first flatus and first semi-liquid intake, along with improved sleep quality on postoperative day one. These benefits may be attributable to reduced sympathetic tone and enhanced vagal activity, both of which are known to support gastrointestinal motility and sleep recovery.[34,35] Together, these findings highlight SGB's potential role as both an analgesic technique and a supportive intervention for early postoperative recovery after major thoracic surgery.

Importantly, SGB did not increase the risk of major postoperative complications. Consistent with previous reports,[2] pulmonary complications were the most common., It is likely due to the invasiveness and prolonged duration of esophagectomy, especially in cases requiring extensive mediastinal lymphadenectomy.[36] Additionally, the study was conducted during the COVID-19 pandemic, a period during which respiratory complications were more prevalent, potentially amplifying the overall incidence. As for other major complications, anastomotic leakage occurred in one patient from each group and resulted in mortality in the control group, which is also in line with prior studies.[37] Collectively, these safety outcomes support the feasibility of incorporating SGB into perioperative protocols without adding morbidity.

This study had several limitations. The sample size was based on previously reported POAF incidence of 40% in esophagectomy patients.[6] However, the actual incidence in the control group was only 10%, which may have reduced the power to detect between-group differences. Moreover, as a single-center study, the generalizability of these findings to other institutions or broader patient populations may be limited.

Conclusion

Although preoperative SGB did not significantly reduce the incidence of POAF after esophagectomy, it was associated with improved heart rate control, reduced postoperative pain and enhanced recovery. These findings suggest that SGB may have clinical value as an adjunctive component of perioperative care. Future large-scale, multicenter randomized trials with extended monitoring periods are warranted to further validate its role in preventing POAF and to explore its broader benefits in thoracic surgical populations.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author, Dr. Gang Chen, upon reasonable request.

Ethical Approval and Consent to Participate

This study was approved by the Ethics Committee of Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University (Approval No. 20220385, October 28, 2022) and and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants after they received a detailed explanation of the study objectives and procedures.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Consent for Publication

All authors approved the manuscript for publication, and written informed consent was obtained.

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Disclosure

The authors declare that they have no conflicts of interest related to this work.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71(3):209–249. doi:10.3322/caac.21660
2. Mariette C, Markar SR, Dabakuyo-Yonli TS, et al. hybrid minimally invasive esophagectomy for esophageal cancer. *N Engl J Med*. 2019;380 (2):152–162. doi:10.1056/NEJMoa1805101
3. Mc Cormack O, Zaborowski A, King S, et al. New-onset atrial fibrillation post-surgery for esophageal and junctional cancer: incidence, management, and impact on short- and long-term outcomes. *Ann Surg*. 2014;260(5). doi:10.1097/SLA.0000000000000960
4. Lohani KR, Nandipati KC, Rollins SE, et al. Transthoracic approach is associated with increased incidence of atrial fibrillation after esophageal resection. *Surg Endosc*. 2015;29(7):2039–2045. doi:10.1007/s00464-014-3908-9

5. Ojima T, Nakamori M, Nakamura M, et al. Randomized clinical trial of landiolol hydrochloride for the prevention of atrial fibrillation and postoperative complications after oesophagectomy for cancer. *Br J Surg*. 2017;104(8):1003–1009. doi:10.1002/bjs.10548
6. Tisdale JE, Wroblewski HA, Wall DS, et al. A randomized, controlled study of amiodarone for prevention of atrial fibrillation after transthoracic esophagectomy. *J Thorac Cardiovasc Surg*. 2010;140(1):45–51. doi:10.1016/j.jtcvs.2010.01.026
7. Murthy SC, Law S, Whooley BP, Alexandrou A, Chu K-M, Wong J. Atrial fibrillation after esophagectomy is a marker for postoperative morbidity and mortality. *J Thorac Cardiovasc Surg*. 2003;126(4):1162–1167.
8. Rühlmann F, Tichelbäcker T, Mackert AF, et al. Incidence, associated risk factors, and outcomes of postoperative arrhythmia after upper gastrointestinal surgery. *JAMA Network Open*. 2022;5(7):e2223225. doi:10.1001/jamanetworkopen.2022.23225
9. Frendl G, Sodickson AC, Chung MK, et al. AATS guidelines for the prevention and management of perioperative atrial fibrillation and flutter for thoracic surgical procedures. Executive summary. *J Thorac Cardiovasc Surg*. 2014;148(3):772–791. doi:10.1016/j.jtcvs.2014.06.037
10. van de Kar MRD, van Brakel TJ, M VV, et al. Anticoagulation for post-operative atrial fibrillation after isolated coronary artery bypass grafting: a meta-analysis. *Eur Heart J*. 2024;45(29):2620–2630. doi:10.1093/eurheartj/ehae267
11. Amar D, Zhang H, Miodownik S, Kadish AH. Competing autonomic mechanisms precede the onset of postoperative atrial fibrillation. *J Am Coll Cardiol*. 2003;42(7):1262–1268.
12. Chen PS, Chen LS, Fishbein MC, Lin S-F, Nattel S. Role of the autonomic nervous system in atrial fibrillation: pathophysiology and therapy. *Circ Res*. 2014;114(9):1500–1515. doi:10.1161/CIRCRESAHA.114.303772
13. Gaudino M, Di Franco A, Rong LQ, Piccini J, Mack M. Postoperative atrial fibrillation: from mechanisms to treatment. *Eur Heart J*. 2023;44(12):1020–1039. doi:10.1093/eurheartj/ehad019
14. Horikoshi Y, Goyagi T, Kudo R, Kodama S, Horiguchi T, Nishikawa T. The suppressive effects of landiolol administration on the occurrence of postoperative atrial fibrillation and tachycardia, and plasma IL-6 elevation in patients undergoing esophageal surgery: a randomized controlled clinical trial. *J Clin Anesth*. 2017;38:111–116. doi:10.1016/j.jclinane.2017.01.036
15. Tisdale JE, Jaynes HA, Watson MR, Corya AL, Shen C, Kesler KA. Amiodarone for prevention of atrial fibrillation following esophagectomy. *J Thorac Cardiovasc Surg*. 2019;158(1). doi:10.1016/j.jtcvs.2019.01.095
16. Hochreiter M, Schmidt T, Siegler BH, et al. Diltiazem prophylaxis for the prevention of atrial fibrillation in patients undergoing thoracoabdominal esophagectomy: a retrospective cohort study. *World J Surg*. 2020;44(7):2295–2304. doi:10.1007/s00268-020-05444-y
17. Amar D, Zhang H, Chung MK, et al. Amiodarone with or without N-acetylcysteine for the prevention of atrial fibrillation after thoracic surgery: a double-blind, randomized trial. *Anesthesiology*. 2022;136(6):916–926. doi:10.1097/ALN.0000000000004201
18. Van Mieghem W, Coolen L, Malysse I, Lacquet LM, Deneffe GJ, Demedts MG. Amiodarone and the development of ARDS after lung surgery. *Chest*. 1994;105(6):1642–1645.
19. Trohman RG, Sharma PS, McAninch EA, Bianco AC. Amiodarone and thyroid physiology, pathophysiology, diagnosis and management. *Trends Cardiovasc Med*. 2019;29(5):285–295. doi:10.1016/j.tcm.2018.09.005
20. Leftheriotis D, Flevari P, Kossyvakis C, et al. Acute effects of unilateral temporary stellate ganglion block on human atrial electrophysiological properties and atrial fibrillation inducibility. *Heart Rhythm*. 2016;13(11):2111–2117. doi:10.1016/j.hrthm.2016.06.025
21. Connors CW, Craig WY, Buchanan SA, Poltak JM, Gagnon JB, Curry CS. Efficacy and efficiency of perioperative stellate ganglion blocks in cardiac surgery: a pilot study. *J Cardiothorac Vasc Anesth*. 2018;32(1):e28–e30. doi:10.1053/j.jvca.2017.10.025
22. Yildirim V, Akay HT, Bingol H, et al. Pre-emptive stellate ganglion block increases the patency of radial artery grafts in coronary artery bypass surgery. *Acta Anaesthesiol Scand*. 2007;51(4):434–440.
23. Wu C-N, Wu X-H, Yu D-N, Ma W-H, Shen C-H, Cao Y. A single-dose of stellate ganglion block for the prevention of postoperative dysrhythmias in patients undergoing thoracoscopic surgery for cancer: a randomised controlled double-blind trial. *Eur J Anaesthesiol*. 2020;37(4):323–331. doi:10.1097/EJA.0000000000001137
24. Moher D, Hopewell S, Schulz KF, et al. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *Int J Surg*. 2012;10(1):28–55. doi:10.1016/j.ijsu.2011.10.001
25. Narouze S. Ultrasound-guided stellate ganglion block: safety and efficacy. *Curr Pain Headache Rep*. 2014;18(6):424. doi:10.1007/s11916-014-0424-5
26. Zhang J, Liang J, Liu T, et al. Ultrasound-guided stellate ganglion block in patients with electrical storm: a single-center case series. *J Clin Anesth*. 2025;104:111850. doi:10.1016/j.jclinane.2025.111850
27. Hindricks G, Potpara T, Dagres N, et al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): the Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. *Eur Heart J*. 2021;42(5):373–498. doi:10.1093/eurheartj/ehaa612
28. Markar SR, Karthikesalingam A, Low DE. Enhanced recovery pathways lead to an improvement in postoperative outcomes following esophagectomy: systematic review and pooled analysis. *Dis Esophagus*. 2015;28(5):468–475. doi:10.1111/dote.12214
29. Low DE, Allum W, De Manzoni G, et al. Guidelines for perioperative care in esophagectomy: enhanced recovery after surgery (ERAS®) society recommendations. *World J Surg*. 2019;43(2):299–330. doi:10.1007/s00268-018-4786-4
30. Shen J, Lall S, Zheng V, Buckley P, Damiano RJ, Schuessler RB. The persistent problem of new-onset postoperative atrial fibrillation: a single-institution experience over two decades. *J Thorac Cardiovasc Surg*. 2011;141(2):559–570. doi:10.1016/j.jtcvs.2010.03.011
31. Ojima T, Iwahashi M, Nakamori M, et al. Atrial fibrillation after esophageal cancer surgery: an analysis of 207 consecutive patients. *Surg Today*. 2014;44(5):839–847. doi:10.1007/s00595-013-0616-3
32. Kumar N, Thapa D, Gombar S, Ahuja V, Gupta R. Analgesic efficacy of pre-operative stellate ganglion block on postoperative pain relief: a randomised controlled trial. *Anaesthesia*. 2014;69(9). doi:10.1111/anae.12774
33. Xiang X-B, Wu Y-Y, Fang Z, et al. Stellate ganglion block for visceral pain in elderly patients undergoing video-assisted thoracoscopic lung cancer surgery: a randomized, controlled trial. *Int J Surg*. 2024;110(11):6996–7002. doi:10.1097/JS9.0000000000001867
34. Yang R-Z, Li Y-Z, Liang M, et al. Stellate ganglion block improves postoperative sleep quality and analgesia in patients with breast cancer: a randomized controlled trial. *Pain Ther*. 2023;12(2):491–503. doi:10.1007/s40122-022-00473-y

35. Lu D-H, Xu X-X, Zhou R, et al. Ultrasound-guided stellate ganglion block benefits the postoperative recovery of patients undergoing laparoscopic colorectal surgery: a single-center, double-blinded, randomized controlled clinical trial. *BMC Anesthesiol*. 2024;24(1):137. doi:10.1186/s12871-024-02518-5
36. Pham TH, Perry KA, Dolan JP, et al. Comparison of perioperative outcomes after combined thoracoscopic-laparoscopic esophagectomy and open Ivor-Lewis esophagectomy. *Am J Surg*. 2010;199(5):594–598. doi:10.1016/j.amjsurg.2010.01.005
37. Linden PA, Towe CW, Watson TJ, et al. Mortality after esophagectomy: analysis of individual complications and their association with mortality. *J Gastrointest Surg*. 2020;24(9):1948–1954. doi:10.1007/s11605-019-04346-2