doi.org/10.36721/PJPS.2025.38.4.REG.13370.1

Evaluation of the risk-benefit of thoracic paravertebral nerve block combined with propofol anesthesia and inhalation combined anesthesia for radical treatment in elderly lung cancer based on diaphragm functional parameters

Feng Han[1] and Xin-Xin Tian[2]*
[1]Anaesthesiology Department, Hangzhou Geriatric Hospital, Hangzhou City, China
[2]Department of Infectious Diseases, Hangzhou Ninth People's Hospital, Hangzhou City, China

Abstract: To evaluate the benefit-risk of thoracic complex propofol anesthesia for elderly lung cancer based on diaphragm function parameters. 137 elderly patients with lung cancer undergoing radical resection of thoracic surgery at Hangzhou First People's Hospital were selected. The patients were divided into: paravertebral complex propofol anesthesia (PPA, N = 68) group and static aspiration compound anesthesia (SGA, N. = 69) group. In the PPA group, the amount of remifentanil, postoperative sufentanl, 24h, anesthesia onset time, eye opening time, directional force recovery time, instruction time, IL-10, 6h, 12h, 48 h VAS score, active cough at 6h, 12h, 24 h, postoperative respiratory depression, upper airway obstruction, pulmonary complications were significantly lower than the SGA group (*P <0.05*), The diaphragm function parameters DTF, DD and diaphragm contraction velocity were significantly higher than those in the SGA group (*P> 0.05*); The benefit values of the PPA and SGA groups were 83, 47, Risk values were 17, respectively, 39, Benefit-total risk of 55, 36. The benefit-risk value was highest in PPA group. PPA anesthesia can not only effectively improve the effect of radical resection of elderly lung cancer on diaphragm function, but also has the characteristics of high anesthesia quality and few adverse reactions.

Keywords: Multi-criterion decision analysis; diaphragm function parameters; paravertebral nerve block-propofol intravenous balanced general anesthesia; sevoflurane inhalation balanced general anesthesia; benefit; risk

Submitted on 09-09-2024 – Revised on 19-11-2024– Accepted on 27-01-2025

INTRODUCTION

Lung cancer is one of the most prevalent malignancies worldwide, with high morbidity and mortality (Huang *et al*., 2021). While radical surgery is currently one of the primary approaches to treating lung cancer, elderly patients face a high risk of surgery and incidence of complications due to factors such as physiological decline and multiple combined chronic diseases (Huang *et al*., 2021; Warkentin *et al*., 2024). Anesthesia management plays an essential role in the surgical process of elderly patients with lung cancer, which not only contributes to the smooth operation but also directly affects the postoperative rehabilitation and long-term prognosis.

In recent years, the selection and optimization of anesthesia methods has become a hot topic in clinical research. Sevoflurane inhalation balanced general anesthesia (SGA) and paravertebral never block-propofol intravenous balanced general anesthesia (PPA) are two common anesthesia methods, in which SGA is widely used in various surgeries due to its stable anesthetic effect and ease of control (Mao *et al*., 2022). However, SGA may lead to residual neuromuscular blockade during the recovery from anesthesia, affecting postoperative recovery and thus increasing the risk of adverse events such as postoperative nausea, vomiting and pain (Wu *et al*., 2025). By contrast, PPA provides better postoperative analgesia by combining nerve block and intravenous anesthesia while reducing the incidence of postoperative complications due to less postoperative use of opioids (Chiu *et al*., 2024; Abdallah *et al*., 2024). However, it remains inconclusive whether anesthesia is associated with long-term prognosis in cancer patients and which anesthesia is more beneficial to patients (Choi and Hwang, 2024). In addition, diaphragmatic functional status has also gained increasing attention as an essential parameter for assessing postoperative respiratory function in patients with lung cancer. Moreover, diaphragmatic function impairment not only affects the patient's postoperative recovery but may also increase the risk of postoperative complications.

Therefore, this study is designed to systematically evaluate the benefits and risks of PPA and SGA in elderly patients undergoing radical resection of lung cancer using multi-criteria decision analysis based on diaphragmatic function parameters, thereby providing a more scientific reference for the selection of clinical anesthesia options. In this regard, the clinical problem to be solved in this study is whether PPA is superior to SGA in improving diaphragmatic function, reducing postoperative complications and improving the quality of postoperative rehabilitation in elderly patients undergoing radical resection of lung cancer. Through comparison and analysis of the benefits and risks of the 2 anesthesia approaches, this

**Corresponding author:* e-mail: tianxinxin2408@163.com

study is expected to provide theoretical support for elderly patients with lung cancer to select the optimal anesthesia strategy, thereby improving the postoperative prognosis of patients and reducing the incidence of postoperative complications.

MATERIALS AND METHODS

Study subjects

This is a single-center retrospective study, in which 137 elderly patients with lung cancer who underwent radical resection of lung cancer in the Department of Thoracic Surgery at Hangzhou First People's Hospital (a comprehensive tertiary hospital) from January 2021 to January 2022 were selected as the subjects and divided into the PPA group (n=68) and the SGA group (n=69) according to different anesthesia methods. Specifically, the PPA group included 34 males and 34 females, aged 55-73 years, with a mean age of (62.14±6.44) years, while The SGA group consisted of 34 males and 35 females, aged 55-71 years, with a mean age of (62.95±6.06) years. This study has been approved by the Ethics Committee of Hangzhou First People's Hospital (Approval No. [2021]KYYL No. 222-01).

Inclusion and exclusion criteria

Inclusion criteria

(1) Male or female patients aged 55-80 years; (2) Meet the diagnostic criteria for lung cancer (Chinese Medical Association Oncology Branch *et al*., 2022); (3) Treated with radical lung cancer surgery; (4) No contraindications to anesthesia, ASA grade I-II; (5) No radiotherapy or chemotherapy received before surgery; (6) Patients who voluntarily signed informed consent forms and agreed to participate in this study; (7) Patients with complete clinical data.

Exclusion criteria

(1) Patients who underwent chemoradiotherapy before surgery or were using hormonal and immunosuppressive drugs; (2) Patients who were allergic to the drugs used in this study and had contraindications; (3) Patients who were not suitable for thoracic paravertebral nerve block, e.g., back infection and spinal deformity; (4) Patients with combined severe arrhythmia, hypertension, various acute infections and drug addiction; (5) Pregnant and lactating women; (6) Patients who participated in other clinical studies within 3 months before surgery; (7) Patients who were difficult to complete follow-up or with various factors affecting compliance; (8) Patients who refused to sign informed consent forms.

Study methods

Data collection

The general data of patients, including age, gender, body mass index (BMI), blood loss, tumor stage and pathological types, were collected through the electronic medical record at the hospital.

Preoperative fasting was routinely performed for 8 h, along with drinking prohibited for 4 h. After the patient entered the operating room, routine monitoring of ECG, non-invasive blood pressure and pulse oxygen saturation was performed; a mask was provided for oxygen inhalation; peripheral vein and right internal jugular central vein were opened for infusion: and radial artery puncture and catheterization were performed under local anesthesia to monitor invasive ambulatory blood pressure and bispectral index. All anesthesia and surgical procedures were performed by the same group of physicians.

Anesthesia was induced with slow intravenous injections of propofol 2 mg/kg, midazolam 2 mg, cisatracurium besylate 0.15 mg/kg and sufentanil 0.4-0.6 μg/kg in both groups. Patients in the PPA group underwent thoracic paravertebral nerve block on the operated side 30 min preoperatively, with pump injection maintained using propofol and remifentanil after induction of anesthesia and the medication dosage was adjusted following the monitored bispectral index.

By contrast, patients in the SGA group received continuous intravenous pumping of propofol and remifentanil for sedation and analgesia while sevoflurane inhalation anesthesia was used intraoperatively, along with the dose of medication and the concentration of inhalation anesthetics adjusted following the monitored bispectral index.

Observation indicators

Consumption of analgesic drugs

The intra- and postoperative consumption of opioids was observed.

Postoperative analgesia

The VAS score and number of rescue analgesia at rest and active cough state postoperatively were observed.

Pain score: The degree of pain at rest and cough state at 6, 12, 24, 48 and 72h postoperatively were evaluated using the VAS score in the 2 groups. The score ranges from 0-10 points, 0 points = painless and 10 points = severe pain, with higher scores indicating more severe pain (Wan *et al*., 2020).

Incidence of adverse reactions

Adverse reactions included sinus bradycardia, hypotension, pruritus, postoperative respiratory depression, hypoxemia, upper respiratory tract obstruction, nausea, vomiting, urinary retention, pulmonary complications, etc.

Diaphragmatic function parameters

Diaphragm Thickening Fraction (DTF)

The patient took the supine position, with a linear array probe (thyroid mode) placed between the 8 to 10 intercostal spaces and the right anterior axillary line. Then the patient was instructed to breathe normally, with the respiratory status monitored to freeze the clear images of the diaphragm at the end of expiration and the end of inspiration, respectively. After each measurement, the patient was instructed to rest for 1 min, with a total of 3 measurements performed followed by taking the mean value. Afterward, DTF was calculated using the formula: DTF (%) = (end-inspiratory diaphragm thickness - end-expiratory diaphragm thickness)/ end-expiratory diaphragm thickness ×100%. Normal value: > 20% in normal subjects.

Degree of diaphragm (DD) and diaphragmatic contraction velocity (DCV)

The patient took the supine position, with the cardiac probe S5-1 (3.5HZ) placed at the junction of the anterior axillary line and the lower edge of the costal arch while using the liver as the acoustic window, followed by showing the diaphragmatic movement amplitude using the M-mode ultrasound. Meanwhile, the diaphragm amplitude at the end of inspiration and the end of expiration was measured and recorded, respectively. DD was calculated using the formula: DD (mm) = end-inspiratory diaphragmatic movement amplitude - end-expiratory diaphragmatic movement amplitude, along with the calculation of the corresponding DVC using the formula: DCV (mm/s) = DD (mm)/inspiration time (s).

STATISTICAL ANALYSIS

First, the Shapiro-Wilk test was performed to detect the normality of measurement data. Data following normal distribution were expressed as mean ± standard deviation (x±s) and independent two-sample t-tests were utilized for inter-group comparisons. Data not following normal distribution were expressed as medians and interquartile ranges (IQR), with inter-group comparisons performed using the Mann-Whitney U test. In the meantime, count data were expressed as number of cases and rate (%) and the χ^2 test was utilized for inter-group comparisons. All statistical tests were performed using two-sided tests and $P<0.05$ was considered statistically significant.

Additionally, Hiview 3 software was utilized to establish the decision tree, with the swing weighting applied to assign weight to each index. RevMan 5.3 software was used to pool the benefit and risk values of patients in the PPA and SGA groups. The benefit, risk and benefit-risk values of each outcome indicator were calculated by Hiview 3 software. Monte Carlo simulation was run by Crystal Ball 4.0 software, with the obtained benefit, risk and benefit-risk values used as output variables, respectively and 30,000 iterations were performed to read the 95% CI and the probability of differences in benefit-risk values between different groups, so as to optimize the evaluation results of the multi-criterion decision model. If changes to benefit or risk index weight were > 20%, which led to different evaluation results, it was considered that the evaluation results were relatively stable and the model was not significantly affected by the index weight. Test level $\alpha = 0.05$.

RESULTS

Comparison of general data between the 2 groups

No significant differences were observed in age, gender, BMI, operation time, blood loss, pathological stage, cancer type, VAS scores at 24 and 72 h at rest state, VAS scores at 48 and 72 h at active cough state, anesthesia time, IL-6 levels, sinus bradycardia, hypotension, itching, hypoxemia, nausea, vomiting and urinary retention between the 2 groups ($P>0.05$). Meanwhile, the intraoperative remifentanil dosage, postoperative sufentanil dosage, number of rescues at 24 h postoperatively, time to onset of anesthesia, time to eye-opening, time to recovery of orientation, time to follow instructions, IL-10 levels, VAS score at 2, 8 and 48 h at rest state, VAS scores at 2, 8 and 24 h at active cough state, postoperative respiratory depression, upper respiratory tract obstruction and pulmonary complications in the PPA groups were significantly lower than the levels of those in the SGA group ($P<0.05$). However, the diaphragmatic function parameters of DTF, DD and DCV were significantly higher in the PPA groups than in the SGA group ($P<0.05$). See table 1.

Establishment of decision tree for risk-benefit evaluation indicators of ppa and sga for elderly patients undergoing radical resection of lung cancer

Hiview 3 software was used to establish a decision tree for benefit-risk indicators of PPA versus SGA for radical resection of lung cancer in elderly patients, as shown in fig.1. The swing weighting was applied to assign weights to the risk and benefit indicators, in which a weight of 100 was assigned to the indicators of DTF, DD and DCV that significantly affected elderly patients undergoing radical resection of lung cancer in the benefit indicators, with the respective weights to other benefit indicators obtained through comparison with them. Meanwhile, a weight of 100 was assigned to the risk indicators of postoperative respiratory depression, pulmonary complications and upper respiratory tract obstruction and the respective weights to other risk indicators were obtained following comparison with them. Additionally, the preference values for each indicator were converted using the fixed scale method, with the results converted into scores of 0-100 to determine the optimal and worst values, as shown in table 2.

Pooling of benefit and risk indicators between the ppa and sga groups

The benefits and risk indicators and 95% CIs of the PPA and SGA groups were pooled using RevMan 5.3 software, as shown in table 3. Meanwhile, patients in both PPA and SGA groups showed significant effects in relieving postoperative pain, with better effects in the PPA group than in the SGA group (P < 0.05). Moreover, the adverse reactions in the PPA group were significantly lower than those of the SGA group, with statistically significant differences (P<0.05).

Benefit values for elderly patients undergoing radical resection of lung cancer between the pa and sga groups

The benefit values for the PPA and SGA groups were 83 and 47, respectively, with a significant difference value of 36 in the benefit of elderly patients undergoing radical resection of lung cancer between the 2 groups. Additionally, the anesthesia method for the PPA group significantly reduced the effect of radical resection of lung cancer in elderly patients on the diaphragmatic motor function, with the Monte Carlo simulation showing a 100% probability of difference between the 2 groups. See table 4.

Risk values for radical resection of lung cancer in elderly patients between the ppa and sga groups

The risk values for the PPA and SGA groups were 17 and 39, respectively, with a significant difference of 22 in the risk of radical resection of lung cancer in elderly patients between the 2 groups. At the same time, the Monte Carlo simulation indicated a higher probability of adverse reactions to anesthesia in the SGA group than in the PPA group (53.12% vs 19.47%) (P<0.05), as shown in table 5.

Overall benefit and risk values

The benefit-risk values for the PPA and SGA groups were pooled as 55 and 36, respectively. Specifically, the total benefit-risk value of the PPA group was 19 (95% CI: 14.21-24.78) higher than that of the SGA group, while the PPA group showed a 100% probability of total benefit-risk, higher than the SGA group, as shown in fig.2,3.

Sensitivity analysis of benefit-risk evaluation of radical resection of lung cancer in elderly patients between the ppa and sga groups

At the relative weight of the current risk (50%), the total benefit-risk value of the anesthesia method in the PPA group was higher than that in the SGA group and the evaluation results of sensitivity remained unchanged regardless of changing the relative weight of the risk, indicating stable results of this model. See fig.4.

DISCUSSION

Surgical resection is the primary therapy for lung cancer and perioperative anesthesia and analgesia management are closely related to the postoperative recovery of lung cancer, even influencing the rates of recurrence, metastasis and overall survival (Chen *et al*., 2022). It has been shown that patients using SGA may experience residual neuromuscular blockade during the recovery from anesthesia, which may impact the postoperative recovery and complicate their awakening from anesthesia. Additionally, patients may experience adverse respiratory events during this process, affecting their prognosis (Pardo *et al*., 2022; Carcamo-Cavazos and Cannesson, 2022). Studies have demonstrated that PPA is characterized by excellent analgesic effects, fewer adverse reactions and improved postoperative respiratory dysfunction. Therefore, the effect of PPA on elderly patients undergoing radical resection of lung cancer was investigated in this study based on diaphragmatic function parameters, which found that PPA can mitigate the adverse effects of radical resection of lung cancer on diaphragmatic function in elderly patients, positively influencing their prognosis. Moreover, PPA could reduce the consumption of opioids and general anesthetics during cancer surgery, alleviate acute postoperative pain, improve postoperative immunosuppressive states and tumor microenvironments and enhance antitumor potential, thus facilitating rapid postoperative recovery (Garg *et al*., 2022; Chae *et al*., 2022). Furthermore, the findings of this study also indicated that the intraoperative remifentanil dosage, postoperative sufentanil dosage, number of rescue doses at 24 h postoperatively, time to onset of anesthesia, time to eye-opening, time to recovery of orientation, time to follow instructions, IL-10 levels, VAS scores at 6, 12 and 48 h at rest state, VAS scores at 6, 12 and 24 h at active cough state, postoperative respiratory depression, upper respiratory tract obstruction and pulmonary complications in the PPA group were all significantly lower than the levels of those in the SGA group, indicating that PPA exhibits better analgesic effects with fewer adverse reactions.

Local anesthetics of PPA act near the spinal nerves exiting the thoracic intervertebral foramen, blocking motor, sensory and sympathetic nerves on that side, which effectively blocks the transmission of peripheral nociceptive signals due to surgical trauma and pain to the central nervous system, resulting in a series of physiological effects such as analgesia and anti-inflammation, thereby protecting lung function under pathological conditions (Liu *et al*., 2022; Wei and Chen, 2022). The diaphragm is a critical respiratory muscle in the human body, with human respiratory pump power primarily derived from systolic muscle strength, diastolic muscle strength and movement amplitude of the diaphragm and the movement of the diaphragm effectively reflects a person's respiratory function (Zhen *et al*., 2022; Lei 2022). When problems occur in the diaphragm, patients may experience compromised ventilation function and respiratory distress, posing threats to their lives (Elmunzer *et al*., 2021; Zhan *et al*., 2021). In this regard, the diaphragmatic function is crucial for the respiration of patients. Additionally, the findings of this study indicated that the diaphragmatic function parameters of DTF, DD and DCV in the PPA group were significantly higher than those in the SGA group, suggesting a significantly better diaphragmatic function in the PPA group than in the SGA group. This improvement may be due to the better analgesic effects and fewer adverse reactions in the PPA group, which better protects the patient's respiratory function, enhancing diaphragm contraction and movement.

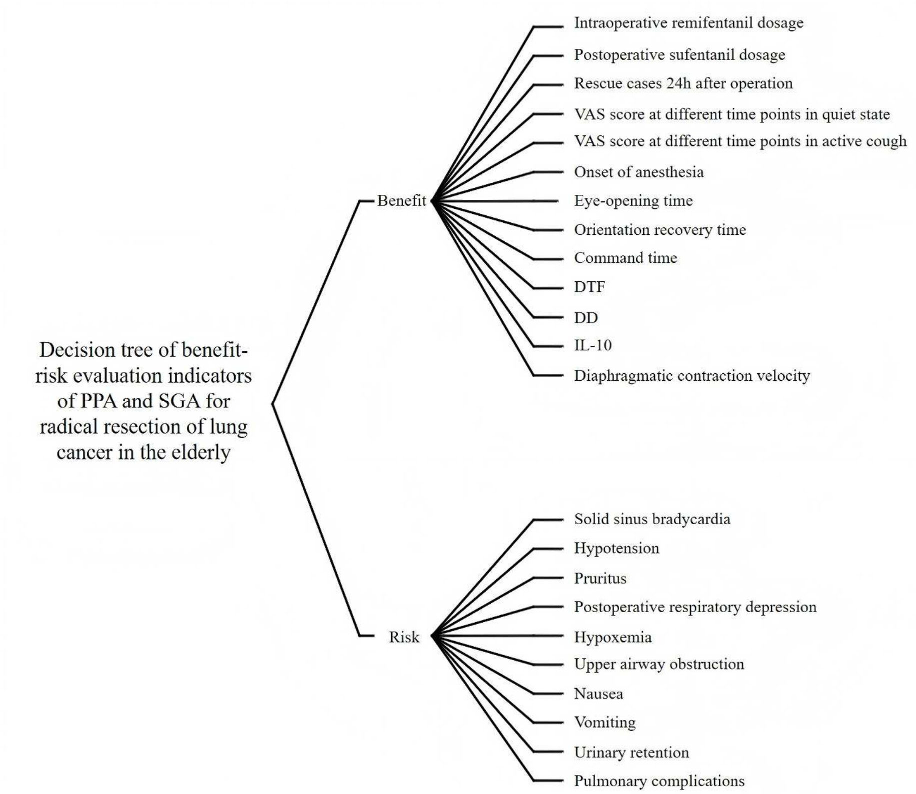

Fig. 1: Decision tree of benefit-risk evaluation indicators of PPA and SGA for radical resection of lung cancer in elderly patients

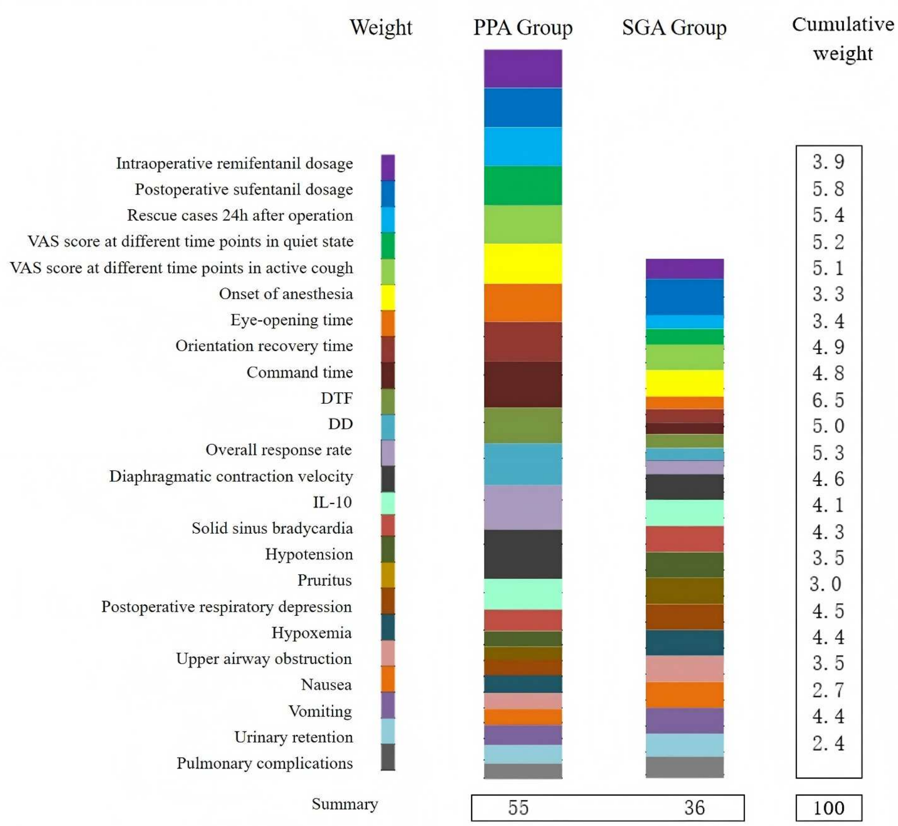

Fig. 2: Benefit-risk values of radical resection of lung cancer in elderly patients between the PPA and SGA groups

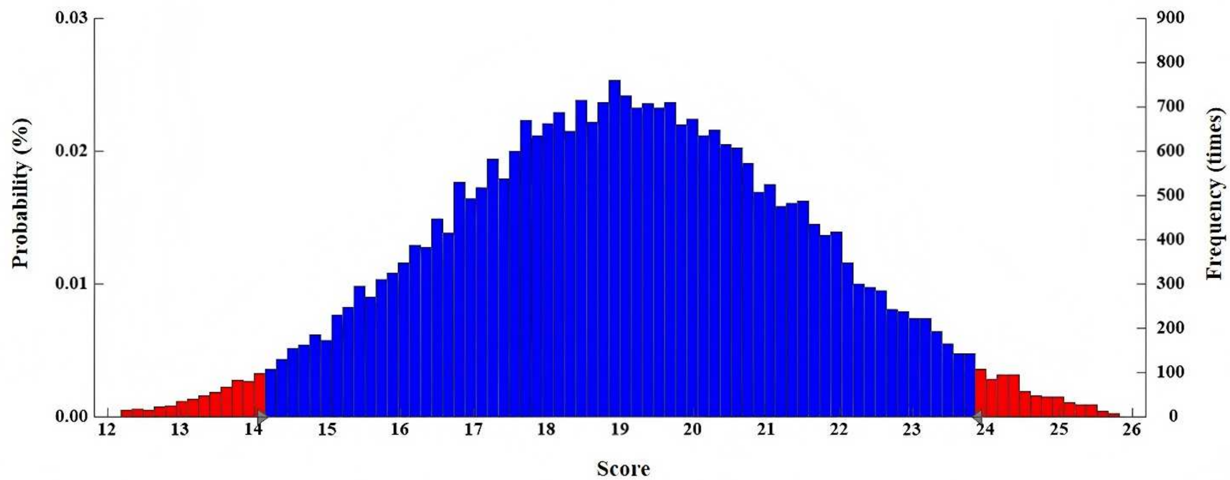

Fig. 3: Simulation of benefit-risk differences for radical resection of lung cancer in elderly patients between the PPA and SGA groups

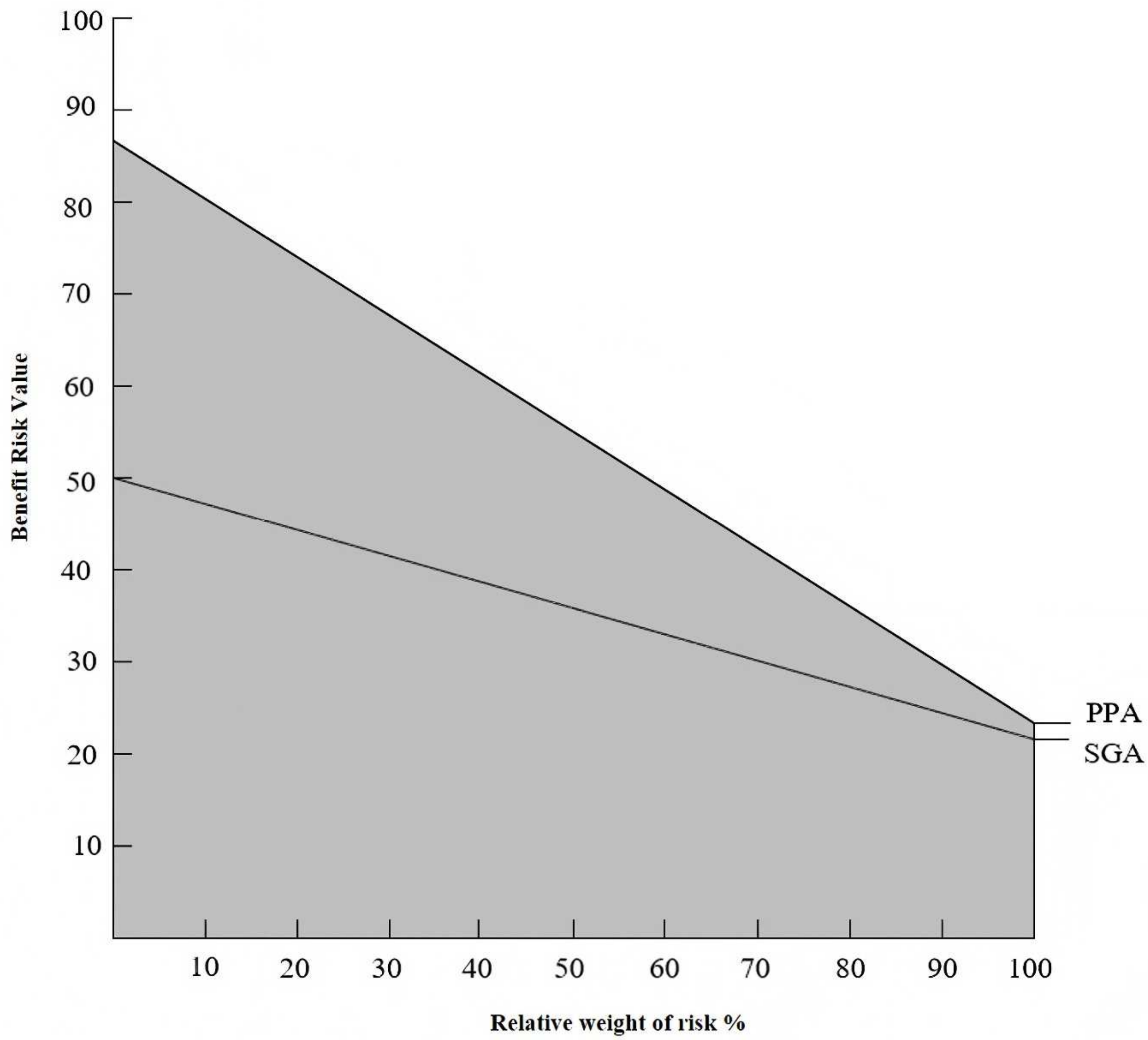

Fig. 4: Sensitivity analysis of benefit-risk of radical resection of lung cancer in elderly patients between the PPA and SGA groups

Table 1: Analysis of general data of patients in PPA group and SGA group

Item	PPA Group(n=68)	SGA Group(n=69)	χ^2/t	*P*
Age(year)	62.14±6.44	62.95±6.06	0.758	0.450
Gender [n(%)]			0.007	0.932
Male	34(50.00)	34(49.28)		
Female	34(50.00)	35(50.72)		
BMI(kg/m2)	22.15±2.24	22.31±2.16	0.426	0.671
Operative time (min)	147.24±37.12	146.98±37.21	0.041	0.967
Bleeding volume (ml)	142.45±40.65	141.35±41.21	0.157	0.875
Pathological stage			0.065	0.799
I	34(50.00)	36(52.17)		
II	18(26.47)	19(27.54)		
III	16(23.53)	14(20.29)		
Cancer type			0.189	0.664
Adenocarcinoma/	48(70.59)	51(73.91)		
Squamous cell carcinoma	20(29.41)	18(26.09)		
Intraoperative remifentanil dosage (mg)	0.98±0.25	1.50±0.40	9.109	＜0.001
Postoperative sufentanil dose (μg)	49.28±1.26	58.80±5.69	13.474	
Rescue cases 24h after operation	5(7.35)	15(21.74)	5.685	0.017
VAS score at different time points in quiet state				
2h	0.68±0.74	1.64±0.85	7.046	＜0.001
8h	1.14±0.73	2.38±1.01	8.226	＜0.001
24h	1.20±0.88	2.00±0.93	1.428	0.156
48h	1.04±0.99	1.36±0.69	2.198	0.030
72h	0.84±0.84	1.06±0.65	1.716	0.088
VAS score at different time points in active cough				
2h	2.02±1.36	4.12±1.12	9.872	＜0.001
8h	2.82±1.14	4.60±1.21	8.860	＜0.001
24h	2.94±1.24	3.88±1.21	4.491	＜0.001
48h	2.64±1.10	3.00±1.14	1.881	0.062
72h	2.38±1.21	2.74±0.92	1.962	0.052
Adverse Reactions Comparison				
Sinus bradycardia	3(4.41)	2(2.90)	0.223	0.637
Hypotension	1(1.47)	2(2.90)	0.326	0.568
Pruritus	3(4.41)	2(2.90)	0.223	0.637
Postoperative respiratory depression	2(2.94)	9(13.040)	4.733	0.030
Hypoxemia	1(1.47)	2(2.90)	0.193	0.661
Upper airway obstruction	2(2.94)	11(15.94)	6.740	0.009
Nausea	1(1.47)	1(1.45)	0.000	0.992
Vomiting	1(1.47)	2(2.90)	0.326	0.568
Urinary retention	1(1.47)	2(2.90)	0.326	0.568
Pulmonary complications	3(4.41)	12(17.39)	5.918	0.015
Quality of anesthesia comparison				
Anesthesia time	29.31±7.54	34.55±8.11	0.758	0.450
Onset of anesthesia	1.96±0.38	4.21±1.21	14.638	＜0.001
Eye-opening time	9.51±2.33	17.15±4.59	12.257	＜0.001
Orientation recovery time	28.98±5.69	35.72±6.12	6.674	＜0.001
Command time	30.84±.17	37.72±6.49	8.732	＜0.001
Diaphragmatic function parameters				
DTF (%)	32.89±10.47	22.62±8.76	6.222	
DD(mm)	21.36±8.42	17.54±7.07	2.874	0.005
Diaphragmatic contraction velocity (mm/s)	13.96±7.89	9.65±8.20	3.135	0.002
Inflammatory index 6 hours after operation				
IL-6(pg/L)	46.53±9.45	53.43±13.27	1.428	0.156
IL-10(pg/L)	18.16±4.87	25.93±5.48	4.058	

Table 2: Weight, optimal value and worst value of PPA and SGA for radical benefit and risk indicators of elderly patients with lung cancer

Category	Indicators	Weight	Optimal value	Worst value
Benefit Indicators	Intraoperative remifentanil dosage	73	-25	0
	Postoperative sufentanil dosage	80	-25	0
	Rescue cases 24h after operation	82	-25	0
	VAS score at different time points in quiet state	81	-25	0
	VAS score at different time points in active cough	82	-25	0
	Onset of anesthesia	61	-15	0
	Eye-opening time	63	-15	0
	Orientation recovery time	81	-25	0
	Command time	64	-15	0
	DTF	100	-30	0
	DD	100	-30	0
	Diaphragmatic contraction velocity	100	-30	0
	IL-10	62	-15	0
Risk Indicators	Sinus bradycardia	85	0	1
	Hypotension	84	0	1
	Pruritus	67	0	1
	Postoperative respiratory depression	100	0	1
	Hypoxemia	85	0	1
	Upper airway obstruction	100	0	1
	Nausea	64	0	1
	Vomiting	67	0	1
	Urinary retention	66	0	1
	Pulmonary complications	100	0	1

By contrast, the SGA group exhibited a decreased DTF and a slower DCV, leading to impaired diaphragmatic function and poor prognosis of the patients (Liang *et al*., 2022; Gupta *et al*., 2022). Moreover, the multi-criteria model revealed that the anesthesia methods in both PPA and SGA groups significantly relieved postoperative pain in patients and the benefit and risk values of the former were significantly higher and lower than those in the latter, respectively, with the anesthesia method in the former significantly reducing the effect of radical resection of lung cancer on diaphragmatic motor function in elderly patients. Furthermore, the Monte Carlo simulation indicated a 100% probability of difference between the 2 groups. The improved diaphragm function observed in the PPA group has several important implications. First, better diaphragm function is associated with enhanced respiratory efficiency, which can improve oxygenation and reduce postoperative hypoxemia. This is particularly beneficial in elderly patients who may already have compromised respiratory function due to age-related changes and underlying comorbidities. Second, optimal diaphragm function can promote more effective coughing and clearance of respiratory secretions, reducing the risk of postoperative pulmonary complications such as pneumonia. Third, a well-functioning diaphragm can promote better overall postoperative comfort and mobility, enabling patients to engage in early mobilization and rehabilitation activities, which are critical to reducing the risk of deep vein thrombosis and promoting overall recovery.

In the study, several major adverse effects closely related to radical resection of lung cancer, particularly in elderly patients, were identified. These adverse effects include sinus bradycardia, hypotension, pruritus, postoperative respiratory depression, hypoxemia, upper airway obstruction, nausea, vomiting, urinary retention and pulmonary complications. These adverse reactions can seriously impact the patient's postoperative recovery and long-term prognosis. To minimize the risk of these adverse reactions, a multifaceted approach was adopted. The anesthetic method was carefully selected, comparing PPA with SGA. Results showed that PPA was associated with a significantly lower incidence of postoperative respiratory depression, upper airway obstruction and pulmonary complications compared with SGA. This suggests that the choice of anesthetic method plays a crucial role in reducing the risk of adverse reactions. In addition to the choice of anesthesia, the perioperative management of patients was optimized. This included preoperative evaluation and preparation, intraoperative monitoring and intervention and postoperative care and follow-up. A thorough preoperative evaluation was conducted to identify any potential risk factors for adverse reactions. During surgery, the patient's vital signs were closely monitored and anesthesia and surgical procedures were adjusted accordingly to minimize stress and trauma. In the postoperative period, timely and effective pain management, respiratory support and other necessary interventions were provided to promote recovery and reduce complications.

Table 3: Combined benefit and risk indicators between PPA group and SGA group

Indicators		PPA Combined Results	SGA Combined Results
Benefit Indicators	Intraoperative remifentanil dosage	-0.97(-0.57,1.12) *P*=0.002	-1.63(-2.02,-1.41) *P*=0.058
	Postoperative sufentanil dosage	-11.23(-15.02,-10.41) *P*=0.045	-20.23(-24.02,-15.41) *P*=0.075
	Rescue cases 24h after operation	-31.23(-41.02,-22.41) *P*=0.004	-23.45(-35.01,-18.24) *P*=0.085
	VAS score at different time points in quiet state	-5.26(-7.02,-3.21) *P*=0.005	-9.24(-11.22,-8.77) *P*=0.012
	VAS score at different time points in active cough	-10.46(-13.62,-7.58) *P*=0.024	-6.22(-11.43,-4.61) *P*=0.012
	Onset of anesthesia	-40.23(-50.24,-30.78) *P*=0.033	-22.36(-32.65,-18.79) *P*=0.098
	Eye-opening time	-1.63(-4.56,0.25) *P*=0.031	-7.26(-10.44,-5.78) *P*=0.089
	Orientation recovery time	-1.86(-3.67,-0.12) *P*=0.054	-3.45(-7.25,-0.14) *P*=0.054
	Command time	-6.78(-9.57,-2.04) *P*=0.054	-5.21(-6.14,-0.12) *P*=0.054
	DTF	5.68(1.57,9.45) *P*=0.014	3.45(1.14,7.65) *P*=0.054
	DD	8.67(1.28,9.47) *P*=0.014	7.51(1.45,10.23) *P*=0.054
	Diaphragmatic contraction velocity	10.56(0.28,14.56) *P*=0.014	3.65(0.47,9.45) *P*=0.054
	IL-10	-6.25(-15.36,-3.24) *P*=0.054	-7.25(-14.25,-5.28) *P*=0.054
	Overall response rate	6.27(3.64,15.76) *P*=0.014	3.25(14.25,1.58) *P*=0.054
Risk Indicators	Sinus bradycardia	0.88(0.46,1.36) *P*=0.054	0.79(0.35,0.98) *P*=0.062
	Hypotension	0.56(0.25,1.76) *P*=0.075	1.23(0.86,2.21) *P*=0.132
	Pruritus	0.14(0.05,2.86) *P*=0.142	0.68(0.44,1.85) *P*=0.102
	Postoperative respiratory depression	12.03(3.78,20.15) *P*=0.018	3.57(1.22,7.68) *P*=0.112
	Hypoxemia	1.12(0.78,3.45) *P*=0.077	1.52(1.04,3.55) *P*=0.065
	Upper airway obstruction	1.23(1.02,1.41) *P*=0.002	1.32(1.12,1.56) *P*=0.071
	Nausea	2.67(0.25,5.68) *P=0.004*	1.25(0.47,6.98) *P=0.891*
	Vomiting	3.56(0.47,6.57) *P=0.014*	2.14(0.78,4.52) *P=0.147*
	Urinary retention	2.41(1.27,8.32) *P=0.024*	5.69(2.65,14.32) *P=0.235*
	Pulmonary complications	2.78(0.41,5.74) *P=0.014*	4.17(0.12,17.36) *P=0.354*

Furthermore, the importance of multidisciplinary collaboration in the management of patients undergoing radical resection was emphasized. This involved close cooperation between surgeons, anesthesiologists, nurses and other medical professionals to ensure that each patient received comprehensive and personalized care. By working together, potential problems could be identified and addressed as early as possible, thereby reducing the risk of adverse reactions.

However, this study also has some limitations that need to be acknowledged. The small sample size included may lead to biased results and the findings may not be generalized to a wider population. In addition, this is a single-center study and lacks multicenter data support. This may limit the external validity of the results. In the future, larger, multicenter studies should be conducted to include more diverse patient populations to further verify the advantages and potential clinical application value of PPA in radical resection of elderly lung cancer.

Table 4: Benefit value of radical resection of lung cancer for patients in PPA group and SGA group

Benefit Indicators	Weight	PPA Group	SGA group	Relative Weight
Benefit Indicators	80	85	65	3.9
Intraoperative remifentanil dosage	80	80	50	5.8
Postoperative sufentanil dosage	80	85	55	5.4
Rescue cases 24h after operation	80	87	62	5.2
VAS score at different time points in quiet state	80	88	60	5.1
VAS score at different time points in active cough	60	65	32	3.3
Onset of anesthesia	60	49	32	3.4
Eye-opening time	80	86	80	4.9
Orientation recovery time	60	65	55	4.8
Command time	100	78	74	6.5
DTF	100	76	76	5.0
DD	100	69	64	5.3
Diaphragmatic contraction velocity	60	58	55	4.6
IL-10	80	85	65	3.9

Table 5: Risk Values of Heart Failure with Iron Deficiency in Treated Patients in PPA and SGA Groups

Benefit Indicators	Weight	PPA Group	SGA group	Relative Weight
Sinus bradycardia	80	20	21	4.1
Hypotension	80	18	15	4.3
Pruritus	60	20	18	3.5
Postoperative respiratory depression	100	38	35	3.0
Hypoxemia	100	36	38	4.5
Upper airway obstruction	80	25	24	4.4
Nausea	60	32	38	3.5
Vomiting	60	41	55	2.7
Urinary retention	60	20	25	4.4
Pulmonary complications	100	17	32	2.4

In addition, this study did not include long-term follow-up data, which would be valuable for evaluating the effects of different anesthetic methods on long-term patient outcomes, such as recurrence rate and overall survival. Future studies should include long-term follow-up to provide a more comprehensive understanding of the benefits and risks of the anesthetic methods used in this patient population.

CONCLUSION

In conclusion, the benefits and risks of PPA for radical resection of lung cancer in elderly patients were investigated in this study using a multi-criterion decision analysis model and the findings suggested higher benefit values and lower risk values for PPA, which could also improve the adverse effects of radical resection of lung cancer in elderly patients on diaphragmatic function, thereby providing a reference for the clinical selection of reasonable anesthesia.

Ethical approval

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Hangzhou Ninth People's Hospital (Approval No. [2021]KYYL No. 222-01).

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships.

Funding

Hangzhou Medical and Health Science and Technology Project (General Project) No.: A20220667.

REFERENCES

Abdallah BM, Elshoeibi AM, ElTantawi N, Arif M, Hourani RF, Akomolafe AF, Hamwi MN, Mahmood FR, Saracoglu KT, Saracoglu A and Chivese T (2024). Comparison of postoperative pain in children after maintenance anaesthesia with propofol or sevoflurane: A systematic review and meta-analysis. *Br. J. Anaesth.*, **133**(1): 93-102.

Carcamo-Cavazos V and Cannesson M (2022). Opioid-free anesthesia: *The Pros. and Cons. Adv. Anesth.*, **40**(1): 149-166.

Chae D, Kim HC, Song Y, Choi YS and Han DW (2022). Pharmacodynamic analysis of intravenous bolus remimazolam for loss of consciousness in patients undergoing general anaesthesia: A randomised, prospective, double-blind study. *Br. J. Anaesth*., **129**(1): 49-57.

Chen P, Liu Y, Wen Y and Zhou C (2022). Non-small cell lung cancer in China. *Cancer Commun (Lond)*. **42**(10): 937-970.

Chinese Medical Association Oncology Branch, Chinese Medical Association Journal (2022). Chinese Medical Association Guidelines for Clinical Diagnosis and Treatment of Lung Cancer. *Chin. Med. J.,* **102**(23): 35.

Chiu WC, Wu ZF, Lee MS, Chen JY, Huang YH, Tseng WC and Lai HC (2024). Propofol-based total intravenous anesthesia is associated with less postoperative recurrence than desflurane anesthesia in thyroid cancer surgery. *PLoS One*. **5**:19(1): e0296169.

Choi H and Hwang W (2024). Anesthetic approaches and their impact on cancer recurrence and metastasis: A comprehensive review. *Cancers (Basel)*. **22**:16(24): 4269.

Elmunzer BJ, Lewis BR, Miller KF, Wolf BJ, Zeiler L, Gutman DA, Elias P, Tansel A, Moran RA and Bolin ED (2021). Paravertebral anesthetic nerve block for pain control after peroral endoscopic myotomy. *Tech. Innov. Gastrointest. Endosc*., **23**(4): 297-303.

Garg B, Ahuja K and Sharan AD (2022). Regional anesthesia for spine surgery. *J. Am. Acad. Orthop. Surg*., **1**:30(17): 809-819.

Gupta VS, Wilson C, Popp EC, Zhaorigetu S, Collum S, Jin D, Khan AM, Karmouty-Quintana H, Lally KP and Harting MT (2022). Neonatal rodent ventilation and clinical correlation in congenital diaphragmatic hernia. *Pediatr. Pulmonol*., **57**(7): 1600-1607.

Huang J, Tian Y, Zhou QJ, Ning JW, Gu ZN, Lu PJ, Li JT, Lin H, Chen TX, Yang YH, Kim MP, Merritt RE, Ghisalberti M, Jiang L and Luo QQ (2021). Comparison of perioperative outcomes of robotic-assisted versus video-assisted thoracoscopic right upper lobectomy in non-small cell lung cancer. *Transl. Lung Cancer Res*., **10**(12): 4549-4557.

Lei F (2022). Analysis of the effect of parathoracic nerve block and compound propofol anesthesia on the perioperative period of elderly thoracotomy. *J. Adv. Med. Sci.,* **5**(1): 42-45.

Liang Z, Jin X, Ren Y, Yu T and Li X (2022). Propofol anesthesia decreased the efficiency of long-range cortical interaction in humans. *IEEE Trans. Biomed. Eng*., **69**(1): 165-175.

Liu X, Sun T and Zhang H (2022). Effect of preoperative induced lung volume meter training on lung function recovery and pulmonary complications after radical lung cancer surgery. *J. Postgrad. Med.,* **35**(11): 1171-1175.

Mao H, Zhu J, Cheng Y, Shi L, Chen X, Zhou R, Xue Z, Liu S, Qiu Z and Jiang H (2022). Effects of sevoflurane anesthesia on cerebral lipid metabolism in the aged brain of marmosets and mice. *Front Mol. Neurosci*., **6**(15): 915570.

Pardo E, Camus M, Verdonk F. Anesthesia for digestive tract endoscopy (2022). *Curr. Opin. Anaesthesiol*., **1**:35(4): 528-535.

Wan L, Zhao Q, Chen J, *et al* (2020). Chinese expert consensus on the application of pain assessment scales (2020 edition). *Chin J Pain.,* **16**(3): 11.

Warkentin MT, Tammemägi MC, Vakil E, Bedard ELR, Cheung WY, Brenner DR and Tremblay A (2024). Brief report: Evaluating early-stage lung cancer survival patterns in patients at the upper age limit for lung cancer screening. *J. Thorac. Oncol*., **30**: S1556-0864(24)02546-2.

Wei HF and Chen YX (2022). Impact of ultrasound-guided thoracic paravertebral nerve block on postoperative infection in lung cancer patients undergoing radical surgery. *Chin J Nosocomiol.,* **32**(9): 1337-1341.

Wu H, Wang S, Dai FB and Tang CL (2025). Research progress in the clinical application of inhaled anesthetic sevoflurane. *Med. Gas Res*., **1**:15(1): 85-92.

Zhan L, Zhang YJ and Wang JX (2021). Combined fascia iliaca compartment block and monitored anesthesia care for geriatric patients with hip fracture: Two case reports. *World J. Clin. Cases*, **26**:9(27): 8268-8273.

Zhen SQ, Jin M, Chen YX, Li JH, Wang H and Chen HX (2022). Ultrasound-guided paravertebral nerve block anesthesia on the stress response and hemodynamics among lung cancer patients. *World J. Clin. Cases*, **6**:10(7): 2174-2183.