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The Effectiveness of Regional Analgesia Techniques in Thoracoscopic Surgeries: A Retrospective Single-Center Study

Torakoskopik Cerrahilerde Rejyonal Anestezi Tekniklerinin Etkinliği: Retrospektif Tek Merkez Çalışması

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ABSTRACT

Objective: Appropriate pain treatment before, during, and after surgery positively affects the immune system and prevents chronic pain. Postoperative thoracotomy pain is both severe and difficult to manage. In addition to systemic opioid and non-opioid analgesics, neuraxial analgesic techniques such as thoracic epidural analgesia or thoracic paravertebral block are widely applied for pain control. Various fascial plane blocks are also used in thoracic surgery. The purpose of this study was to investigate the analgesic effectiveness of regional analgesia techniques used in thoracic surgeries in our clinic.

Methods: Following receipt of approval from the Koç University Clinical Research Ethics Committee, the records of 372 patients who underwent video-assisted thoracoscopic surgeries at the VKV American Hospital, Turkey, between January 2019 and December 2021 were reviewed retrospectively.

Results: Patients who received epidural analgesia exhibited statistically significantly lower pain scores and postoperative additional analgesic needs ($p<0.001$). Rhomboid intercostal subserratus block as the most effective option for postoperative analgesia among alternative regional analgesia methods according to postoperative pain scores and postoperative opioid consumption.

Conclusion: We still recommend thoracic epidural as the first choice for patient comfort, especially in clinics where thoracic anesthesia experience is high. Moreover, with the increasing prevalence of fascial plane blocks, we think that rhomboid intercostal blocks may be an important alternative in thoracic surgery.

Keywords: Thoracoscopic surgery, postoperative analgesia, VATS, fascial plane blocks

ÖZ

Amaç: Ameliyat öncesi, sırası ve sonrasında uygun ağrı tedavisi, bağışıklık sistemini olumlu yönde etkiler ve kronik ağrıları önler. Postoperatif torakotomi ağrısı hem şiddetlidir hem de tedavisi zordur. Sistemik opioid ve opioid olmayan analjeziklere ek olarak, torasik epidural analjezi veya torasik paravertebral blok gibi nöroaksiyel analjezik teknikler ağrı kontrolü için yaygın kullanılan yöntemlerdir. Göğüs cerrahisinde de çeşitli fasyal plan blokları kullanılmaktadır. Bu çalışmanın amacı kliniğimizde göğüs cerrahisi operasyonlarında kullanılan bölgesel analjezi tekniklerinin analjezik etkinliğini araştırmaktır.

Yöntem: Koç Üniversitesi Klinik Araştırmalar Etik Kurulu'ndan onay alındıktan sonra Ocak 2019-Aralık 2021 tarihleri arasında Türkiye'de VKV Amerikan Hastanesi'nde video yardımlı torakoskopik cerrahi uygulanan 372 hastanın kayıtları geriye dönük olarak incelendi.

Bulgular: Epidural analjezi alan hastalar istatistiksel olarak anlamlı derecede daha düşük ağrı skorları ve daha az postoperatif ek analjezik ihtiyaçları gösterdi ($p<0,001$). Rhomboid interkostal subserratus blok, postoperatif ağrı skorları ve postoperatif opioid tüketimine göre alternatif bölgesel analjezi yöntemleri arasında en efektif postoperatif analjezi sunan seçenek olarak bulundu.

Sonuç: Özellikle torasik anestezi deneyiminin yüksek olduğu kliniklerde hasta konforu açısından halen ilk tercih olarak torasik epidural önermekteyiz. Ayrıca fasyal plan bloklarının artan prevalansı ile birlikte özellikle rhomboid interkostal bloğun göğüs cerrahisinde önemli bir alternatif olabileceğini düşünmekteyiz.

Anahtar sözcükler: Torakoskopik cerrahi, postoperatif analjezi, VATS, fasyal plan blokları

INTRODUCTION

Thoracic and abdominal surgeries cause severe pain that contributes to perioperative morbidity and mortality. Appropriate pain treatment before, during, and after surgery exhibits positive effects on the immune system and prevents chronic pain (1). Surgical incisions cause somatic and visceral pain. A surgical stress response is one of the main causes of systemic inflammation and endocrine responses. The central nervous, endocrine, and immune systems are interconnected and in

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constant communication. Perioperative pain contributes to perioperative immune modulation by activating the neuroendocrine axis. Effective pain management causes a decrease in proinflammatory cytokine levels and an increase in lymphocyte activity (2,3).

Postoperative thoracotomy pain is both severe and extremely difficult to manage. In addition to systemic opioid and non-opioid analgesics, neuraxial analgesic techniques such as thoracic epidural analgesia (TEA) or thoracic paravertebral block (TPVB) are widely applied for the purpose of pain control. Although thoracotomy is highly effective in controlling pain, there are some concerns regarding TEA. Alternative methods are currently emerging due to the significant side-effects of these techniques (such as hypotension, neurological damage, infection, and hematoma), situations in which they may be contraindicated, and the adverse consequences of the difficulty of administration. Thoracic paravertebral block is as effective for post-thoracotomy pain as TEA, but has a lower complication and side-effect profile. However, TPVB is still considered a neuraxial block with similar contraindications and major complications to those of TEA (4).

Recent advances in thoracic surgery, especially microinvasive approaches such as video-assisted thoracic surgery (VATS) and robot-assisted thoracic surgery (RATS), have encouraged the use of alternative analgesics instead of TEA in anesthesia practise. Various fascial plane blocks are used for this purpose in thoracic surgery (5). Thoracic wall blocks represent alternatives to TEA and TPVB in terms of ease of performance and safety. Since the injection targets are far distant from critical anatomical structures, there is little or no theoretical risk of significant complications or lung injury. Anatomical knowledge is of crucial importance for proper block performance, block technique, and proper matching of the surgical procedure (5). This includes the innervation of the anatomical course of target nerves and related anatomical tissues. Considering the innervation of the relevant nerves, anterior-medial, anterolateral, and posterior chest wall and axillary innervations should be targeted. When targeting anterolateral chest wall analgesia, pectoralis (PECS) and serratus anterior blocks are recommended for use, either alone or in combination. Combinations of parasternal-intercostal blocks and PECS II blocks are recommended when targeting anteromedial chest wall analgesia. Paraspinal fascial plane blocks are recommended for posterior chest wall analgesia. Erector spinae plane block (ESPB), retrolaminar block, mid-point transverse process to pleura block, and rhomboid intercostal subserratus plane block (RISS) are widely used among the paraspinal fascial plane blocks (5,6).

The purpose of this study was to investigate the postoperative analgesic effectiveness of regional analgesia techniques used in thoracic surgery in our clinic.

MATERIAL and METHODS

Following the receipt of approval from the Koç University Clinical Research Ethics Committee (2021.465.IRB1.132), the records of patients who had undergone thoracic surgery at the VKV American Hospital, Turkey, between January 2019 and December 2021 were reviewed retrospectively.

The patients' demographic data were retrieved from the preoperative evaluation forms and the operation types from the surgery reports. Intra-operative anesthesia follow-up forms were examined to determine whether regional anesthesia was performed, which regional anesthesia technique was used, and the type and amount of opioids employed during the operation. Post-operative transfer to the ward, nurse record, and follow-up forms were also examined. Pain scores, vital signs, mobilization, and starting times of respiratory exercises were all recorded. Finally, we also investigated whether patient-controlled analgesia (PCA) was used for postoperative pain monitoring.

Patient Management in Thoracic Surgery in Our Clinic

Our clinic's primary surgical approach in thoracic surgery involves VATS. All patients are taken for surgery at least 24 h after preoperative anesthesia evaluation. Two experienced anesthesiologists are involved in thoracic surgery and perform all procedures. All patients are operated under general anesthesia. Regional analgesia techniques are employed, except in case of contraindications, in order that patients may experience a comfortable postoperative analgesia period. Thoracic epidural analgesia is employed as the gold standard method in lobectomy operations. Facial plane blocks are used in wedge resection/segmentectomy or non-resection thoracoscopic surgeries. All thoracic epidural catheterization was performed under sedation approximately 30 minutes before the surgery. Thoracic epidural catheters are usually inserted between T4 and T6. We use various fascial plane blocks in thoracic surgeries. Although TPVB, ESPB, RISS and serratus anterior blocks are the fascial plane blocks we most frequently employ, these are also used in intercostal and thoracic paravertebral blocks. All fascial plane blocks were performed under general anesthesia and at the end of surgery, approximately 30 minutes before extubation. If the TEA is applied, then we use epidural PCA for postoperative pain control. If the fascial plane block is applied, then we employ intravenous morphine PCA for postoperative pain control. Epidural PCA doses of bupivacaine 1.33% are used as a standard for VATS postoperative analgesia in our clinic. Infusion and bolus doses are adjusted according to the patient. Bupivacaine concentration of 0.25% is used in all fascial plane blocks. Twenty mL of local anesthetic is used for ESPB, serratus anterior block, TPVB and 30 mL for RISS block. Paracetamol was used in the routine analgesic protocol in all patients' ward follow-ups,

and tramadol was administered as the rescue analgesic. The same two anesthesiologists perform all invasive procedures.

Exclusion Criteria

Patients with a history of cerebrovascular events, Alzheimer's disease and dementia, inadequate cognitive functions, history of chronic pain, or long-term opioid therapy were excluded from the study.

Statistical Analysis

Data were summarized as mean±standard deviation for continuous variables, frequencies (percentiles) for categorical variables. Student's t test or Mann Whitney U test was used for independent group comparisons, depending on the distributional properties of the data. Chi-square test was used for proportions and its counterpart Fisher's Exact test was used when the data were sparse. One Way Anova model Anova and/or Kruskal Wallis tests used to compare more than two independent group and when the p-value from these test statistics are statistically significant, pairwise comparisons were used to know which time point differ from which others (Duncan and Dunn's tests, respectively). Comparisons of time dependent measures such as pain score and opioid doses measurements were done by paired t-test. A p value of less than 0.05 was considered statistically significant and SPSS 15.0 for Windows were used for all these statistical analyses.

RESULTS

The records of 479 patients who underwent thoracic surgery between January 2019 and December 2021 were reviewed. Ninety-eight patients were excluded from the study due to extrapulmonary operations and receiving gabapentin/opioid therapy, and nine patients due to missing records for postoperative pain management. There was no record of cerebrovascular events and inadequate cognitive functions. The records of 372 patients were thus finally evaluated. Regional analgesia was applied to all patients.

Table I. Demographic Data and Operation Characteristics (Number of Patients) [Mean ± SD]

Gender (M/F)	224/148
Age (years)	46.8±12.4
BMI (kg m^{-2})	24.8±5.7
Wedge and segmentectomy	171
Lobectomy and pneumonectomy	201

BMI: Body mass index, **M:** Male, **F:** Female.

The patients' demographic data and operation characteristics are shown in Table I. The distribution was predominantly in favor of male gender. In term of comorbid diseases, the most common accompanying disease was hypertension, while thoracoscopic lobectomy was most frequently performed. There was a significant difference in male-female distribution for the wedge and lobectomy main groups, which was investigated by chi-square analysis (p=0.020). There was no significant difference in the distribution of males and females between subgroups of wedge/lobectomy patients investigated by Fisher's exact test analysis (p=0.993). Among other parameters, no significant difference was found between patients who underwent lobectomy and wedge/segmentectomy (p>0.05).

The distribution of regional analgesia methods is shown in Table II. The main regional analgesia technique was TEA, which was used in all thoracoscopic lobectomy operations. Thoracic epidural analgesia or alternative regional analgesia methods are used in patients undergoing thoracoscopic wedge resection. The intercostal block was added at the chest tube level in serratus anterior block patients.

The postoperative recovery unit (PACU), intensive care, and ward follow-up forms were examined, the patients' first 24-h and 24-48-h pain scores are given in Table III. Patients who received epidural analgesia exhibited statistically significantly lower pain scores (p<0.001). Rhomboid intercostal subserratus plane block emerged as the most effective option among the alternative regional analgesia methods. Thoracic paravertebral block was effective in the first 24 h, but the effect duration decreases between 24 and 48 h.

Morphine consumption rates during the first postoperative 48 h are given in Table IV. Serratus anterior block was associated with significantly higher morphine consumption compared to other regional analgesia techniques (p<0.001). The lowest morphine consumption among the alternative analgesia methods was in the RISS block group (p<0.05). Opioid consumption in patients undergoing TPVB was mostly observed between 24 and 48 h. Examination of the PACU and ward nurse observation forms and physician order forms revealed that all patients were given tramadol as additional

Table II. Distribution of Regional Analgesia Methods Applied (Number of Patients)

	TEA	ESPB	TPV	RISSB	SAP
Lobectomy and pneumonectomy	201	-	-	-	-
Wedge and Segmentectomy	103	23	17	25	3

TEA: Thoracic epidural analgesia, **ESPB:** Erector spinae plane block, **TPV:** Thoracic paravertebral block, **RISSB:** Rhomboid intercostal sub-serratus plane block, **SAP:** Serratus anterior plane block.

Table III. Postoperative 0 -24 Hour Pain Scores [(NRS) Mean ± SD]

	TEA	ESPB	TPV	RISS	SAP	p
0 – 24 hour	1.5±1[I]	5±0.6	3.3±1.5[II]	3.5±0.9[III]	6.1±1.6	<0.001[I,II,III]
24 – 48 hour	1.3±1.1[I]	3.7±0.6	4.1±0.6[II]	3.5±1.2[III]	5.7±1.5	<0.001[I,II,III]

[I]Comparison between TEA and other all fascial plane blocks
[II,III]Comparison of all fascial plane blocks with each other
NRS: Numeric pain rating scale, **TEA:** Thoracic epidural analgesia, **ESPB:** Erector spinae plane block, **TPV:** Thoracic paravertebral block, **RISSB:** Rhomboid intercostal sub-serratus plane block, **SAP:** Serratus anterior plane block.

Table IV. Postoperative 48-Hour Opioid Consumption (Mean ± SD)

	TEA	ESPB	TPV	RISS	SAP	p
Morphine (mg)	-	54.5±5.9[I]	51.5±8.4[I]	47.4±7.1[I]	109.8±8.9	<0.001[I]
Tramadol (mg)	31.2±35.9[II]	106.2±35.9[III]	96.8±49.8[III]	87.5±22.3[III]	233.3±57.7	<0.001[II,III]

[I] Comparison of morphine consumption of ESPB, TPV, and RISS block compared to serratus anterior block (p<0.001), Comparison of morphine consumption of ESPB, TPV, and RISS blocks with each other (p>0.05)
[II]Comparison of tramadol consumption of TEA compared to other regional analgesia techniques (p<0.001)
[III]Comparison of tramadol consumption of ESPB, TPV, and RISS block compared to serratus anterior block (p<0.001), Comparison of tramadol consumption of ESPB, TPV, and RISS blocks with each other (p>0.05)
ESPB: Erector spinae plane block, **TPV:** Thoracic paravertebral block, **RISSB:** Rhomboid intercostal sub-serratus plane block, **SAP:** Serratus anterior plane block.

rescue analgesia. The use of tramadol in the first 48 h postoperatively is shown in Table IV. Tramadol requirements were lowest in patients who underwent TEA (p<0.001). A comparison of ESPB, TPVB, and RISS block in terms of intravenous tramadol consumption revealed significantly lower tramadol consumption and requirements in the RISS block (p<0.05).

Analysis of the intraoperative anesthesia forms and acute pain team forms revealed that TEA was applied at the T4-6 and T6-8 levels. No major thoracic epidural catheter-related complications were observed. Examination of the pain follow-up forms showed that the catheter emerged spontaneously on the first postoperative day in three patients. In addition, motor block developed in five patients on the first postoperative day and prevented mobilization, which was achieved by adjusting the PCA doses. Examination of the ward follow-up and nurse follow-up forms showed no difference in terms of respiratory exercise start times.

DISCUSSION

According to our study results, TEA was the most frequently used technique in thoracic surgery, and exhibited the highest analgesic effect. The rhomboid intercostal block was found to provide the most effective postoperative analgesia among the different fascial plane blocks.

Thoracic surgery causes very severe pain. Severe and unavoidable pain-induced respiratory complications such as atelectasis and pneumonia can also lead to poor outcomes such as longer hospital stays, poor quality of life, and chronic pain.

The source of pain seen after thoracic surgery is mediated by nociceptive somatic and visceral mechanisms, neuropathic mechanisms, and pain referred from the phrenic nerve. The latter is usually felt in the shoulder and may not be relieved by TEA because it originates from the cervical roots. The nociceptive somatic component is the main source of pain and originates from the intercostal nerves activated by damage to the chest wall and pleura. Skin incision, trocar insertion, muscle damage due to the surgical incision, rib retraction, and chest tubes or surgical drains contribute to this pain. Inflammatory cytokines released from the surgical site directly activate nociceptive receptors, resulting in the release of glutamate that activates N-methyl-D-aspartate (NMDA) receptors in the spinal cord. Activation of NMDA receptors is important because it increases the cell's response to painful stimuli and reduces neuronal sensitivity to opioid receptor agonists (7-9).

There are several analgesic options for patients undergoing thoracic surgery, including systemic agents and regional techniques. Although regional analgesia is the most important method, the multimodal analgesic approach is the most effective technique in these patients. Systemic analgesics include non-steroidal anti-inflammatory drugs (NSAIDs), NMDA receptor antagonists, acetaminophen, gabapentinoids, and opioids. Systemic analgesics are an important step in multimodal analgesia. Non-steroidal anti-inflammatory drugs are especially useful in cases such as shoulder pain that cannot be relieved by epidural analgesia. They also increase the quality of epidural analgesia. Opioid-based intravenous PCA is widely used after thoracic surgeries. However, the use of

intravenous opioids in thoracic surgery has evolved from being a primary analgesic to a rescue agent due to both opioid-related side-effects and respiratory problems that may occur due to ineffective analgesia. The aim is to minimize opioid consumption in order to avoid opioid-related side effects (10,11). In the present study, opioid consumption was very low in patients receiving epidural analgesia. This can be important in early rehabilitation, especially after thoracic surgery. Opioid-free analgesia is the desired objective in postoperative pain (12). Epidural analgesia providing low opioid consumption is therefore regarded as the gold standard.

Inadequate pain management increases the risk of the development of hypoxemia, hypercarbia, increased myocardial workload, myocardial ischemia, and post-thoracotomy pain syndrome in the postoperative period. An improved pathway for thoracic surgery should therefore combine multimodal analgesia with regional analgesia techniques while seeking to avoid the use of opioids and their side-effects. Enhanced recovery after surgery protocols describe epidural analgesia as an important part of intraoperative pain management and as the gold standard technique for pain control after major thoracic surgery. Adverse effects associated with the perioperative use of epidural analgesia include urinary retention, hypotension, and muscle weakness (13). These side-effects may be related to the postoperative local anesthetic concentration and volume used in epidural analgesia. A high rate of epidural analgesia was used in the present study, and careful follow-up of epidural analgesia may explain the low incidence of these side-effects in the postoperative period.

In many studies involving ESPB, the effect mechanism of action is controversial and remains unclear. The ventral rami involvement of the spinal nerves and transforaminal and epidural spread are also the subject of debate. Both favorable and unfavorable studies have been published. Numerous studies of thoracic surgery have concluded that the ESPB offers effective analgesia, especially in patients who do not receive regional analgesia. It is also reported to yield better results compared to the thoracic paravertebral block (14). Erector spinae plane block also reduced opioid consumption in the present study, although this effect was not as marked as in epidural analgesia. Our clinical experience suggests that ESPB can be effective and beneficial in single-port VATS.

Finnerty et al. showed that ESPB exhibited better analgesic effects than serratus anterior in minimally invasive thoracic surgery patients (15). Taketa et al. compared ESPB and TPVB and observed equivalent postoperative analgesic effects in VATS (16). Wang et al. compared to SAP and TPV and also observed an equivalent postoperative analgesic effect in uni-portal VATS operations (17). Deng et al. compared the RISS and rhomboid intercostal block in a randomized controlled study, in which RISS exhibited more effective analgesic properties (18). Those authors suggested adding a sub-serratus block to the rhomboid intercostal block in thoracoscopic surgeries. The present study shows that the RISS block is the most effective of the fascial plane blocks in terms of postoperative analgesia efficiency. The least adequate analgesia seems to be provided by the serratus anterior block. However, the small number of serratus anterior blocks performed may be insufficient for a meaningful comparison.

Low pain scores were seen at 12-24 h in ESPB, although these were higher at 0-12 h. These values showed that the duration of analgesia gradually increased. However, the opposite applies in TPVB. Elkoundi et al. investigated local anesthetic plasma concentrations in ESPB and TPVB and observed higher plasma concentrations in ESPB (19). There are a number of limitations to this study. In particular, the numbers of regional analgesia techniques were different. Since the research involved a retrospective examination of the patient records, the block numbers could not be pre-planned and equalized. Due to the unequal numbers of blocks, their success may be capable of different interpretations. However, since the results were similar, we do not expect that the results will change when distribution is examined. Pain scores were interpreted using a single scale. An intercostal block was added at the chest tube level in order to contribute to postoperative analgesia following the serratus anterior block. Our clinical experience required an intercostal block combination of serratus anterior blocks. This can provide an additional advantage to the serratus anterior block alone. However, according to the study results, serratus anterior block was combined with intercostal block, but was most ineffective in terms of postoperative pain. We therefore think this positive contribution added to the serratus anterior block causes no limitations. It has been suggested that the amount of systemic local anesthetic absorption may be significant among the effect mechanisms of ESPB. This may play a role in the duration of analgesia. The variable and prolonged duration of fascial plane blocks is controversial. Further studies are needed in this area.

CONCLUSION

Thoracic epidural analgesia remains the gold standard method in thoracic surgery. It is the most preferred regional anesthesia method, especially after lung resections because of its effective and prolonged postoperative analgesia quality and low complication rates in experienced hands. Rhomboid intercostal and sub-serratus blocks can be the first choice among the alternative methods in fascial plane blocks. We think thoracic epidural analgesia should be the first choice for patient comfort and safety, especially in clinics where the experience of thoracic anesthesia is high.

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AUTHOR CONTRIBUTIONS

Conception or design of the work: SKC

Data collection: SKC

Data analysis and interpretation: SKC, OE

Drafting the article: SKC

Critical revision of the article: SKC, OE

Other (study supervision, fundings, materials, etc): SKC, OE

All authors (SKC, OE) reviewed the results and approved the final version of the manuscript.

Finances: Our research is a retrospective study. The research data are taken from the hospital database.

Conflict of Interest: Researchers do not have any conflicts of interest.

REFERENCES

1. Glare P, Aubrey KR, Myles PS. Transition from acute to chronic pain after surgery. Lancet 2019;393(10180):1537-46.
2. Pinho-Ribeiro FA, Verri WA Jr, Chiu IM. Nociceptor sensory neuron-immune interactions in pain and inflammation. Trends Immunol 2017;38(1):5-19.
3. Novak-Jankovič V, Markovič-Božič J. Regional anaesthesia in thoracic and abdominal surgery. Acta Clin Croat 2019;58(Suppl 1):96-100.
4. Marciniak D, Kelava M, Hargrave J. Fascial plane blocks in thoracic surgery: A new era or plain painful? Curr Opin Anaesthesiol 2020;33(1):1-9.
5. Chin KJ, Versyck B, Pawa A. Ultrasound-guided fascial plane blocks of the chest wall: A state-of-the-art review. Anaesthesia 2021;76(Suppl 1):110-26.
6. Chin KJ. Thoracic wall blocks: From paravertebral to retrolaminar to serratus to erector spinae and back again - A review of evidence. Best Pract Res Clin Anaesthesiol 2019; 33(1):67-77.
7. Gandhi W, Pomares FB, Naso L, Asenjo JF, Schweinhardt P. Neuropathic pain after thoracotomy: Tracking signs and symptoms before and at monthly intervals following surgery. Eur J Pain 2020;24(7):1269-89.
8. Marshall K, McLaughlin K. Pain management in thoracic surgery. Thorac Surg Clin 2020;30(3):339-46.
9. Price DD, Mayer DJ, Mao J, Caruso FS. NMDA-receptor antagonists and opioid receptor interactions as related to analgesia and tolerance. J Pain Symptom Manage 2000;19(1 Suppl):S7-11.
10. Li S, Ding X, Zhao Y, Chen X, Huang J. Intravenous patient-controlled analgesia plus psychoeducational intervention for acute postoperative pain in patients with pulmonary nodules after thoracoscopic surgery: A retrospective cohort study. BMC Anesthesiol 2021;21(1):281.
11. Xu ZZ, Li HJ, Li MH, et al. Epidural anesthesia-analgesia and recurrence-free survival after lung cancer surgery: A Randomized trial. Anesthesiology 2021;135(3):419-32.
12. Loop T. Does thoracic epidural anaesthesia constitute over-instrumentation in video- and robotic-assisted thoracoscopic lung parenchyma resections? Curr Opin Anaesthesiol 2021;34(2):199-203.
13. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, et al. Guidelines for enhanced recovery after lung surgery: Recommendations of the Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS). Eur J Cardiothorac Surg 2019;55(1):91-115.
14. Huang W, Wang W, Xie W, Chen Z, Liu Y. Erector spinae plane block for postoperative analgesia in breast and thoracic surgery: A systematic review and meta-analysis. J Clin Anesth 2020;66:109900.
15. Finnerty DT, McMahon A, McNamara JR, Hartigan SD, Griffin M, Buggy DJ. Comparing erector spinae plane block with serratus anterior plane block for minimally invasive thoracic surgery: A randomised clinical trial. Br J Anaesth 2020;125(5):802-10.
16. Taketa Y, Irisawa Y, Fujitani T. Comparison of ultrasound-guided erector spinae plane block and thoracic paravertebral block for postoperative analgesia after video-assisted thoracic surgery: A randomized controlled non-inferiority clinical trial. Reg Anesth Pain Med 2019 Nov 8:rapm-2019-100827.
17. Wang L, Wang Y, Zhang X, Zhu X, Wang G. Serratus anterior plane block or thoracic paravertebral block for postoperative pain treatment after uniportal video-assisted thoracoscopic surgery: A retrospective propensity-matched study. J Pain Res 2019;12:2231-8.
18. Deng W, Hou XM, Zhou XY, Zhou QH. Rhomboid intercostal block combined with sub-serratus plane block versus rhomboid intercostal block for postoperative analgesia after video-assisted thoracoscopic surgery: A prospective randomized-controlled trial. BMC Pulm Med 2021;21(1):68.
19. Elkoundi A, Balkhi H, Bensghir M, Baite A. Levobupivacaine plasma level between erector spinae plane block and thoracic paravertebral block. Reg Anesth Pain Med 2021;46(1):90-1.