Original Article

Impact of paravertebral blockade use in geriatric patients undergoing thoracic surgery on postoperative adverse outcomes

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Background: While it is known that thoracic paravertebral blockade (TPVB) could reduce pain undergoing thoracic surgery, it has not been confirmed whether this reduction in pain reduces pulmonary complications in an elderly population.

Methods: We performed a monocentric retrospective analysis for a prospectively collected patients receiving thoracic surgery with or without intraoperative TPVB between November 7, 2018 and April 1, 2019, at Shanghai Chest Hospital. Whether or not to use TPVB depending on anesthesiologists' preference, the chances of harm and benefit of each patients after discussed with their anesthetist. Chest wall resection, bilateral lung resection, conversion to thoracotomy and ipsilateral reoperation were excluded. A total of 154 patients with lung operations were included in the final analysis, 34 of whom received general anesthesia combined with TPVB (GA-TPVB). The primary outcome was the incidence of postoperative pulmonary complications (PPCs). The secondary outcomes were the incidence of cardiovascular and other complications, required analgesia in post anesthesia care unit (PACU), patient controlled analgesia (PCA) pressing frequency in 24h, chest tube duration, ICU stay and the hospital length of stay (LOS).

Results: The incidence of PPCs undergoing thoracic surgery was about 21.4% (33/154). Compared with GA, GA-TPVB could reduce the incidence of PPCs (25% *vs.* 9%, P=0.042), mostly reduce postoperative atelectasis (19% *vs.* 3%, P=0.021). TPVB could reduce the rate of required analgesia in PACU, PCA pressing frequency in 24 h and chest tube duration. However, there were no significant differences on the rate of cardiovascular and other complications, ICU stay and LOS between the two groups (P>0.05). Multivariable logistic regression analysis identified preoperative DLCO% ≥92% (OR =0.293, P=0.006), duration of surgery <75 min (OR =0.278, P=0.008) and GA-TPVB (OR =0.270, P=0.048) was associated with fewer PPCs.

Conclusions: Our study shows that general anesthesia combined with TPVB may reduce PPCs by reducing postoperative pain in geriatric patients undergoing thoracic surgery compared with general anesthesia alone.

Trial registration: Chinese Clinical Trial Registry number, ChiCTR1800019526. Registered on Nov 7, 2018.

Keywords: Anesthetic methods; thoracic paravertebral blockade (TPVB); thoracic surgery; postoperative pulmonary complications (PPCs)

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Introduction

Postoperative pulmonary complications (PPCs) are one of the common surgical complications after anesthesia, and the main cause are prolonged hospital stay, increased medical costs and mortality (1-4). Especially in lung resection surgery, the incidence of PPCs is 15–37.5% has become a major concern after surgery (1,5,6). An appropriate postoperative analgesia after thoracic surgery is mandatory to improve the patient's outcome, reduce complications rate, morbidity, hospital cost and length of stay (LOS) (7). Thoracic paravertebral blockade (TPVB), as a safe and effective method of postoperative analgesia, has the same postoperative analgesic effect and could reduce postoperative complications compared with thoracic epidural (8-10) (which was regarded as the gold standard for postoperative analgesia in thoracic surgery). TPVB is superior to intravenous analgesia in providing stable and long-lasting pain control (7,11), and is more conducive to postoperative pulmonary function recovery (12). As thoracic epidural was shown associated with less PPCs in chronic obstructive pulmonary disease (COPD) patients compared with systemic analgesia (13), the impact on PPCs with intraoperative TPVB in geriatric patients remains unknown. We hypothesized that general anesthesia combined with TPVB in geriatric patients could reduce postoperative adverse outcomes compared with general anesthesia alone.

Methods

Study design and patient population

We performed a monocentric retrospective analysis for a prospectively collected patients receiving thoracic surgery with or without intraoperative TPVB between November 7, 2018 and April 1, 2019, at Shanghai Chest Hospital. Whether or not to use TPVB depending on anesthesiologists' preference, the chances of harm and benefit of each patient after discussed with their anesthetist. This study was approved by the Institutional Review Board (KS1862) of Shanghai Jiao tong University Shanghai Chest Hospital with the consent of the patient or family member and signed informed consent (Chinese Clinical Trial Registry number, ChiCTR1800019526).

Criteria for inclusion and exclusion

Inclusion criteria were patients at least 65 years, ASA I–III grade were scheduled for thoracic surgery were selected. Chest wall resections, bilateral lung resection, conversion to thoracotomy and ipsilateral reoperation were excluded. A total of 154 patients with lung operations were included in the final analysis, 34 of whom received general anesthesia combined with TPVB (GA-TPVB).

Preoperative preparations and anesthesia protocol

Patients were monitored with electrocardiography, non-invasive blood pressure, pulse oximetry, capnography. General Anesthesia was induced with 0.6 μg/kg sufentanil and a target-controlled infusion of propofol set to a plasma concentration of 4 μg/mL, cisatracurium 0.2 mg/kg was given to facilitate double-lumen bronchial tube intubation. Propofol administration was adjusted to of 2.5 μg/mL and Cisatracurium adjusted to 0.12 mg/kg/hour, remifentanil adjusted to 0.1 μg/kg/h in the maintenance period. Invasive blood pressure monitoring was achieved by radial artery cannulation (IBP) and right internal jugular central venous catheterization (CVP). Patients were placed in lateral decubitus. For TPVB, 15 mL of 0.5% ropivacaine was given to T4–T5, performed by specific anesthesiologists under ultrasound guidance before operation. Intraoperatively adoption of lung protective ventilation strategies, including low tidal volume (≤8 mL/kg) ventilation based on ideal body weight, PEEP =5 cmH_2O, lung recruitment and maintenance of airway pressure <30 cmH_2O. Sufentanil 5 μg was given before skin incision. Patient controlled analgesia (PCA) pump was used in all patients after operation. The drug used in the pump was sufentanil 1 μg/kg + dezocine 0.4 mg/kg.

Measurements

The demographic and baseline data, including gender, age, ASA grade, BMI, history of hypertension, Diabetes, cerebral infarction, radiotherapy and chemotherapy, FEV_1/FVC, DLCO% and preoperative cognitive function assessment. Operative time, surgical procedure (VATS/thoracotomy/robotic assisted VATS), type of operation (anatomical lobectomy/non-anatomical lobectomy), type of anesthesia (GA/GA-TPVB), intraoperative hypoxemia (SpO_2 <90%, lasting for more than 10 minutes), total fluid volume and duration in PACU were also recorded. The primary outcome was the incidence of PPCs (atelectasis, pulmonary infection, respiratory failure). The secondary outcomes were the incidence of cardiovascular and other complications, required analgesia in post anesthesia care

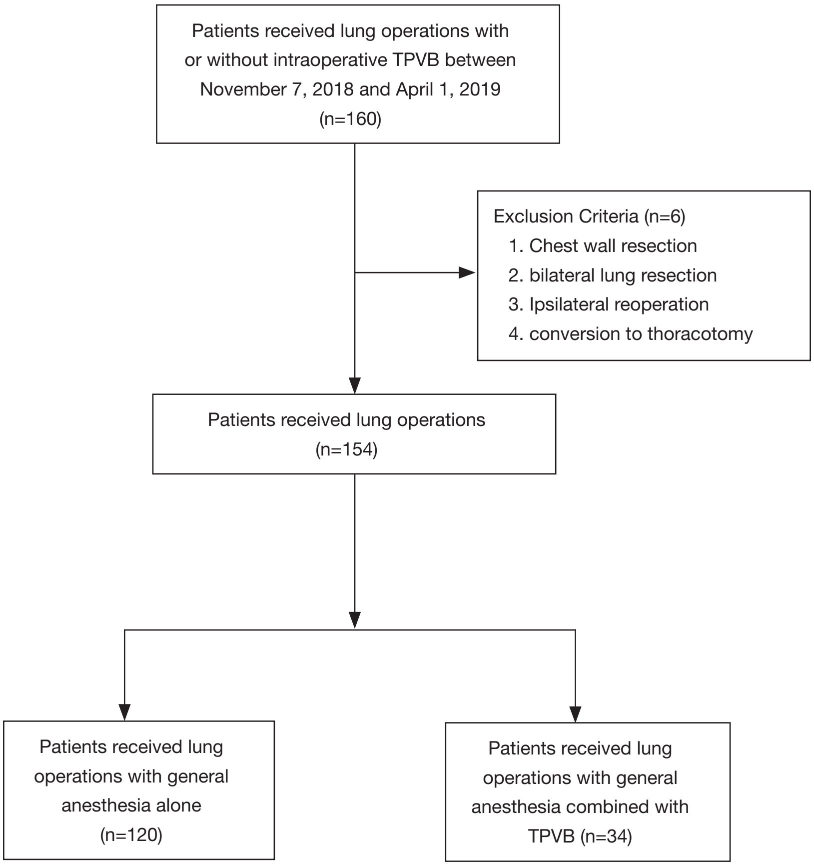

Figure 1 Patient flowchart. TPVB, thoracic paravertebral blockade.

unit (PACU), PCA pressing frequency in 24 h, chest tube duration, ICU stay and the hospital LOS. Atelectasis was measured by radiologists through CXR within 3 days after surgery. Assessment of respiratory failure and pulmonary infection with reference to EPCO (14). All PPCs were evaluated within 7 days after surgery. The extubation criteria were determined by experienced surgeons based on patient's postoperative recovery.

Statistical analysis

SPSS25.0 statistical software (SPSS Inc., Chicago, IL, USA) was used for data processing. Continuous variables are expressed as mean ± standard deviation (SD) or median (range) depending on data distribution. Frequency and percentage are used for categorical variables. Two independent sample *t*-test was used to compare the continuous variables with normal distribution. Mann-Whitney U-test was used to compare continuous variables with non-normal distribution. Chi-square test or Fisher exact test were used to compare categorical variables. We used Kaplan-Meier estimates for chest tube duration, ICU stay and LOS. All risk factors found significantly associated ($P<0.1$) with PPCs by univariate analysis were entered into a multivariable logistic regression model using a forward (LR) selection strategy. The thresholds for DLCO% and operative time were determined by ROC analysis. $P<0.05$ was statistically significant.

Results

A total of 154 patients were enrolled in the final analysis, 34 patients (22%) who received GA-TPVB (*Figure 1*). The incidence of PPCs undergoing thoracic surgery was about 21.4% (33/154). There were no significant differences in pre- and intraoperative patient characteristics between the two groups (*Table 1*).

Compared with GA, GA-TPVB could reduce the incidence of PPCs (25% *vs.* 9%, P=0.042), mostly reduce postoperative atelectasis (19% *vs.* 3%, P=0.021). TPVB

Table 1 Pre- and intraoperative patient characteristics

Variables[a]	GA group (n=120)	GA-TPVB group (n=34)	P value
Age, years	69.0±3.9	69.8±5.0	0.423
Sex			0.410
Male	59 (49.2)	14 (41.2)	
Female	61 (50.8)	20 (58.8)	
BMI (kg/m^2)	23.1±3.9	23.2±2.9	0.925
ASA grade			0.295
II	104 (86.7)	27 (79.4)	
III	16 (13.3)	7 (20.6)	
Comorbidity			
Hypertension	54 (45.0)	20 (58.8)	0.154
Diabetes	21 (17.5)	2 (5.9)	0.093
Stroke	8 (6.7)	3 (8.8)	0.708
Radiotherapy/chemotherapy	5 (4.2)	3 (8.8)	0.376
FEV_1/FVC, %	100.9±9.3	102.6±10.2	0.349
DLCO%	93.9±15.2	97.1±17.4	0.309
MCI	58 (48.3)	18 (52.9)	0.635
Operative time, min	90.7±44.8	92.5±41.2	0.832
Surgical procedure			0.795
VATS	102 (85.0)	27 (79.4)	
Thoracotomy	10 (8.3)	4 (11.8)	
Robotic assisted VATS	8 (6.7)	3 (8.8)	
Type of operation			0.408
Anatomical lobectomy	83 (69.2)	26 (76.5)	
Non-anatomical lobectomy	37 (30.8)	8 (23.5)	
Total fluid volume, mL	1,043.3±254.9	1,101.5±198.6	0.222
Intraoperative hypoxemia	5 (4.2)	1 (2.9)	0.999
Duration in PACU, min	31.8±15.3	31.2±15.0	0.824

[a], continuous data are shown as mean ± standard deviation and categorical data as number (%). Intraoperative hypoxemia: SpO_2 <90%, lasting for more than 10 minutes. BMI, body mass index; ASA, American Society of Anesthesiologists; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; DLCO, diffusion capacity for carbon monoxide; MCI, mild cognitive impairment; VATS, video-assisted thoracoscopic surgery; PACU, post anesthesia care unit.

could reduce the rate of required analgesia in PACU, PCA pressing frequency in 24 h and chest tube duration. However, there were no significant differences on the rate of cardiovascular and other complications, ICU stay and LOS between the two groups (P>0.05) (*Table 2*).

Univariate and multivariate analysis of potential risk factors for PPCs

The thresholds for DLCO% and operative time were determined by ROC analysis, which showed area under the curve values of 0.699 and 0.691, respectively. Inserting the

Table 2 Outcomes between GA or GA-TPVB group

Variables[a]	GA group (n=120)	GA-TPVB group (n=34)	P value
PPCs	30	3	0.042
Atelectasis	23	1	0.021
Pulmonary infection	9	2	0.999
Respiratory failure	4	0	0.576
Cardiovascular	10	0	0.119
Atrial arrhythmia	8	0	
Acute cerebral infarction	1	0	
Myocardial infarction	1	0	
Other complications	1	2	0.118
Chylothorax	0	1	
Blood transfusion	1	1	
Required analgesia in PACU	14	0	0.041
PCA pressing frequency in 24h	14±5	9±3	<0.001
Chest tube duration, day	4 [3–4]	3 [2–3]	0.011
Length of stay, day	4 [3–5]	4 [3–5]	0.694
ICU stay, day	1 [1–3]	1 [1–2]	0.770

[a], continuous data are shown as mean± standard deviation and categorical data as number (%). Chest tube duration, length of stay and ICU stay, values as median (range). ICU, intensive care unit; PPCs, postoperative pulmonary complications; PACU, post anesthesia care unit; PCA, patient controlled analgesia; ICU, intensive care unit.

variables with P<0.1 at univariate analysis in a multivariable logistic regression analysis model, preoperative DLCO% ≥92% (OR =0.293, P=0.006), duration of surgery <75 min (OR =0.278, P=0.008) and GA-TPVB (OR =0.270, P=0.048) was associated with fewer PPCs (*Table 3*).

Discussion

Our study showed that GA-TPVB in geriatric patients undergoing thoracic surgery was associated with fewer PPCs compared with GA. TPVB could reduce the rate of required analgesia in PACU, PCA pressing frequency in 24 h and chest tube duration. However, based on the data of this study, the effects of GA-TPVB on cardiovascular and other complications, ICU stay and LOS cannot be obtained. Perioperative TPVB use may help to provide interventions for patients at greatest risk of major adverse outcomes after surgery, so interventions can be targeted to those most likely to benefit.

That about 21.4% (33/154) geriatric patients scheduled for thoracic surgery have probable PPCs is not surprising given the same prevalence of PPCs in other clinical studies (5,6). For instance, depending upon definition of PPCs and type of surgery, the prevalence of PPCs ranges from 9% to 40% (15-18). The definition of PPCs in this study is based on the European Perioperative Clinical Outcome definition (14), which is determined by experienced anesthesiologists and surgeons with relative reliability. Moreover, TPVB is performed by experienced anesthesiologists under the guidance of ultrasound, which could ensure the effectiveness and safety of postoperative analgesia. Furthermore, this study is not limited to one type of thoracic surgery (including VATS/thoracotomy/robotic assisted VATS), so our study is applicable to a wider range of elderly patients undergoing elective thoracic surgery.

In our study, TPVB could reduce the rate of required analgesia in PACU, PCA pressing frequency in 24 h and chest tube duration. The mechanism probably by which GA-TPVB reduces the incidence of PPCs may be to provide stable and long-lasting pain control after surgery to

Table 3 Univariate[a] and multivariate analysis of potential risk factors for PPCs

Variable	PPCs		Univariate	Multivariate	
	No (n=121)	Yes (n=33)	P value	OR (95% CI)	P value
BMI (kg/m^2)	23.5±2.8	21.8±5.7	0.018		
DLCO%			0.003		
<92% (reference)	51	23			
≥92%	69	9		0.293 (0.121–0.708)	0.006
Anesthesia methods			0.042		
GA (reference)	90	30			
GA-TPVB	31	3		0.270 (0.074–0.991)	0.048
Operative time (min)			0.007		
≥75 min (reference)	64	26			
<75 min	57	7		0.278 (0.108–0.718)	0.008
Intra-hypoxemia	2	4	0.019		

[a], Hosmer-Lemeshow test P=0.532; C statistic: 0.741. CI, confidence interval; OR, odds ratio; BMI, body mass index; DLCO, diffusion capacity for carbon monoxide; PPCs, postoperative pulmonary complications; GA-TPVB, general anesthesia combined with thoracic paravertebral block.

promote recovery of lung function (7,11). While poor pain control after surgery which do not allow the patients to take deep breath and ultimately lead to atelectasis and retention of secretions (7,19,20).

Protective lung ventilation (PLV) during one-lung ventilation (OLV) for thoracic surgery is frequently recommended to reduce pulmonary complications (21). However, the effect of anesthesia methods on PPCs has been controversial, especially in regional anesthesia. Powell *et al.* (22) compared the effects of TPVB and epidural blockade on postoperative adverse outcomes after pneumonectomy and concluded that the increased incidence of major PPCs was associated with thoracic epidural block, but did not prolong the hospital length of day. A retrospective propensity score-matched study by Blackshaw *et al.* (23) found that TPVB did not reduce the incidence of PPCs, other postoperative complications, morbidity and mortality and prolong postoperative hospital stay compared with epidural block in open lung resection which were consistent with randomised controlled trials and systematic reviews (24,25). Thoracic epidural analgesia was associated with reduced PPCs and mortality in patients with severe COPD compared with systemic analgesia (13). Therefore, we infer that TPVB use in geriatric patients could reduce PPCs after surgery compared with general anesthesia alone, and the results of this study also confirm this. There were no significant differences in rates of other postoperative complications, ICU stay and LOS based on this study.

Previous studies have identified risk factors of PPCs, including increased age, gender, BMI ≥30 kg/m^2, smoking, ASA score ≥3, preoperative FEV_1 ≤60%, COPD, duration of surgery, open surgery and increased intraoperative fluid administration (26-32). In our study, multivariable logistic regression analysis also showed that preoperative DLCO% <92%, duration of surgery ≥75 min and general anesthesia alone were independent risk factors for PPCs. All of these modifiable risk factors should be of concern to clinicians to minimize the incidence of PPCs after thoracic surgery.

This study also has certain limitations. It has the same bias as any secondary analysis of data. Also, we were unable to directly compare analgesic efficacy due to incomplete data. Finally, since the patients were not randomized into receiving GA or GA + TPVB. The biases introduced by this decision may have an impact on PPCs.

Conclusions

Our study shows that general anesthesia combined with TPVB may reduce PPCs by reducing postoperative pain in geriatric patients undergoing thoracic surgery compared with general anesthesia alone.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was approved by the Institutional Review Board (KS1862) of Shanghai Jiao tong University Shanghai Chest Hospital with the consent of the patient or family member and signed informed consent.

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