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Assessing the clinical advantage of opioid-reduced anesthesia in thoracoscopic sympathectomy: a prospective randomized controlled trial

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Abstract

Background Opioid-reduced multimodal analgesia has been used clinically for many years to decrease the perioperative complications associated with opioid drugs. We aimed to assess the clinical effects of opioid-reduced anesthesia during thoracoscopic sympathectomy.

Methods Surgical patients ($n=151$) with palmar hyperhidrosis were randomly divided into control (Group C, 73 patients) and test (Group T, 78 patients) groups. All patients were administered general anesthesia using a laryngeal mask. In Group C, patients received propofol, fentanyl, and cisatracurium for anesthesia induction, and maintenance was achieved with propofol and remifentanil, along with mechanical ventilation during the operation. In Group T, anesthesia was induced with propofol, dezocine, and dexmedetomidine (DEX) and maintained with propofol, DEX, and an intercostal nerve block, along with spontaneous breathing throughout the operation. Perioperative complications related to opioid use include hypotension, bradycardia, hypertension, tachycardia, hypoxemia, nausea, vomiting, urine retention, itching, and dizziness were observed. To assess the impact of these complications, we recorded and compared vital signs, blood gas indices, visual analogue scale (VAS) scores, adverse events, and patient satisfaction between the two groups.

Results Perioperative complications related to opioid use were similar between groups. There were no significant differences in the type of perioperative sedation, analgesia index, respiratory and circulatory indicators, blood gas analysis, postoperative VAS scores, adverse reactions, propofol dosage, postoperative recovery time, and patient satisfaction.

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Conclusions In minimally invasive surgeries such as thoracoscopic sympathectomy, opioid-reduced anesthesia was found to be safe and effective; however, this method did not demonstrate clinical advantages.

Trial registration Chinese Clinical Trial Register: ChiCTR2100055005, on December 30, 2021.

Keywords Dezocine, Dexmedetomidine, Intercostal nerve block, Sympathectomy

Background

Opioids have played a crucial role in surgical procedures for many years owing to their strong analgesic effects; however, their use can lead to adverse reactions such as dose-dependent inhibition of respiratory and circulatory function, scratching, nausea, vomiting, and drowsiness [1]. In the last few decades, anesthesiologists have attempted to minimise opioid consumption to reduce surgical complications. Opioid-reduced anesthesia is a technique based on perioperative multimodal pain management that uses few or no opioid drugs [2]. It involves using various drugs to minimise the use of opioids and reduce their side effects. These drugs include sedatives, N-methyl-D-aspartate receptor antagonists, anti-inflammatory drugs, α2 receptor agonists, and local anesthetics. Additionally, intrathecal anesthesia (including spinal and epidural) or peripheral nerve block may be used to replace opioids partially or completely [3–5]. With the continuous promotion of enhanced recovery after surgery (ERAS), a combination of opioid receptor excitement-antagonists (such as dezocine and butorphanol), α2-adrenal agonists, non-steroidal anti-inflammatory drugs (NSAIDs), or nerve block techniques has been used to achieve multi-mode anesthesia. This approach has proven to be safe and effective [6–9].

Thoracoscopic sympathectomy is an important treatment for palmar hyperhidrosis, offering precise results, minimal trauma, and rapid postoperative recovery [10, 11]. In this context, we aimed to evaluate the efficacy of opioid-reduced anesthesia for this procedure by investigating the clinical effects of a dezocine, dexmedetomidine (DEX), and intercostal nerve block combination. Further, we sought to determine if this anaesthetic offers comparable analgesic effects to that of strong opioids while reducing the incidence of adverse reactions.

Materials and methods

Study design

This study was registered in the Chinese Clinical Trial Register (http://www.chictr.org.cn; registration number: ChiCTR2100055005) on 30 December 2021. Ethical approval (Number: 2022-025-02) for this study (Research Ethics Committee) was provided by the Ethics Committee of Shenzhen Third People's Hospital, Shenzhen, Guangdong, China (Chairman Zhang Guoliang) on 24 March 2022. Written informed consent for this research protocol was obtained from all eligible patients.

Patient recruitment

Patients who received general anesthesia through a laryngeal mask between May 2022 and March 2023 were recruited. The inclusion criteria were age 18–60 years, diagnosis of palmar hyperhidrosis, elective single/bilateral endoscopic thoracic sympathectomy, and American Society of Anesthesiologists class I or II. The exclusion criteria included a body mass index (BMI) > 30 kg/m^2; breastfeeding or pregnancy; history of thoracic surgery or previous thoracic sympathetic nerve resection; significant organ system dysfunction; spontaneous bleeding or coagulation disorders; chronic pain history; upper airway infection in the past 2 weeks; abuse of opioid or NSAIDs; known hypersensitivity or allergy to nonsteroidal drugs, alcohol, or local anesthetics; and concurrent mental illness or cognitive impairment. Patients who experienced serious surgical complications, required conversion to thoracotomy, or had changes in the anesthesia method were also excluded.

Sample size calculation

This was a non-inferiority-designed clinical trial. Preliminary test results showed that both traditional strong opioid anesthesia and opioid-reduced anesthesia met the requirements of perioperative analgesia. This study adopted a 1:1 intergroup ratio design, assuming that the patients in the test and control groups experienced similar analgesic effects and had the same visual analogue scale (VAS) score after surgery. The sample size was estimated using PASS software version 23.0. The combined standard deviation of the two groups, based on pretrial results, using 0.2 as the acceptable non-inferiority margin ($\delta = 0.2$), with $\sigma = 0.5$, $\alpha = 0.025$ (one side), $\beta = 0.1$, inspection efficiency (1- β)= 0.9, the minimum sample size required for each group was 68 cases. To account for an expected 20% loss to follow-up, a total of 164 patients were recruited.

Randomization

The patients were divided into two groups based on computer-generated random numbers. If the number was odd, they were placed in the control group (Group C); if the number was even, they were assigned to the test group (Group T).

Blinding design

This was a single-blind trial in which the patients were unaware of the grouping, but the anaesthesiologists who administered the clinical anesthesia were aware of the patient grouping. Moreover, the experimental data were collected by clinicians who were blinded to the grouping.

Anesthesia protocol

All patients fasted for 10 h; however, a 200 mL carbohydrate drink was administered orally 2 h before surgery. As patients entered the operating room, their electrocardiogram (ECG), heart rate (HR), mean arterial pressure (MAP), pulse oxygen saturation (SPO_2), bispectral index (BIS), and pain index (PI) were recorded. Upper limb venous access was established; lactate sodium Ringer's solution was continuously infused at a rate of 4–8 mL/kg/h, and oxygen was administered via mask at a rate of 2 L/min.

In group C, a targeted infusion of propofol 3–6 μg/mL, fentanyl 4 μg/kg, and cisatracurium 0.15 mg/kg were intravenously injected for general anesthesia induction. Laryngeal mask intubation was performed when BIS was ≤60 and PI was ≤50. Anesthesia maintenance was achieved through a targeted propofol infusion at 3–6 μg/mL and an intravenous remifentanil infusion at 0.1 μg/kg/min. During the operation, mechanical ventilation was used with 100% oxygen inhalation, a tidal volume of 5–6 mL/kg, and a respiratory rate of 14–20 beats/min. The end-tidal carbon dioxide partial pressure ($P_{ET}CO_2$) was maintained between 35 and 45 mmHg. The BIS was maintained between 40 and 60 mmHg and the PI between 30 and 50 mmHg. When the HR and MAP were 20% higher than baseline, anesthesia was deepened by increasing the propofol targeted concentration by 1 μg/mL. If this measure was ineffective within 3 min, a bolus of 10 μg remifentanil was administered. If anesthesia was still inadequate, an intravenous injection of 10–20 mg of urapidil or 0.5 mg/kg of esmolol was administered. Conversely, if the HR and MAP were 20% lower than baseline, anesthesia was reduced by decreasing the propofol target concentration by 1 μg/mL. If this adjustment was ineffective within 3 min, atropine (0.5 mg) or ephedrine (5–15 mg) was administered. Flurbiprofen (50 mg) was injected before the skin incision. During intrathoracic surgery, mechanical ventilation was temporarily paused. Oxygen at 2 L/min was provided through the inhalation end of the threaded tube, and the expiratory end was disconnected from the anesthesia machine to assist in lung collapse on the surgical side. When SPO_2<90%, low-tidal volume ventilation was initiated. If SPO_2 was not maintained above 90% within 1 min, mechanical ventilation was restored. Before closing the pleural cavity, manual breathing was performed to fully inflate the lungs. Ondansetron (4 mg) was administered, and general anesthesia was discontinued.

In Group T, DEX 1 μg/kg was intravenously pumped 15 min before anesthesia. General anesthesia induction included an infusion of propofol 3–6 μg/mL and dezocine 5 mg intravenous injection. Laryngeal mask intubation was performed with a BIS of 60 and a PI of 50. The anesthesia was maintained with intravenous propofol of 3–6 μg/mL and DEX 0.3–0.5 μg/kg/h; spontaneous breathing was maintained during the surgery. If the SPO_2 decreased below 90%, intermittent auxiliary ventilation was administered. Before surgery, flurbiprofen (50 mg) was injected, and the surgeon performed an intercostal nerve block using 0.33% ropivacaine and 1% lidocaine (10 mL/side). DEX was discontinued after completion of the first-side sympathetic nerve transection. If the surgical procedure was unilateral, DEX was discontinued at the beginning of surgery. Manually controlled ventilation was performed before closing the thoracic cavity. Spontaneous breathing was resumed after sufficient lung expansion, with $P_{ET}CO_2$ levels maintained at <45 mmHg. The other treatments were identical to those used for Group C.

Postoperative analgesia management

VAS was used for postoperative pain evaluation. A 100 mm straight line was drawn, with the left end representing no pain and the right end representing severe pain. Patients marked the line to indicate their pain level, with higher scores reflecting more severe pain [12]. After surgery, if the VAS scores were ≥4, both groups received an intramuscular injection of 50 mg tramadol.

Laryngeal mask removal

Withdrawal of the laryngeal mask complied with the following principles: response to calls in a normal voice, recovery of coughing and swallowing reflex, regular autonomous breathing rhythm, tidal volume>5 mL/kg, respiratory rate 12–20 times/min, SPO_2>95% when air was inhaled for more than 5 min, and hemodynamic stability.

Complete awakening standard

The patient's complete wakefulness was based on the following criteria: ability to identify time and place, complete directive movements, muscle tension restored to normal (such as strong fist clenching), ability to lift the head for more than 10 s, and ability to speak normally.

Discharge criteria

After meeting the discharge criteria, patients were discharged from the ward and sent home. The discharge time was determined by a thoracic surgeon based on the patient's recovery: stable respiratory and circulatory

function, no signs of bleeding or infection at the incision, VAS≤3, and the ability to eat normally and move around independently.

Data collection

Perioperative complications related to opioids [13–15] included hypotension (non-invasive blood pressure (NIBP)≤90/60 mmHg or a reduction in MAP of over 20%, bradycardia (HR≤50 beats/min), hypertension (NIBP≥140/90 mmHg or an increase in MAP of over 20%), tachycardia (HR≥100 beats/min), hypoxemia (SpO_2<90%), nausea (sensation of needing to vomit), vomiting (expulsion of stomach contents through the mouth), urine retention (inability to expel urine trapped in the bladder), itching (subjective sensation of the need to scratch), and dizziness (sensation of head heaviness, lack of clarity, or feeling top-heavy) were observed. HR, MAP, SPO_2, BIS, PI, and venous blood gas indices—including oxygen partial pressure (PO_2), partial pressure of carbon dioxide (PCO_2), base excess (BE), hydrogen carbonate (HCO_3^-), blood glucose (BG), and lactate levels—were recorded at the following time points: before anesthesia (T_1), immediately after skin incision (T_2), at the end of surgery (T_3), and upon leaving the operating room (T_4). VAS scores were observed at the following times: immediately after awakening (P_1), upon exiting the operating room (P_2), 2 h after surgery (P_3), 6 h postoperation (P_4), at discharge (P_5), and 24 h postoperatively (P_6). Other adverse events related to anesthesia, such as surgery interruption, change in anesthesia method, perioperative neurocognitive disorders (PND—central nervous system complications after major surgeries manifesting as mental confusion, memory, perceptual motor function, learning, communication impairment, and more) [16], and anaphylaxis, were recorded. Additionally, patient demographics, propofol dose, laryngeal mask removal time, directional recovery time, and postoperative hospital stay were documented. Patient satisfaction with anesthesia was assessed upon leaving the facility using the following categories: Very satisfied: no discomfort during the entire anesthesia process, willing to undergo anesthesia again; satisfied: minimal discomfort during anesthesia, willing to accept anesthesia again; basically satisfied: discomfort caused by anesthesia was tolerable, willing to accept another examination if necessary; dissatisfied: intolerable discomfort caused by anesthesia, unwilling to accept anesthesia again).

Outcomes

The primary outcomes were perioperative complications associated with opioid use. Secondary outcomes included BIS, PI, vital signs, blood gas index, and VAS scores. Additional outcomes were propofol concentration, postoperative recovery, other adverse events, and patient satisfaction.

Statistical analyses

Statistical analyses were performed using the SPSS 19.0 statistical package. Data are presented as means±standard deviation ($\bar{x} \pm s$) or median (interquartile range [IQR]), and qualitative data are displayed as numbers and percentages (n [%]). Quantitative data such as weight, height, BMI, operation time, propofol dosage, laryngeal mask removal time, directional recovery time, and postoperative hospital stay were compared and analysed between the groups using the independent sample *t-test* or Mann–Whitney *U test*. VAS, HR, MAP, SPO_2, BIS, PI, and blood gas indices were assessed using repeated-measures *ANOVA*. Categorical data, such as sex, surgery type, and perioperative complications, were compared using the *chi-square* test or *Fisher's exact* test. Statistical significance was set at $P<0.05$.

Results

This study initially recruited 164 patients, of which 13 (7.9%) were excluded because their basic parameters did not meet the inclusion criteria, including three (1.8%) with a BMI>30 kg/m^2, three (1.8%) with a history of thoracic surgery, four (2.4%) in Group C and one (0.6%) in Group T who did not receive the assigned intervention, and two (1.2%) in Group C who developed pneumothorax after surgery and required closed pleural drainage. Finally, 151 patients (92.1%) were analysed—73 in Group C and 78 in Group T (Fig. 1).

Demographic profile

There were no statistically significant differences in sex, age, weight, height, BMI, surgery type, or operation time between the groups (Table 1).

Perioperative complications related to opioids

None of the patients experienced hypoxemia, vomiting, urine retention, or itching. There were no significant differences in the incidences of hypotension, bradycardia, hypertension, tachycardia, nausea, or dizziness between the two groups, and the total number of patients with complications was similar between the groups (Table 2).

Other adverse reactions related to anesthesia

All patients successfully underwent surgical treatment, with no cases of surgical interruption, changes in the anesthesia method, PND, or anaphylaxis.

Changes in perioperative sedation and analgesia index

The BIS and PI values declined sharply after general anesthesia induction and then gradually increased to near preanesthesia levels as patients left the operating room,

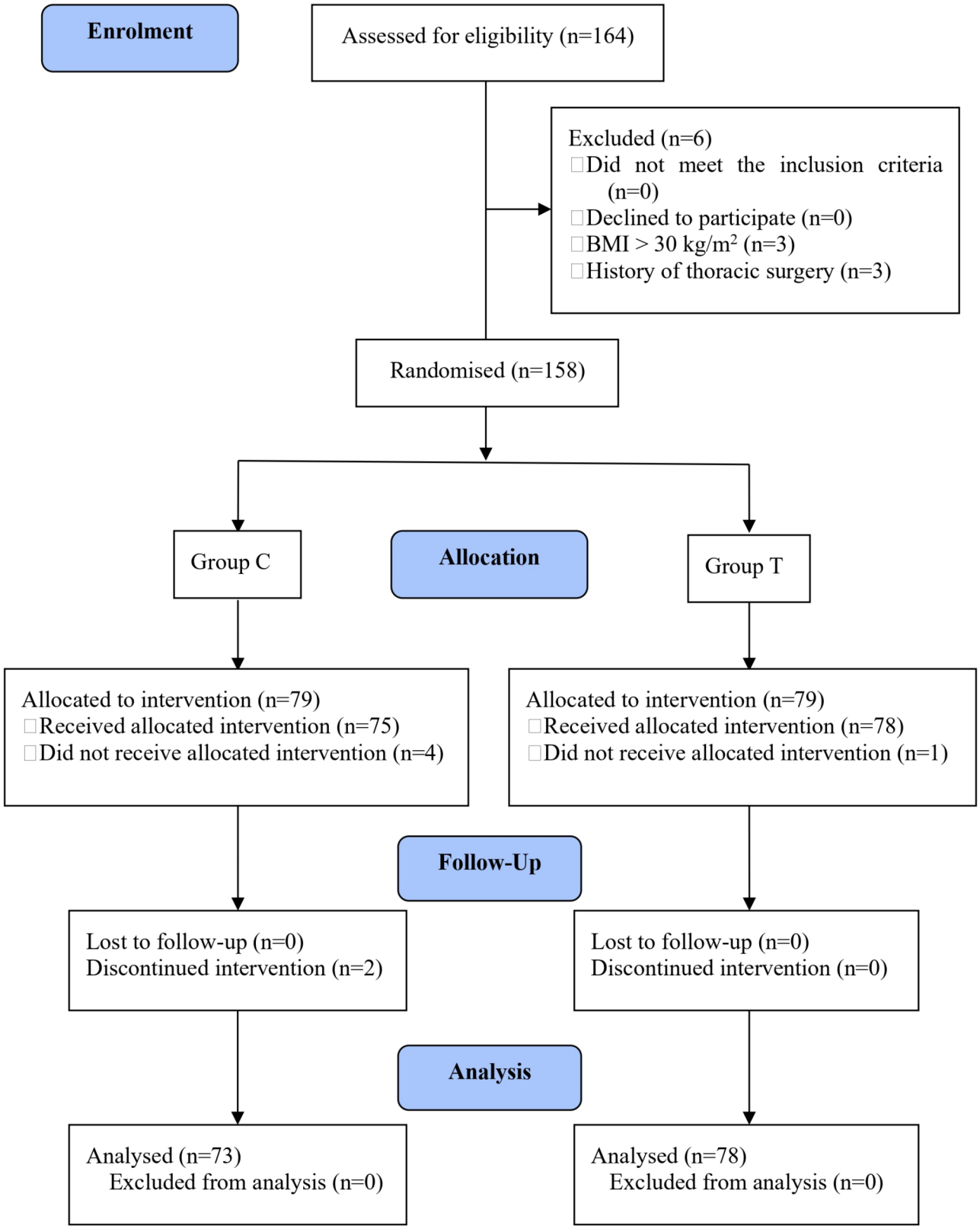

Fig. 1 Flow diagram of the study

Table 1 Comparison of demographic data between the two groups

Item	Group C	Group T	F/χ^2	*P*
Sex (male/female), n (%)	32/41 (43.8/56.2)	29/49 (37.2/62.8)	0.694	0.405
Age (year), ($\bar{x} \pm s$)	26 ± 5	25 ± 4	2.502	0.133
Height (cm), ($\bar{x} \pm s$)	165 ± 7	164 ± 8	1.487	0.233
Weight (kg), ($\bar{x} \pm s$)	57 ± 11	56 ± 10	2.609	0.501
BMI (kg/m^2), ($\bar{x} \pm s$)	21 ± 3	21 ± 2	3.171	0.985
Surgery (single/double), n (%)	44/29 (60.3/39.7)	39/39 (50.0/50.0)	1.612	0.204
Operation time (min), ($\bar{x} \pm s$)	24 ± 13	22 ± 10	1.806	0.484

BMI, body mass index

Table 2 Occurrence of perioperative adverse reactions related to opioids

Item	Group C	Group T	χ^2	*P*
Hypotension, n (%)	47 (64.4)	44 (56.4)	1.003	0.317
Bradycardia, n (%)	27 (37.0)	28 (36.0)	0.019	0.889
Hypertension, n (%)	3 (4.1)	5 (6.4)	0.403	0.526
Tachycardia, n (%)	6 (8.2)	8 (10.3)	0.187	0.666
Nausea, n (%)	6 (8.2)	2 (2.6)	2.494	0.114
Dizziness, n (%)	1 (1.4)	4 (5.1)	1.789	0.181
Total cases, n (%)	50 (68.5)	57 (73.1)	0.384	0.536

Table 3 Comparison of BIS and PI between the two groups

Item	Time point	Group C	Group T	F	*P*
BIS, ($\bar{x} \pm s$)	T_1	96 ± 2	96 ± 4	3.673	0.890
	T_2	47 ± 7$^{\#\#}$	46 ± 8$^{\#\#}$	0.015	0.227
	T_3	57 ± 10$^{\#\#}$	56 ± 12$^{\#\#}$	0.518	0.438
	T_4	91 ± 6$^{\#\#}$	91 ± 5$^{\#\#}$	0.849	0.681
F		1060.708	866.573		
P		< 0.001	< 0.001		
PI, ($\bar{x} \pm s$)	T_1	75 ± 12	73 ± 9	0.333	0.369
	T_2	35 ± 10$^{\#\#}$	36 ± 11$^{\#\#}$	0.830	0.487
	T_3	37 ± 10$^{\#\#}$	38 ± 11$^{\#\#}$	0.632	0.608
	T_4	56 ± 14$^{\#\#}$	55 ± 13$^{\#\#}$	0.123	0.714
F		312.529	254.487		
P		< 0.001	< 0.001		

Compared with group T_1, $^{\#}P < 0.05$, $^{\#\#}P < 0.01$

BIS, bispectral index; PI, pain index

though they remained lower than the baseline. In both groups, a statistically significant difference was observed in BIS and PI between T_2 and T_4 as compared with T_1; however, no significant difference was noted in the above indicators between the two groups (Table 3).

Variety of perioperative respiratory and circulatory indicators

HR and MAP declined markedly after anesthesia and increased slowly as the operation progressed, whereas changes in SPO_2 were relatively minimal. HR and MAP were lower at T_2, T_3, and T_4 than at T_1 in both groups, whereas SPO_2 in Group C was relatively higher at T_2.

Table 4 Comparison of HR, MAP, and SPO_2 between the two groups

Item	Time point	Group C	Group T	F	*P*
HR (beat/min),	T_1	77 ± 12	73 ± 12	0.972	0.059
($\bar{x} \pm s$)	T_2	64 ± 11$^{\#\#}$	65 ± 11$^{\#\#}$	0.002	0.930
	T_3	68 ± 11$^{\#\#}$	66 ± 10$^{\#\#}$	0.629	0.096
	T_4	72 ± 11$^{\#\#}$	67 ± 10$^{\#\#}$	0.738	0.011
F		25.872	17.885		
P		< 0.001	< 0.001		
MAP (mmHg),	T_1	90 ± 11	88 ± 11	0.277	0.287
($\bar{x} \pm s$)	T_2	73 ± 8$^{\#\#}$	75 ± 11$^{\#\#}$	1.167	0.216
	T_3	76 ± 11$^{\#\#}$	73 ± 11$^{\#\#}$	0.008	0.101
	T_4	83 ± 10$^{\#\#}$	79 ± 10$^{\#\#}$	0.010	0.009
F		68.537	47.708		
P		< 0.001	< 0.001		
SPO_2 (%),	T_1	98.8 ± 1.3	98.8 ± 1.3	0.226	0.890
($\bar{x} \pm s$)	T_2	99.2 ± 1.0$^{\#}$	99.1 ± 1.3	0.623	0.452
	T_3	99.0 ± 1.0	99.1 ± 1.0	0.547	0.340
	T_4	98.6 ± 2.6	98.9 ± 1.2	1.176	0.308
F		2.718	1.368		
P		0.046	0.253		

Compared with group T_1, $^{\#}P < 0.05$, $^{\#\#}P < 0.01$

HR, heart rate; MAP, mean arterial pressure; SPO_2, pulse oxygen saturation

However, there were no significant differences in HR, MAP, or SPO_2 between Groups C and T (Table 4).

Changes in perioperative blood gas analysis

Following anesthesia, PH, PCO_2, BE, HCO_3^-, BG, and lactate showed mild fluctuations, and PO_2 significantly increased in both groups. In both Groups C and T, PH was relatively higher at T_2 but lower at T_3 and T_4; PCO_2 decreased at T_2 but increased at T_3 and T_4; PO_2 increased sharply from T_2 to T_4, and BE, HCO_3^-, and BG increased marginally at T_3 and T_4 compared with those at T_1. Furthermore, lactate levels at T_4 were higher than those at T_1 in Group C. Nevertheless, there was no significant difference in blood gas index between the two groups (Table 5).

Postoperative VAS

No patient required additional analgesics (such as tramadol) after surgery. The VAS scores at P_2 to P_6 in Group C and from P_3 to P_6 in Group T showed a substantial increase compared with those at P_1. However, there were no significantly differences in VAS scores between Groups C and T (Table 6).

Dosage of propofol and postoperative recovery time

There were no statistically significant differences in the dosage of propofol, postoperative complete awakening time, or length of hospital stay between the two groups. Compared to that in group C, the laryngeal mask removal time was prolonged in group T (Table 7).

Table 5 Comparison of perioperative blood gas index between the two groups

Item	Time point	Group C	Group T	F/ Z	*P*
PH, ($\bar{x} \pm s$)	T_1	7.37 ± 0.03	7.38 ± 0.02	0.506	0.063
	T_2	7.38 ± 0.03$^{\#\#}$	7.39 ± 0.03$^{\#\#}$	0.026	0.529
	T_3	7.33 ± 0.03$^{\#\#}$	7.32 ± 0.04$^{\#\#}$	0.323	0.126
	T_4	7.35 ± 0.03$^{\#\#}$	7.34 ± 0.02$^{\#\#}$	0.093	0.224
F		67.729	133.667		
P		< 0.001	< 0.001		
PCO_2 (mmHg),	T_1	42 ± 4	42 ± 4	0.142	0.904
($\bar{x} \pm s$)	T_2	39 ± 4$^{\#\#}$	39 ± 4$^{\#\#}$	0.750	0.670
	T_3	48 ± 7$^{\#\#}$	49 ± 8$^{\#\#}$	0.000	0.203
	T_4	45 ± 6$^{\#\#}$	46 ± 5$^{\#\#}$	0.053	0.192
F		56.607	92.771		
P		< 0.001	< 0.001		
PO_2 (mmHg),	T_1	48 ± 12	48 ± 8	6.581	0.926
($\bar{x} \pm s$)	T_2	277 ± 85$^{\#\#}$	278 ± 89$^{\#\#}$	0.015	0.960
	T_3	209 ± 88$^{\#\#}$	207 ± 88$^{\#\#}$	0.118	0.904
	T_4	122 ± 65$^{\#\#}$	112 ± 45$^{\#\#}$	7.378	0.274
F		262.066	300.559		
P		< 0.001	< 0.001		
BE (mmol/L),	T_1	0 (-1, 1)	0 (-1, 1)	-0.245	0.806
M (IQR)	T_2	0 (-1, 1)	0 (-1, 1)	-0.571	0.568
	T_3	1 (0, 2) $^{\#\#}$	2 (0, 3) $^{\#\#}$	-0.691	0.489
	T_4	1 (1, 2) $^{\#\#}$	2 (1, 3) $^{\#\#}$	-1.095	0.274
F		19.796	29.200		
P		< 0.001	< 0.001		
HCO_3^- (mmol/L),	T_1	25 ± 2	24 ± 2	0.005	0.484
($\bar{x} \pm s$)	T_2	24 ± 2	24 ± 2$^{\#\#}$	2.649	0.102
	T_3	26 ± 2$^{\#\#}$	27 ± 2$^{\#\#}$	2.821	0.181
	T_4	26 ± 2$^{\#\#}$	26 ± 2$^{\#\#}$	12.384	0.156
F		41.504	67.930		
P		< 0.001	< 0.001		
BG (mmol/L),	T_1	5.1 ± 0.8	5.2 ± 0.7	0.762	0.699
($\bar{x} \pm s$)	T_2	5.2 ± 0.8	5.3 ± 0.5	7.429	0.797
	T_3	5.4 ± 1.1$^{\#\#}$	5.4 ± 0.6$^{\#}$	3.670	0.984
	T_4	5.4 ± 1.0$^{\#\#}$	5.4 ± 0.6$^{\#}$	4.182	0.984
F		8.014	6.290		
P		< 0.001	< 0.001		
Lactate (mmol/L),	T_1	1.1 ± 0.4	1.1 ± 0.4	0.094	0.538
($\bar{x} \pm s$)	T_2	1.2 ± 0.4	1.1 ± 0.4	0.046	0.112
	T_3	1.2 ± 0.4	1.1 ± 0.4	0.001	0.124
	T_4	1.3 ± 0.4$^{\#}$	1.2 ± 0.3	0.737	0.057
F		4.407	0.806		
P		0.005	0.492		

Compared with group T_1, $^{\#}P<0.05$, $^{\#\#}P<0.01$

BE, base excess; BG, Blood glucose; HCO_3^-, hydrogen carbonate; PCO_2, partial pressure of carbon dioxide; PO_2, oxygen partial pressure

Patient satisfaction with anesthesia

There were no cases of basic satisfaction or dissatisfaction in both group, and the proportion of those who were very satisfied or satisfied was similar between the groups (Table 8).

Table 6 Comparison of postoperative VAS scores between the two groups

Item	Time point	Group C	Group T	Z	*P*
VAS, M (IQR)	P_1	0 (0, 0)	0 (0, 0)	-1.805	0.071
	P_2	1 (0, 1) $^{\#\#}$	0 (0, 0)	-4.839	< 0.001
	P_3	1 (1, 2) $^{\#\#}$	1 (1, 1) $^{\#\#}$	-3.600	< 0.001
	P_4	1 (1, 2) $^{\#\#}$	1 (1, 2) $^{\#\#}$	-0.512	0.609
	P_5	1 (1, 2) $^{\#\#}$	1 (1, 2) $^{\#\#}$	-0.221	0.825
	P_6	1 (0, 1) $^{\#\#}$	1 (0, 1) $^{\#\#}$	-1.024	0.306
F		91.075	166.054		
P		< 0.001	< 0.001		

Compared with group T_1, $^{\#}P<0.05$, $^{\#\#}P<0.01$

VAS, visual analogue scale

Table 7 Comparison of propofol dose and postoperative recovery time between the two groups

Item	Group C	Group T	F	*P*
Propofol dose (mg), ($\bar{x} \pm s$)	298 ± 80	302 ± 88	0.139	0.772
Laryngeal mask removal time (min), ($\bar{x} \pm s$)	8 ± 6	10 ± 6	0.125	0.024
Complete awakening time (min), ($\bar{x} \pm s$)	13 ± 7	13 ± 7	0.120	0.978
Postoperative hospital stay (min), ($\bar{x} \pm s$)	5 ± 1	5 ± 2	2.775	0.102

Table 8 Comparison of patient satisfaction with anesthesia between two groups

Item	Group C	Group T	χ^2	*P*
Very satisfied, n (%)	64 (87.7)	71 (91.0)	0.448	0.503
Satisfied, n (%)	9 (12.3)	7 (9.0)		
Basically satisfied, n (%)	0 (0)	0 (0)		
Dissatisfied, n (%)	0 (0)	0 (0)		

Discussion

To reduce perioperative complications and the incidence of side effects related to anesthesia drugs, opioid-reduced anesthesia combined with non-intubation and nerve block techniques has been increasingly promoted. These methods have achieved good results in thoracic surgeries in recent years [17, 18]. In this study, we combined multiple methods to monitor opioid-reduced anesthesia in patients with palmar hyperhidrosis who underwent thoracoscopic sympathectomy. The results indicated that this anesthesia scheme was safe and effective but did not demonstrate evident clinical advantages.

Dezocine, an opioid κ receptor partial agonist, has been widely used for treating acute pain for many years. It has weak inhibitory effects on cardiovascular function and a low incidence of side effects (drowsiness, nausea, vomiting, etc.) [19]. The trauma associated with sympathectomy was minimal, and the pain caused by this surgery was mild. Consequently, the use of dezocine was sufficient to meet the requirements of intraoperative analgesia. DEX, a selective α2-adrenal receptor agonist, activates corresponding receptors in the brain and spinal

dorsal horn to produce sedative and analgesic effects. It has been widely used in perioperative adjuvant analgesic treatment [20]. In this study, patients in Group T received an infusion of DEX before anesthesia to reduce the excitability of the sympathetic nervous system, and no cases of tachycardia were observed during surgery. Furthermore, to implement the ERAS concept, all patients in this study were orally administered carbohydrate-containing beverages 2 h before surgery. The perioperative blood volume was sufficient, and there was no significant difference in the incidence of bradycardia and hypotension between the groups. The HR, MAP, and incidence of adverse reactions were similar between groups, suggesting that the use of DEX in this surgery was safe. Flurbiprofen, a classic NSAID with strong anti-inflammatory and analgesic effects, plays an important role in the development of multimodal analgesia during surgery [21]. This medication was used in both groups, and the postoperative pain experienced by the patients was low. This result confirms the rationality of these drug combinations.

Analgesia and sedation are crucial indicators during anesthesia, with PI and BIS being measures of intraoperative analgesia and sedation [22, 23]. The VAS score is a common tool for evaluating pain intensity; typically, a VAS score>4 signifies minimal pain [24, 25]. We combined PI and BIS to guide the dosing of sedatives and analgesics during surgery, and various VAS scores were used to assess postoperative pain. The intercostal nerve block is a common regional technique that effectively alleviates pain caused by the incision and thoracic drainage tube, reduces the required dosage of analgesic drugs, and promotes rapid postoperative recovery of patients undergoing thoracic surgery [26]. To improve the intraoperative analgesic effect, we used an intercostal nerve block in patients in Group T. The results showed that the VAS, PI, and BIS values were similar between the groups and maintained at clinically appropriate levels, suggesting that analgesia via a combination of multiple analgesics and nerve blocks was effective.

In this study, the incidence of perioperative complications was vital for assessing the effects of opioid-reduced anesthesia. Patients in the two groups did not show significant differences in terms of opioid-related adverse reactions, indicating that the use of opioid-reduced anesthesia during thoracoscopic sympathectomy is safe and feasible.

During spontaneous breathing, preserving general anesthesia, hypoxemia, and hypercapnia are the major challenges faced by anesthesiologists [27]. In this study, after repeated preliminary tests, patients in both groups were treated with laryngeal mask intubation to alleviate upper respiratory tract obstruction and prevent hypoxia caused by such obstruction. Auxiliary ventilation was administered, as necessary. In addition, during single-lung ventilation, oxygen was supplied to all patients through the inhalation end of the threaded tube to ensure adequate oxygen supply. The exhalation end of the threaded tube was detached from the anesthesia machine, which aided in the emission of carbon dioxide during lung collapse on the surgical side. Before completing the surgery, manual ventilation was performed to fully inflate the lungs and prevent postoperative atelectasis. In Group T, some patients experienced insufficient tidal volume and elevated transient carbon dioxide levels during surgery. In this situation, excessive manual ventilation was performed after completing the sympathectomy to maintain near-normal levels of $P_{ET}CO_2$ before the end of surgery. Blood gas analysis showed that the partial pressures of oxygen and carbon dioxide were at healthy levels when the patients exited the operating room. These results are consistent with those obtained by Li et al. [28] who reported that short-term mild hypercapnia during thoracic surgery did not affect patient prognosis. In addition, none of the patients experienced complications such as hypoxemia, heart failure, or delayed awakening during the perioperative period. The dosage of propofol was similar across groups; therefore, the postoperative recovery time was not extended. Finally, all patients were either very satisfied or satisfied with anesthesia. These results confirm that implementing an anesthetic strategy without muscle relaxation during thoracoscopic sympathectomy is safe.

In this study, in Group C, a low dose of fentanyl was administered to alleviate the intubation response during anesthesia induction, and remifentanil was used for analgesia during surgery. Owing to the minimal surgical trauma, no patient required additional analgesic after surgery. Conversely, the stress response from laryngeal mask intubation was relatively weaker than that caused by tracheal intubation. Thus, patients in Group T could tolerate the stimulation induced by the laryngeal mask well with the combination of propofol, dezocine, and DEX. Moreover, the intercostal nerve block provided excellent intraoperative analgesia. In this case, there was no need to issue a special red prescription in Group T. However, the anesthesia scheme in Group T was relatively complex and did not reduce the incidence of perioperative complications. Thus, the use of opioid-reduced anesthesia did not have significant advantages in this study.

This study had some limitations. Firstly, to improve patient comfort, all patients underwent peripheral venous puncture and catheterisation. Blood gas analysis samples were obtained from the venous indwelling needle during the perioperative period. For subjects with apparent anxiety before anesthesia, oxygen inhalation was initiated immediately after admission. This might have affected the blood gas index results. Secondly, this

was a single-centre, single-blind trial supported by our institution's 2-year funding cycle. After completing the preliminary preparation, subjects were recruited within 10 months. Multicentre, large-sample, and longer-term research is necessary to enhance the reliability and findings of this study.

In summary, during minimally invasive surgery, such as thoracoscopic sympathectomy, opioid-reduced anesthesia was found to be safe and effective; however, this method did not show clinical advantages.

Abbreviations

BE	Base excess
BG	Blood glucose
BIS	Bispectral index
BMI	Body mass index
DEX	Dexmedetomidine
ECG	Electrocardiogram
ERAS	Enhanced recovery after surgery
HCO_3^-	Hydrogen carbonate
HR	Heart rate
IQR	Interquartile range
MAP	Mean arterial pressure
NSAIDs	Non-steroidal anti-inflammatory drugs
PCO_2	Partial pressure of carbon dioxide
$P_{ET}CO_2$	End tidal carbon dioxide partial pressure
PI	Pain index
PO_2	Oxygen partial pressure
POCD	Postoperative cognitive dysfunction
SPO_2	Pulse oxygen saturation
VAS	Visual analogue scale

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

Liu Minqiang, Ma Mingfei, and Wu Qiang conceived and designed the study. Hong Fengzhu, Li Yang, Guo Shanshan, and Shi Qinlang collected data. Liu Minqiang and Hong Fengzhu performed statistical analyses. Liu Minqiang and Ma Mingfei drafted the manuscript. He Renliang, Li Zepeng, and Wu Qiang revised the manuscript. Li Zepeng and Wu Qiang assumed direct responsibility for the manuscript. All authors approved the final submission.

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Data availability

This study was recorded on ResMan Research Manager: http://www.medresman.org.cn/uc/projectsh/projectedit.aspx?proj=5899.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of Shenzhen Third People's Hospital (No. 29 Bulan Road, Longgang District, Shenzhen, Guangdong, China; approval number: 2022-025-02; date: 2012-3-24). Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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