

Comparison of the effect of ultrasound-guided thoracic paravertebral nerve block and intercostal nerve block for video-assisted thoracic surgery under spontaneous-ventilating anesthesia

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SUMMARY

OBJECTIVE: The aim of the current study was to compare the efficacy of two different techniques for blocking chest nerves during video-assisted thoracic surgery (VATS) under spontaneous-ventilating anesthesia.

METHODS: One hundred patients were recruited in this study and divided into two groups. The first, P group, underwent the TPVB approach; the second, I group, underwent the ICNB approach. Then, the rate of clinical efficacy, duration of the block procedure, and its complications were recorded for comparison of the effect of the two approaches.

RESULTS: No difference was found in the clinical effect of chest nerve blocks between the two groups. Two patients in the ICNB group were converted to general anesthesia due to severe mediastinal flutter (grade three). The number of patients who had grade one mediastinal flutter in the TPVB group was significantly higher than in the ICNB group. Vascular puncture was detected in four patients in the ICNB group and in one patient in the TPVB group. No other complications were observed.

CONCLUSIONS: No difference was found regarding the clinical efficacy in the two groups. However, ultrasound-guided TPVB was superior to ultrasound-guided ICNB during VATS for pulmonary lobectomy under spontaneous-ventilating anesthesia. Additionally, vascular puncture should receive more attention.

KEYWORDS: Anesthesia. Nerve block. Thoracic surgery. Video-assisted surgery.

INTRODUCTION

Thoracic disease is a high-risk clinical finding. Thoracoscopic pulmonary nodule resection represents the most effective and suitable treatment for pulmonary nodules and can provide essential histopathologic information for definitive diagnosis, staging,

and primary treatment. However, conventional thoracoscopic surgery is performed under general anesthesia with double-lumen endotracheal intubation¹. This requires the use of a large number of anesthetics, including sedatives, analgesics, and muscle relaxants,

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which may cause airway damage, respiratory and cardiac complications, as well as residual effects of the drug, precluding early recovery²⁻⁴. It has been reported that the incidence of postoperative complications is 12%-40%³. Pulmonary complications are the main reason for prolonging hospital and intensive care unit (ICU) stays. A nerve block can reduce the incidence of pulmonary complications⁴; therefore, this is an essential and vital anesthetic technique to ensure the rapid recovery of patients after thoracoscopic surgery⁶.

A variety of techniques have been proposed to complete thoracoscopic surgery under spontaneous-ventilating anesthesia, including epidural blocks, paravertebral nerve blocks, intercostal blocks, and local incision anesthesia^{7,8}. Along with the technologic advances in ultrasonographic applications over the last decade, many ultrasound-guided nerve block methods have been reported, including ultrasound-guided thoracic paravertebral nerve block (TPVB) and ultrasound-guided intercostal nerve block (ICNB). Within the thoracic paravertebral space, the spinal nerves go out of the intervertebral space and travel to the paravertebral space. The spinal nerves are divided into anterior, posterior, and sympathetic nerves. The posterior branch is divided into the back muscles and skin. The anterior branch divides into a traffic branch, then courses laterally and becomes an intercostal nerve. We directly inject the drug into the paraspinal space, which is composed of the anterior lateral pleural wall layer, the posterior rib transverse ligament, and the medial vertebral body structure⁹. The intercostal nerve is formed by the anterior branch of the thoracic nerve, which is located in the intercostal space. The muscle branches of the intercostal nerve dominate the inner and outer intercostal, thoracic transverse, upper and lower serratus, intra-abdominal and external oblique, abdominal transverse, and abdominal rectus muscles. A local anesthetic is injected approximately 0.3 cm inside the lower edge of the rib¹⁰. During thoracoscopic surgery, even if the ICNB is completed, it is impossible to ensure that the patient has good analgesia when incising the skin¹¹. However, the paravertebral space communicates with the rib space outward, communicates with the vertebral canal inward, and communicates upward and downward with the adjacent segmental paraspinal space. Thus, drug injection into the gap can not only block the corresponding level of the paravertebral nerve but also spread to the adjacent paravertebral nerve and epidural space¹²⁻¹⁴.

Theoretically, a TPVB has greater superiority; however, there is a paucity of clinical evidence to support this point.

We compared the effect of the two approaches in patients undergoing thoracoscopic pulmonary nodule resection.

METHODS

Patients

In this prospective randomized study, we enrolled 50 patients (18–50 years of age). The allocation of patients receiving a TPVB (P-group) or ICNB (I-group) was performed using a computer-generated randomization scheme. Approval of the study was obtained from the Ethics Committee of the Affiliated People's Hospital of Jiangsu University, and written informed consent was obtained from each of the participants. This study was conducted in accordance with the Declaration of Helsinki.

Inclusion and exclusion criteria

All patients met the American Society of Anesthesiologists' physical classification class I–II and were intended to undergo thoracoscopic pulmonary nodule resection with spontaneous-ventilating anesthesia. Patients with a known allergy to LAs, an infection at the site of injection, a coagulopathy, a neuromuscular disorder, a BMI ≥ 25 kg/m², an estimated operative time >3 h, the possibility of major bleeding intra-operatively, a severe cardiopulmonary complication, a spinal or thoracic deformity, respiratory obstruction, and a foreseeable difficult airway were excluded.

Sample size calculation

We calculated the sample size prior to the implementation of the study using a power and sample size program¹⁵. According to the existing literature, the pain scores were 5.4 on a scale of 1-10. We considered a pain score reduction of at least 1.5 as clinically significant¹⁶. If the mean of cohort 1 was 5.4, the mean of cohort 2 was 3.9, and assuming a SD of 2.4, the required sample size in each cohort was 42 with a power of 80%. The significance level was set at an $\alpha=0.05$. Thus, our study recruited 50 patients in each group to meet the sample size requirement.

Procedure

Upon arrival to the operating room, intravenous access was established, and the patients received

invasive blood pressure monitoring, electrocardiography using lead II, and pulse oximetry monitoring. TPVBs and ICNBs are invasive operations. To improve patient comfort and promote comfortable anesthesia, this study used TPVBs or ICNB after induction of general anesthesia. The patient inhaled oxygen via face mask, followed by anesthesia induction. Dexmedetomidine was injected intravenously with 0.40 µg/kg (infusion in 15 min). The propofol target-controlled infusion (TCI) was 2.50–3.00 µg/mL. The remifentanyl target-controlled infusion (TCI) was 1.00–1.50 µg/mL. When spontaneous respirations ceased, a laryngeal mask was placed¹⁴.

After anesthesia induction, the P group underwent ultrasound-guided TPVB (figure 1). A 22-gauge, 80-mm echogenic needle (SonoPlex cannulas; Pajunk®, Geisingen, Germany), MylabTM25 Gold (Esaote, Genova, Italy), and a linear probe (LA435: 6–18 MHz; Esaote) were used. Povidone-iodine was used to make an aseptic field. The locations of the spinous process, transverse process, and ribs were confirmed by ultrasound. The first rib was identified in the parasagittal plane, and the ribs were counted in order. The T3–4 intercostal space and the transverse process were confirmed by an in-plane intercostal approach, as described by Shibata and Nishiwaki¹⁶. The needle was in the thoracic paravertebral space, and 1 mL of test dose was applied to confirm the displacement of the pleura. The assistant subsequently injected 14 mL of the prepared drug. The same procedure was applied to the fifth thoracic paravertebral space. At this time, the thoracic paraspinal space was dilated, and the pleura were

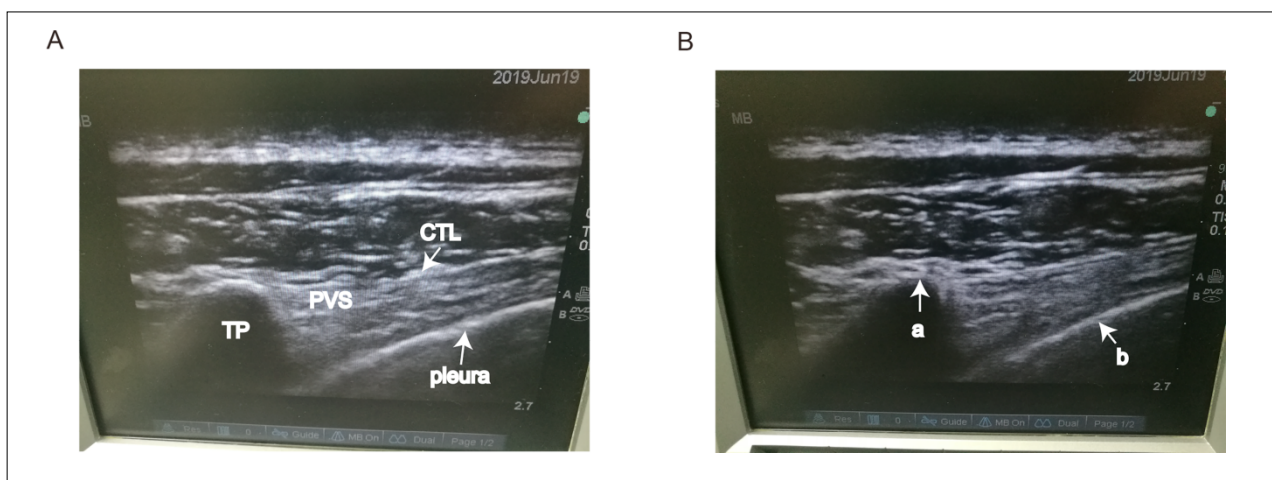
pushed to the ventral side by local anesthetic. In the I group, ultrasound-guided ICNB¹⁷ (figure 2) was performed in the lateral position. A linear ultrasound probe was placed in the longitudinal plane with the superior portion of the probe rotated 15 degrees laterally at the posterior angulation of the desired rib. The three layers of intercostal muscle (external, internal, and innermost) were identified in the intercostal space between the adjacent ribs. The needle was introduced under guidance until the tip was resting within the internal layer of the intercostal muscle. At that point, the needle was meticulously advanced into the innermost layer of the intercostal muscle. After negative aspiration for air or blood, 0.25% ropivacaine was administered in divided doses at the level of the incision and two spaces above and below the incision.

After the nerve block was completed, the anesthesia was maintained with propofol (TCI, 2.50 µg/mL) and dexmedetomidine (0.20 µg/kg·h) for continuous pumping. After the artificial pneumothorax collapsed, 0.375% ropivacaine mixed with 1.00% lidocaine was used for the thoracic vagus nerve block, 2.00% lidocaine (5.0 mL) was sprayed on the lung surface and observed for 30 sec. After the vital signs were stable, surgery commenced.

Outcome assessment

Video-assisted thoracic surgery (VATS) for pulmonary lobectomy was performed by the same thoracic surgery team. The severity of mediastinal flutter was evaluated by the thoracic surgeon who was blinded to the chest nerve block approach used.

FIGURE 1. ULTRASOUND-GUIDED PARAVERTEBRAL NERVE BLOCK



(A) The transverse process (TP), costotransverse ligament (CTL), and pleura are identified, and the paravertebral space (PVS) is visualized. (B) a is transverse process; b is parietal pleura.

The mediastinal flutter was classified as follows: grade 1= slight mediastinal flutter; grade 2= moderate mediastinal flutter which would not disturb the surgery; and grade 3= severe mediastinal flutter, which would prevent surgery. Grades 1 and 2 were both considered clinically effective. Patients with grade 3 mediastinal flutter during surgery were converted to general anesthesia with the administration of non-depolarizing muscle relaxants. The duration of the block procedure and complications, such as LA intonation, vascular puncture, hematoma formation, nerve injury, and visceral injury, if any, were also recorded.

Statistical analysis

Data are expressed as the mean \pm SD for age, height, weight, operation, and duration of block procedure. An independent sample unpaired t-test was applied for comparison of age, height, weight, operation, and duration of block procedure in normal distributions, and Mann-Whitney U tests were performed for continuous ASA scores. Chi-squared tests were performed for gender, method of chest nerve block, and complications. All statistical analyses were performed using SPSS 16.0 (SPSS, Inc., Chicago, IL, USA). P-value ≤ 0.05 was considered as statistically significant.

RESULTS

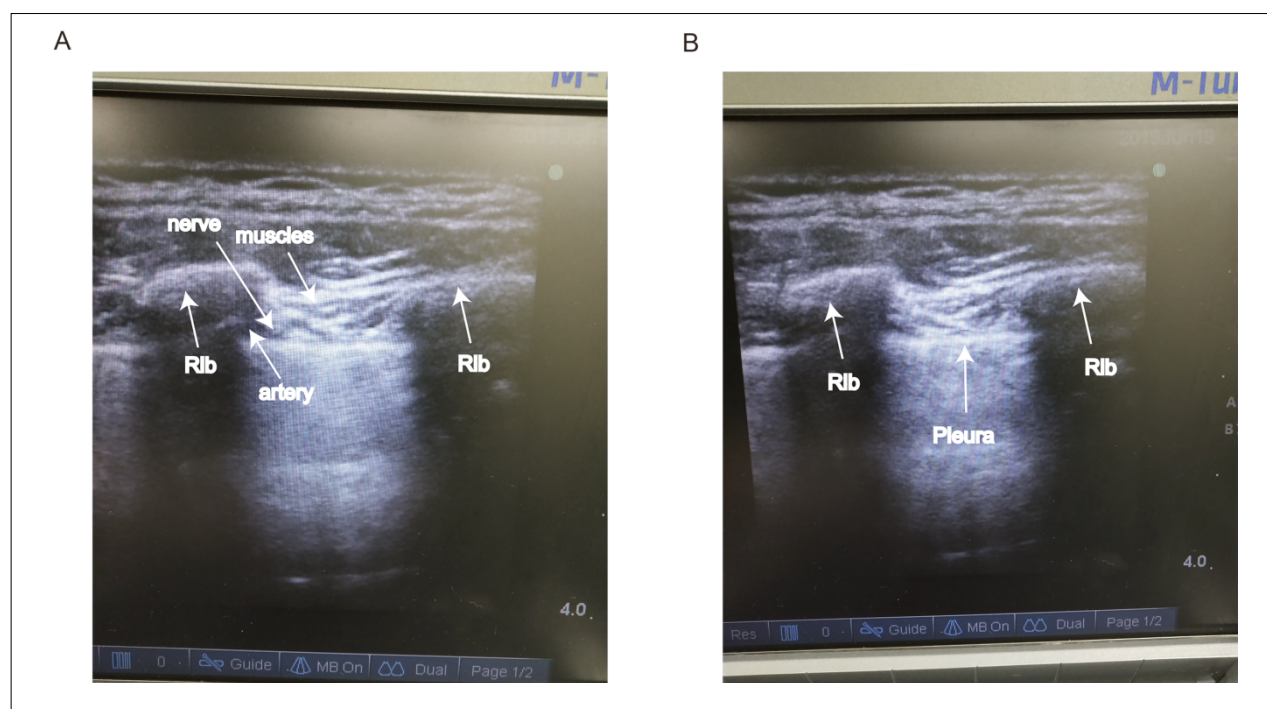
The demographics of the patients are presented in Table 1. There were no significant differences in the duration of surgery or block procedure between

TABLE 1. DEMOGRAPHICS OF PATIENTS

	P-group	I-group	P-value
Age (years)	41.2 \pm 6.1	40.4 \pm 6.3	0.55
Sex			
Male	36	35	0.62
Female	14	15	
Height (cm)	166.9 \pm 6.4	167.1 \pm 6.3	0.79
Weight (kg)	65.8 \pm 7.5	66.1 \pm 8.1	0.78
ASA score			
I	12	13	0.59
II	38	37	
Site of chest nerve block			
Right	24	25	0.56
Left	26	25	
Duration of operation (mins)	52 \pm 7.8	51 \pm 8.2	0.69
Duration of block procedure (hs)	8.6 \pm 2.1	8.8 \pm 1.8	0.49
Complications			
Local anesthetic intonation	0	0	1.0
Vascular puncture	1	4	0.01
Hematoma	0	0	1.0
Nerve injury	0	0	1.0
Visceral injury	0	0	1.0

Abbreviation: ASA, American Society of Anesthesiologists' physical status classification.

FIGURE 2. ULTRASOUND-GUIDED INTERCOSTAL NERVE BLOCK



(A) Depicting the positions of the intercostal muscles, artery, and adjacent ribs. (B) Ultrasound view of the intercostal space.

the two groups. No difference was found in the clinical efficacy of the chest nerve block between the two groups. Two patients in the ICNB group were converted to general anesthesia for severe mediastinal flutter (grade three). The number of patients who had grade one mediastinal flutter in the TPVB group was significantly higher than in the ICNB group. Vascular puncture was noted in four patients in the ICNB group and in one patient in the TPVB group. No other complications were observed.

DISCUSSION

A TPVB or ICNB combined with a laryngeal mask to retain spontaneous-breathing anesthesia achieved “integral minimally-invasive,” including anesthesia, avoiding damage and complications caused by endotracheal intubation, and reducing the use of anesthetics. The adverse reactions and side effects of the drug were alleviated, the influence on the function of the neuroendocrine-immune system of the body was reduced, the post-operative feeding time was shortened, the time course of antibiotics was less, the indwelling time of the drainage tube was shortened, the hospital stay was reduced, rapid recovery was achieved, and medical resources were saved, thus fostering economic and social benefits and greatly improving patient satisfaction^{3,4}. We evaluated the effect of TPVB or ICNB based on the mediastinal flutter during surgery and ensured the safety of the procedure by changing the anesthesia technique in a timely fashion. The results of this study indicate that both approaches had similar clinical effectiveness, suggesting a feasible alternative for chest nerve block¹⁸.

When TPVB and ICNB are not effective, the patient will have changes in body movement, blood pressure, and heart rate, and an increase in breathing and in the amplitude of the mediastinal flutter; thus, seriously affecting the operation¹⁹. The incidence of grade 1 was significantly higher in the P group than the group I, indicating that the TPVB method was superior to the ICNB. Because of the interneuronal brachialization of the intercostal space, the ICNB is also in the position of the surgical incision. The intercostal nerves of the upper and lower gaps should also be blocked at the same time. The intercostal nerve is located in the rib groove at the lower edge of the rib under the arteries and veins. The intercostal nerve and intercostal arteriovenous supply are not easily

recognized via ultrasound and increase the probability of arterial injury and the incidence of pneumothorax. We could try to avoid vascular puncture using ultrasound guidance, but complete prevention cannot be assumed and might account for the four vascular puncture patients in group I. A TPVB can achieve a good analgesic effect. A local anesthetic can be injected into the paravertebral space and can spread up or down through the rib head and rib neck, spread to the opposite side through the intervertebral foramen, and outward to the intercostal space level, thereby blocking its movement, sensation, and sympathetic nerves, and exerting clinical effects²⁰. This anatomic feature explains the results observed in this study.

As mentioned previously, four approaches have been proposed in different studies and are summarized in Table 2. Ultrasound-guided TPVB or ICNB was used in this study²¹. The operation was simple, the analgesia was exact, and the complications were few; however, the plasma concentration of propofol TCI required in the P group was lower than the I group, which may indicate that the paravertebral block effect is better, the stress response is lighter, and a sympathetic block is achieved. We could try to avoid vascular puncture using ultrasound guidance, but complete prevention cannot be assumed and might account for the two vascular puncture patients in the group I.

There were two limitations to the current study. One major limitation was the small sample size. In addition, a multitude of factors underlies mediastinal flutter, which is mainly caused by insufficient analgesia. In this study, however, the amplitude of the mediastinal flutter was used to reflect the block effect (good or bad); thus, the research results may be biased, seeking better indicators for the effect of the block, and make the research results more realistic.

In summary, ultrasound-guided TPVBs and ICNBs are simple and successful alternative techniques for thoracoscopic surgery. However, TPVB has more merit. In addition, attention should be paid to the problem of vascular puncture and pneumothorax.

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Disclosure

The authors report no conflicts of interest in this work.

Author Contributions

Conceptualization, Yongfeng Zheng; formal analysis, Hong Wang, Zheng Cheng and Xiaodong Ma; writing—original draft preparation Yongfeng Zheng;

writing—review and editing, Yongfeng Zheng and Donghua Shao; supervision, Weibao Cao; funding acquisition, Donghua Shao.

RESUMO

OBJETIVO: O objetivo do presente estudo é comparar a eficácia de duas técnicas diferentes para o bloqueio nervoso torácico durante cirurgia torácica vídeo-assistida (CTVA) e anestesia com ventilação espontânea.

METODOLOGIA: Cem pacientes foram incluídos no estudo e divididos em dois grupos. Em um (grupo P), foi utilizada a abordagem de BPVT e no outro (grupo I), a abordagem de BIC. Então, a taxa de eficácia clínica, duração do procedimento de bloqueio e suas complicações foram registradas para a comparação do efeito das duas abordagens.

RESULTADOS: Nenhuma diferença foi observada no efeito clínico do bloqueio nervoso torácico entre os dois grupos. Dois pacientes no grupo de BIC foram convertidos para anestesia geral devido a fibrilação mediastinal grave (grau três). O número de pacientes com fibrilação mediastinal de grau um no grupo de BPVT foi significativamente maior do que no grupo de BIC. Perfuração vascular foi detectada em quatro pacientes do grupo de BIC e em um do grupo de BPVT. Não foram observadas outras complicações.

CONCLUSÃO: Não houve diferença de eficácia clínica entre os dois grupos. No entanto, BPVT guiado por ultrassom foi superior ao BIC guiado por ultrassom durante CTVA para lobectomia pulmonar com anestesia em ventilação espontânea. Além disso, deve-se prestar mais atenção quanto à perfuração vascular.

PALAVRAS-CHAVE: Anestesia. Bloqueio nervoso. Cirurgia torácica. Cirurgia vídeoassistida.

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