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Effects of serratus anterior plane block and thoracic paravertebral nerve block on analgesia, immune function and serum tumor markers in patients after thoracoscopic radical resection of lung cancer

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ABSTRACT

We aimed to assess the effects of serratus anterior plane block (SAPB) and thoracic paravertebral nerve block (TPVB) on analgesia, immune function and serum tumor markers in patients after thoracoscopic radical resection of lung cancer. A total of 132 patients enrolled from February 2019 to November 2020 were prospectively selected and randomly divided into 3 groups (n=44). Control group received general anesthesia. After induction of general anesthesia, TPVB or SAPB group was given TPVB or SAPB. Their clinical data, operation conditions, Visual Analogue Scale (VAS) score, immune function, serum tumor markers and adverse reactions were compared. TPVB and SAPB groups had lower dosage of sufentanil during operation, later time of first pressing patient-controlled intravenous analgesia (PCA) pump after operation and smaller number of pressing PCA pump within 48 h after operation than those of control group ($P<0.05$). VAS scores at rest and coughing decreased 6 and 12 h after operation in TPVB and SAPB groups compared with that in control group ($P<0.05$). Cluster of differentiation 3 $(CD3)^+$, $CD4^+$ and $CD4^+/CD8^+$ ratio were higher, while $CD8^+$ was lower 24 and 48 h after operation in TPVB and SAPB groups than those of control group ($P<0.05$). TPVB and SAPB groups had lower serum tumor marker levels 24 h after operation than those of control group ($P<0.05$). The three groups had similar incidence rates of adverse reactions ($P>0.05$). SAPB and TPVB can markedly improve postoperative analgesic effect, enhance immune function and decrease serum tumor marker levels in patients receiving thoracoscopic radical resection of lung cancer, without increasing adverse reactions. However, TPVB may puncture the pleura.

Keywords: serratus anterior plane block, thoracoscopic radical resection, lung cancer, immune function, serum tumor marker

Abbreviations:
BMI: body mass index
CA125: carbohydrate antigen 125
CD3: cluster of differentiation 3
CEA: carcinoembryonic antigen
CYFRA21-1: cytokeratin 19 fragment 21-1
NSE: neuron-specific enolase
PCA: patient-controlled intravenous analgesia

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SAPB: serratus anterior plane block
TPVB: thoracic paravertebral nerve block
VAS: Visual Analogue Scale

INTRODUCTION

As the first choice for treatment of lung cancer, thoracoscopic radical resection of lung cancer can not only precisely excise the lesion site, but also cause a small trauma and benefit recovery.[1] Through continuous deepening of clinical research, it has been discovered that thoracoscopic radical resection of lung cancer still results in long-term pain, causes an impact on coughing and expectoration of patients and even leads to complications such as pulmonary infection, thus delaying postoperative recovery.[2] Currently, many analgesic methods after thoracoscopic surgery have certain disadvantages. Ultrasound-guided serratus anterior plane block (SAPB) is a new technology developed in recent years, which is proposed by Blanco et al inspired by transabdominal fascia block, and it has been widely applied to perioperative anesthesia and analgesia of shoulder and rib fracture surgery, thoracotomy and breast cancer operation. Moreover, a number of reports have denoted that this technology has favorable analgesic effect on anterolateral chest wall, and it is characterized by safety, rapid onset and few complications.[3,4] At present, the effect of SAPB on analgesia following thoracoscopic radical resection of lung cancer has been reported, but there are few studies on the influences of SAPB on immune function and serum tumor markers. In this study, therefore, ultrasound-guided thoracic paravertebral nerve block (TPVB) was compared with SAPB to explore the impacts of SAPB on the analgesic effect, immune function and serum tumor markers after thoracoscopic radical resection of lung cancer, aiming to enrich the theoretical basis of clinical research on analgesia after such an operation.

MATERIALS AND METHODS

Subjects

A total of 132 patients undergoing uniportal thoracoscopic surgery of lung cancer in our hospital from February 2019 to November 2020 were prospectively selected and divided into 3 groups using a random number table. Control group (n=44) only received general anesthesia, TPVB group (n=44) was treated with TPVB after induction of general anesthesia, and SAPB group (n=44) was subjected to SAPB after induction of general anesthesia. Inclusion criteria: (1) Patients aged above 18 years old, (2) those with American Society of Anesthesiologists (ASA) grade I-II, (3) those with an incision of 3–5 cm in length, (4) those with complete clinical medical records, and (5) those who and whose families were informed of the study, had high compliance and voluntarily participated in the study. Exclusion criteria: (1) Patients complicated with severe diseases of the heart, liver, kidney or other organs, (2) those with coagulation disorder, (3) those with thoracic or spinal deformity, (4) those with a history of allergy to local anesthetics, (5) those with infection at the puncture site, (6) those complicated with disturbance of consciousness or mental and/or psychological diseases, (7) those who took psychotropic drugs or sedative and analgesic drugs for a long time, (8) those alternatively treated with thoracotomy during operation because of the disease, (9) those who stopped using analgesia pump within 24 h after operation due to serious adverse reactions, or (10) those unable to keep functional exercise after operation.

Nine cases were finally excluded, including 2 cases who were given thoracotomy instead during surgery, 1 case complicated with liver dysfunction, 1 case with coagulation dysfunction, 1 case with thoracic or spinal deformity, 1 case with a history of local anesthetic allergy, 1 case complicated with disturbance of consciousness and 2 cases with long-term use of psychiatric, sedative or analgesic drugs.

Anesthesia induction

All patients were fasted for 8 h and deprived of water for 4 h. The vital signs of the patients were routinely tested after admission to the operation room, and peripheral venous access was opened, from which 1.5–3.0 mg/kg propofol, 0.05–0.1 mg/kg midazolam, 0.5–0.6 μg/kg sufentanil and 0.1 mg/kg vecuronium bromide were injected to induce anesthesia. Then a proper double-lumen tube was used for tracheal intubation, and the partial pressure of end-tidal carbon dioxide of the patient was maintained at 35–45 mmHg after mechanical ventilation.

Block operation

In TPVB group, the patients lay in the surgical posture after anesthesia induction, the seventh cervical spinous process was found via palpation, and the T5-6 interspinous space was positioned downward. After routine disinfection and draping, a 2–5 MHz convex ultrasonic probe was used to identify the thoracic paravertebral space by moving to the lateral segment along the middle line of the spine, and the probe was fixed. Next, a 22G puncture needle (0.71×50 mm) was inserted by means of in-plane technique, and the needle tip was pushed to the T5 paravertebral space by penetrating the costotransverse ligament under the guidance of ultrasound. Finally, 20 mL of 0.375% ropivacaine was slowly injected when no gas and blood was withdrawn.

In SAPB group, the patients lay in the surgical posture after anesthesia induction, a 6–13 MHz linear ultrasonic probe was placed at the midaxillary line on the affected side, and the fifth rib was identified. After routine disinfection and draping, the superficial latissimus dorsi muscle and deep serratus anterior muscle were recognized, and the probe was fixed. Subsequently, a 22G puncture needle (0.71×50 mm) was inserted through the in-plane technique, and the needle tip was slowly pushed in the cephalad direction to the surface of serratus anterior muscle. Finally, 20 mL of 0.375% ropivacaine was slowly injected when no gas and blood was withdrawn.

Anesthesia maintenance

Before operation, the patients were administered with 10 mg of dexamethasone, 10–15 μg of sufentanil and 2–3 mg of vecuronium bromide to deepen the anesthesia. Then the patients inhaled about 0.5 MAC sevoflurane during operation and were pumped with 0.2–0.5 μg/kg/h dexmedetomidine and 3–6 mg/kg/h propofol to maintain the Narcotrend index at 40–50. Meanwhile, 0.10–0.15 μg/kg/h remifentanil was pumped to sustain analgesia. The administration of vasoactive agents was determined based on the blood pressure fluctuations, and anesthesiologists were responsible for deciding whether additional vecuronium bromide or sufentanil is needed according to their experience, so as to ensure muscle relaxation and appropriate depth of anesthesia.

Postoperative analgesia

After operation, patient-controlled intravenous analgesia (PCA) pump containing 20 mg of azasetron and 100 mL of sufentanil (2 μg/kg) added with normal saline was employed for all patients. The load was set as 2 mL, the background infusion rate was 2 mL/h, the additional dosage was determined as 2 mL, and the lockout interval was 15 min. The patients voluntarily pressed the PCA pump when the Visual Analogue Scale (VAS) score was higher than 3 points at rest or 6 points at coughing. Pethidine (50 mg) was injected intramuscularly in the case of

unsatisfactory effects, and the patients quitted this study if the effects were still unsatisfactory.

Collection of baseline clinical data and surgical outcomes

The gender, age, body mass index (BMI), smoking history, ASA grade, operative site, operation time, extubation time, length of hospital stay after operation, dosage of dexmedetomidine, propofol, remifentanil and sufentanil during operation, time of first pressing PCA pump after operation, number of pressing PCA pump within 48 h after operation, cases of pethidine use, and the incidence of adverse reactions such as nausea, vomiting, dizziness and pruritus were recorded.

VAS scoring

At 6, 12, 24 and 48 h after operation, the pains in patients at rest and coughing were evaluated using VAS. The patients selected the figures 0–10 that could represent the severity of pain, including painlessness (0 points), mild pain (0–3 points), moderate pain (3–6 points) and severe pain (6–10 points). In general, a higher score means severer pain.

Detection of immune function indices

Fasting venous blood (3 mL) was drawn from each patient before operation and at 24 and 48 h after operation, placed at room temperature and centrifuged at low speed. Then the supernatant was obtained and stored at -80 °C for later use. Next, the levels of T lymphocyte subsets, such as cluster of differentiation 3 $(CD3)^+$ T lymphocytes, $CD4^+$ helper T lymphocytes and $CD8^+$ suppressor T lymphocytes, in the serum were measured using a BD FACSCalibur flow cytometer (USA) and corresponding reagents, and the $CD4^+/CD8^+$ ratio was calculated.

Detection of serum tumor markers

A total of 3 mL of fasting venous blood was collected before operation and at 24 h after operation, placed at room temperature and centrifuged at low speed. Then the supernatant was obtained and stored at -80 °C for later use. Subsequently, enzyme-linked immunosorbent assay was performed to determine the levels of serum carcinoembryonic antigen (CEA), carbohydrate antigen 125 (CA125), cytokeratin 19 fragment 21-1 (CYFRA21-1) and neuron-specific enolase (NSE).

Statistical analysis

SPSS 16.0 software was employed for statistical analysis. The numerical data were represented as n (%), and chi-square (χ^2) test was used for intergroup comparison. The measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and repeated measures analysis of variance was conducted for data analysis at different time points among multiple groups. Firstly, the intergroup and temporal differences of measured value were analyzed. Secondly, independent-samples *t*-test was employed for intergroup differences at each time point, and SNK-q test was utilized to compare the temporal difference among groups. $P<0.05$ suggested that a difference was statistically significant.

RESULTS

Baseline clinical data

There were no significant differences in the gender, age, BMI, smoking history and ASA grade among the three groups ($P>0.05$) (Table 1).

Table 1 Baseline clinical data [n (%)] ($\bar{x} \pm s$)

Group	n	Gender [n (%)]		Age (year)	BMI (kg/m^2)	Smoking history [n (%)]	ASA grade [n (%)]	
		Male	Female				Grade I	Grade II
Control	44	26 (59.09)	18 (40.91)	58.95 ± 9.64	21.78 ± 2.25	15 (34.09)	30 (68.18)	14 (31.82)
TPVB	44	29 (65.91)	15 (34.09)	59.23 ± 9.71	22.04 ± 2.27	17 (38.64)	33 (75.00)	11 (25.00)
SAPB	44	28 (63.64)	16 (36.36)	59.16 ± 9.68	21.89 ± 2.24	16 (36.36)	31 (70.45)	13 (29.55)
χ^2/F		0.454		0.436	0.308	0.196	0.517	
P		0.797		0.712	0.691	0.906	0.772	

ASA: American Society of Anesthesiologists
BMI: body mass index
SAPB: serratus anterior plane block
TPVB: thoracic paravertebral nerve block

Surgical conditions

The differences in operative site, operation time, extubation time, length of hospital stay after operation, dosage of dexmedetomidine, propofol and remifentanil during operation and cases of pethidine use after operation were not statistically significant among the 3 groups of patients (P>0.05). TPVB group and SAPB group had lower dosage of sufentanil during operation, later time of first pressing PCA pump after operation and a smaller number of pressing PCA pump within 48 h after operation than control group (P<0.05) (Table 2).

VAS scores

The VAS scores at rest and coughing decreased at 6 and 12 h after operation in TPVB group and SAPB group compared with that in control group (P<0.05). However, TPVB and SAPB groups had similar VAS scores (P>0.05). Moreover, there was no significant difference in VAS scores at rest and coughing at 24 and 48 h after operation among the 3 groups (P>0.05) (Table 3).

Immune function indices

No significant differences in $CD3^+$, $CD4^+$, $CD8^+$ and $CD4^+/CD8^+$ ratio were found among the 3 groups before operation (P>0.05). $CD3^+$, $CD4^+$ and $CD8^+$ declined at 24 and 48 h after operation in contrast with those before operation in the 3 groups. Besides, $CD3^+$, $CD4^+$ and $CD4^+/CD8^+$ ratio were higher, while $CD8^+$ was lower in TPVB group and SAPB group than those in control group (P<0.05) (Table 4).

Serum tumor marker levels

There were no significant differences in CEA, CA125, CYFRA21-1 and NSE among the 3 groups before operation (P>0.05). The levels of those indices were reduced in the 3 groups at 24 h after operation, and the decreases in TPVB group and SAPB group were greater than those in control group (P<0.05) (Table 5).

Postoperative adverse reactions

None of the patients in the 3 groups manifested adverse reactions such as local anesthetic intoxication, constipation, urinary retention, subcutaneous hematoma and infection. There were 4 cases of dizziness and 3 cases of nausea and vomiting in control group. A total of 2 cases of punctured pleura and 1 case of dizziness were observed in TPVB group. Additionally, 2 cases of dizziness occurred in SAPB group, which were relieved by symptomatic treatment. The difference in the incidence rate of adverse reactions was not significant among the 3 groups of patients (P>0.05).

Table 2 Surgical conditions [n (%)] ($\bar{x} \pm s$)

Group	n	Operative site [n (%)]		Operation time (min)	Extubation time (min)	Length of hospital stay after operation (d)	Dexmedetomidine (μg)	Propofol (mg)	Remifentanil (μg)	Sufentanil (μg)	Time of first pressing PCA pump (h)	PCA pump pressing (n)	Pethidine use [n (%)]
		Left lung	Right lung										
Control	44	21 (47.73)	23 (52.27)	128.79±24.63	135.76±46.94	6.27±1.83	43.28±15.06	307.54±34.86	11.25±3.62	132.14±16.13	10.14±1.27	5.86±1.73	7 (15.91)
TPVB	44	24 (54.55)	20 (45.45)	130.12±24.57	136.28±47.59	6.04±1.78	42.96±14.87	310.28±35.19	11.17±3.59	102.35±12.02[a]	13.09±1.82[a]	2.61±1.22[a]	3 (6.82)
SAPB	44	22 (50.00)	22 (50.00)	129.48±24.52	135.91±47.25	5.98±1.75	43.07±14.95	309.46±35.04	11.21±3.64	101.78±11.89[a]	12.58±1.76[a]	2.47±1.15[a]	2 (4.55)
χ^2/F		0.424		0.356	0.152	0.639	0.139	0.527	0.258	9.674	7.819	10.269	3.850
P		0.809		0.710	0.859	0.542	0.623	0.795	0.617	<0.001	<0.001	<0.001	0.146

PCA: patient-controlled intravenous analgesia
SAPB: serratus anterior plane block
TPVB: thoracic paravertebral nerve block
[a]P<0.05 vs control group

Table 3 VAS scores ($\bar{x} \pm s$)

Group	n	VAS score at rest (point)				VAS score at coughing (point)			
		6 h after operation	12 h after operation	24 h after operation	48 h after operation	6 h after operation	12 h after operation	24 h after operation	48 h after operation
Control	44	1.62±0.42	1.91±0.53	2.27±0.63	2.06±0.57	1.91±0.49	2.38±0.61	2.75±0.69	2.46±0.61
TPVB	44	1.04±0.33[a]	1.26±0.40[a]	2.23±0.62	1.99±0.55	1.42±0.38[a]	1.75±0.46[a]	2.73±0.67	2.42±0.59
SAPB	44	0.98±0.31[a]	1.23±0.38[a]	2.21±0.60	1.97±0.56	1.39±0.36[a]	1.72±0.44[a]	2.71±0.65	2.41±0.57
F		9.883	7.394	0.547	0.726	5.327	5.496	0.285	0.392
P		<0.001	<0.001	0.628	0.459	<0.001	<0.001	0.764	0.687

SAPB: serratus anterior plane block
TPVB: thoracic paravertebral nerve block
VAS: Visual Analogue Scale
[a]P<0.05 vs control group

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Table 4 Immune function indices ($\bar{x} \pm s$)

Group	n	$CD3^+$ (%)			$CD4^+$ (%)			$CD8^+$ (%)			$CD4^+/CD8^+$		
		Before operation	24 h after operation	48 h after operation	Before operation	24 h after operation	48 h after operation	Before operation	24 h after operation	48 h after operation	Before operation	24 h after operation	48 h after operation
Control	44	64.12±7.23	45.38±5.26[b]	46.49±5.37[b]	35.26±3.84	19.72±3.15[b]	21.84±3.19[b]	28.79±3.26	25.58±2.79[b]	24.71±2.64[b]	1.21±0.58	0.77±0.43[b]	0.88±0.46[b]
TPVB	44	63.94±7.18	50.69±6.13[ab]	52.10±6.24[ab]	34.85±3.79	27.37±4.04[ab]	28.12±4.16[ab]	29.01±3.22	23.29±2.73[ab]	23.48±2.69[ab]	1.20±0.55	1.18±0.52[a]	1.20±0.53[a]
SAPB	44	63.87±7.15	51.12±6.24[ab]	52.47±6.30[ab]	34.73±3.75	28.01±4.10[ab]	28.29±4.22[ab]	29.08±3.19	23.15±2.68[ab]	23.02±2.73[ab]	1.19±0.57	1.21±0.55[a]	1.23±0.56[a]
F		0.176	4.458	4.623	0.565	6.824	5.716	0.524	0.637	1.389	0.161	4.236	3.453
P		0.824	<0.001	<0.001	0.537	<0.001	<0.001	0.647	0.562	0.116	0.859	<0.001	<0.001

SAPB: serratus anterior plane block
TPVB: thoracic paravertebral nerve block
[a]P<0.05 vs control group
[b]P<0.05 vs before operation

Table 5 Serum tumor marker levels

Group	n	CEA (ng/mL)		CA125 (U/mL)		CYFRA21-1 (ng/mL)		NSE (ng/mL)	
		Before operation	24 h after operation	Before operation	24 h after operation	Before operation	24 h after operation	Before operation	24 h after operation
Control	44	3.19±0.42	2.83±0.36[b]	15.94±1.73	13.65±1.47[b]	3.16±0.52	2.79±0.35[b]	16.77±1.73	14.35±1.51[b]
TPVB	44	3.21±0.44	2.45±0.31[ab]	16.02±1.78	11.73±1.26[ab]	3.18±0.50	2.31±0.29[ab]	16.80±1.75	12.14±1.32[ab]
SAPB	44	3.23±0.45	2.44±0.30[ab]	16.10±1.80	11.69±1.23[ab]	3.20±0.51	2.28±0.30[ab]	16.83±1.74	12.08±1.29[ab]
F		0.427	5.519	0.415	6.857	0.436	7.359	0.172	7.249
P		0.658	<0.001	0.762	<0.001	0.719	<0.001	0.865	<0.001

CA125: carbohydrate antigen 125
CEA: carcinoembryonic antigen
CYFRA21-1: cytokeratin 19 fragment 21-1
NSE: neuron-specific enolase
SAPB: serratus anterior plane block
TPVB: thoracic paravertebral nerve block
[a]P<0.05 vs control group
[b]P<0.05 vs before operation

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DISCUSSION

For lung cancer patients, chest tube needs to be routinely retained after thoracoscopic radical resection, but it is extremely prone to stimulating the pleura and intercostal nerves. In addition, the patients should receive respiratory function exercise after operation, and thoracic pain fibers can induce pain triggered by respiratory activities. The pain is able to affect the perioperative respiratory function exercise of patients if not well controlled. Besides, it can inhibit cough reflex and adversely influence early expectoration, thereby markedly increasing the incidence rate of pulmonary complications.[5]

According to the review of large amount of data, though ultrasound-guided TPVB and SAPB have been extensively applied to various diseases and multiple kinds of thoracoscopic surgery so far, the using time varies from case to case, which has been reported before anesthesia induction, after anesthesia induction and at the end of surgery. In the present study, TPVB and SAPB were performed after anesthesia induction to alleviate the nervous emotion during nerve block, noncompliance with body movement and puncture-induced pain of patients, but their demerit is that whether the nerve block is successful in all patients is hard to determine. A report indicated that the changes in blood pressure and heart rate during operation are able to reflect the success rate and analgesic effect of nerve block to some extent.[6] It was revealed in this study that a lower dosage of sufentanil during operation, later time of first pressing PCA pump after operation and a smaller number of pressing PCA pump within 48 h after operation were observed in TPVB group and SAPB group, proving that the two types of nerve block have a preferable analgesic effect. Several studies have demonstrated that both TPVB and SAPB can effectively mitigate the pain of patients within 24 h after thoracoscopic surgery and reduce the dosage of analgesics, and the same conclusion was obtained in this study.[7] The reason is that single point injection is adopted to save the manipulation time and lower the risk of puncture, and the pharmacodynamics of ropivacaine limits the action time. As a result, patients' pain is prominently alleviated within 24 h after operation.

Tumor-induced wasting can lead to low immune function of lung cancer patients, and the stress response caused by surgical trauma breaks the balance of immune modulation in the body, thus further decreasing the immune function of patients.[8] It has been reported that pain can trigger the stress response in the body to adversely influence the body immunity mainly by stimulating the organism to release massive catecholamines and directly acting on lymphocytes.[9] Moreover, the commonly used opioid analgesics can partially activate cyclooxygenase-2, promote the secretion of prostaglandin E2, stimulate vascular regeneration and accelerate tumor cell growth and diffusion, thus benefiting the distant metastasis and recurrence of tumor cells and finally repressing the activity of natural killer cells and T lymphocyte subsets.[10] Qin et al applied quadratus lumborum block with ropivacaine combined with PCA with sufentanil to patients undergoing radical resection of rectal cancer, and found that the suppression of immune function of such patients was effectively relieved compared with that in patients not treated with quadratus lumborum block with ropivacaine.[11] In this study, ropivacaine was used for nerve block in spite of differences in disease type, operative method and nerve block method. The immune function was evidently improved in TPVB group and SAPB group in comparison with that in control group, consistent with the findings in above reports. It is because, on the one hand, TPVB and SAPB are capable of efficaciously mitigating the pain of patients within 24 h after operation, so as to reduce stress responses in the body, and there may be time delay in the series of responses. On the other hand, TPVB and SAPB can reduce the dosage of opioid analgesics, thereby relieving the inhibitory effect on immune cells.

In recent years, the detection of serum tumor markers has been widely applied to the diagnosis

and treatment of lung cancer. Ropivacaine may activate the mitochondrion-mediated apoptotic pathway to induce the apoptosis of human liver cancer cell line SK-Hep-1, thus inhibiting the cell growth.[12] Additionally, ropivacaine suppresses the proliferation and induces the apoptosis of human colon cancer SW620 cell through the Caspase-3 signaling pathway, and may play an important role in colon cancer resection.[13] The results of this study indicated that the levels of serum tumor markers declined prominently after operation in the two groups of patients receiving nerve block with ropivacaine, which is in line with the aforementioned findings.

There were no serious adverse reactions in the 3 groups of patients in the present study, with no significant differences, which may be related to the insufficient sample size. However, TPVB group and SAPB group exhibited fewer cases of dizziness, nausea and vomiting than control group, which is assumed to be associated with the decreased dosage of opioid analgesics in TPVB group and SAPB group. Furthermore, 2 cases of punctured pleura occurred in TPVB group rather than SAPB group. It is because the ultrasound-guided superficial SAPB adopted in SAPB group can clearly distinguish the anatomic structure, accurately position the needle tip and avoid the blood vessel clusters and pleura. Although there were no severer complications after timely treatment in this study, it was implied that enough importance should be attached to the potential operational risk of TPVB.

In conclusion, SAPB and TPVB can prominently improve the postoperative analgesic effect, enhance the immune function, lower the levels of serum tumor markers and induce no more adverse reactions in patients receiving thoracoscopic radical resection of lung cancer, which is worthy of clinical popularization and application. Nevertheless, TPVB may puncture the pleura. Multi-center large-sample studies will be conducted in the future to further investigate the suitable timing of use of SAPB, thereby providing more reliable theoretical instructions for clinical application.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

AUTHOR CONTRIBUTIONS

The two authors contributed equally to this study.

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