Original Article

Effectiveness and safety of new umbilical paramedian semilunaris approach for transverse abdominis plane block: a prospective, single-arm, observational, evaluation study

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Background: The transversus abdominis plane (TAP) block is a widely used, safe and effective technique for abdominal surgery analgesia, but its range of blocking is not sufficient for some surgeries requiring a large incision. Here we present the novel concept of an ultrasound-guided linea semilunaris block, a modified approach to TAP block, which can potentially offer a wider blocking range.

Methods: Patients undergoing open colorectal surgery at the Shanghai Jiaotong University Affiliated Sixth People's Hospital between May and July 2021 were enrolled to receive ultrasound-guided linea semilunaris block. All blocks were performed in the holding area of the operating theater under routine hemodynamic monitoring while patients were conscious with low-dose opioids. All patients were supine, and a linear probe identified the semilunar line as the connection between the transverse and rectus muscles. Next, 20 mL of 0.25% ropivacaine was injected in the semilunar line using the in-plane technique bilaterally. The main indicator of the blocking range was measured. Postoperatively, the visual analog score (VAS) from 4 to 24 h (every 2 h), the time of the first remedial analgesia, the bowel movement starting time and complications were also recorded.

Results: A total of 31 potentially eligible studies were identified for inclusion. The extent of the cutaneous sensory block was: 3.46±0.59 cm below the xiphoid, 1.74±0.37 cm above the symphysis pubis, 2.02±1.24 cm outside the left midclavicular line, and 2.19±1.25 cm outside the right midclavicular line. The highest and lowest median [interquartile range (IQR)] VAS pain scores were 4 [4–5] of 10 h and 2 [1–2] of 4 h postoperatively. The bowel movement starting time was 3.7±1.1 days after gastrointestinal surgery. There were four patients with nausea and vomiting but none had adverse reactions attributable to local anesthetic (LA) poisoning.

Conclusions: The ultrasound-guided umbilical paramedian semilunaris approach to TAP block is a safe and effective technique in clinical practice, which may provide more effective analgesia than traditional TAP block for open colorectal surgery with a median abdominal incision. Further randomized controlled trials are needed to confirm our results.

Keywords: Analgesia; open colorectal surgery; semilunar line block; transversus abdominis plane block (TAP block); ultrasound-guided

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Introduction

The transversus abdominis plane (TAP) block is widely used for surgical analgesia of the parietal peritoneum, the anterior abdominal wall and the skin (1). Many novel interligamentary plane blocks have been described as alternatives for TAP in order to expand the blocking range (posterior approach, lateral approach, and oblique subcostal approach) (1), as well as the rectus sheath block (2). However, the spread of local anesthetics (LAs) can be blocked by the semilunaris in these methods which limits the range of blocking. Therefore, a combination of two approaches (i.e., 4-point TAP) or two different methods (i.e., TAP combined with serratus anterior plane block), which has a potential risk of poisoning with high doses of LAs, is often required to provide effective postoperative analgesia for some abdominal surgeries requiring a large incision (3,4).

There are no studies investigating the effectiveness of TAP block at the linea semilunaris. The linea semilunaris is a well-known location where the aponeuroses of the external oblique (EO), internal oblique (IO) and transversus abdominis (TA) muscles converge. Bilaterally, the aponeuroses of the lateral three abdominal muscles form the rectus sheath; the sheaths attach to the linea alba and enclose the rectus abdominis muscle (RA). At the umbilical level, all aponeuroses travel anterior to the RA and create the rectus sheath's anterior layer; only the epimysium and the transversalis fascia line the inferior one-quarter of the RA's posterior aspect (5,6). Therefore, the linea semilunaris seems more like a structure of the aponeuroses superimposition than of the aponeuroses fusion. Consider if diffusion of LA across the RA's anterior dense aponeuroses planes reached the posterior loose transversalis fascia. In that case, LA may simultaneously spread medially and laterally at the linea semilunaris site to anesthetize both the anterior and lateral cutaneous branches of the thoracoabdominal nerves, which may potentially provide a wider blocking range and more effective analgesic than traditional TAP block.

Based on anatomical research, we developed a modified ultrasound-guided umbilical semilunar approach for the TAP block, and we evaluated its effectiveness in 31 cases of laparotomy with a median abdominal incision in this study. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-23-245/rc).

Methods

Study design

This study was a prospective, single-arm, observational, evaluation trial which was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The trial was approved by the Ethics Committee of Shanghai Jiaotong University Affiliated Sixth People's Hospital (No. 2021-253) and registered in the Clinical Trial Registry (https://www.chictr.org.cn/index.html) with registration number: ChiCTR2100051767 (03/10/2021). Written informed consent was given by participants before recruitment.

Study population

The inclusion criteria were as follows: (I) patients aged over 18 years old with Anesthesiologists Physical Status classification I to II; (II) subjects scheduled to undergo selected laparotomy operation under general anesthesia. Exclusion criteria were: (I) refusal to sign the consent form; (II) chronic pain under long-term opioid treatment; (III) allergic to ropivacaine; and (IV) skin infection at the abdominal injection site.

From 4th May to 31st July 2021, there were 31 consecutive patients scheduled to undergo median abdominal incision colorectal surgery.

Clinical protocol

On the day of surgery after fasting in accordance with American Society of Anesthesiology (ASA) guidelines, peripheral venous access was established in the ward. No

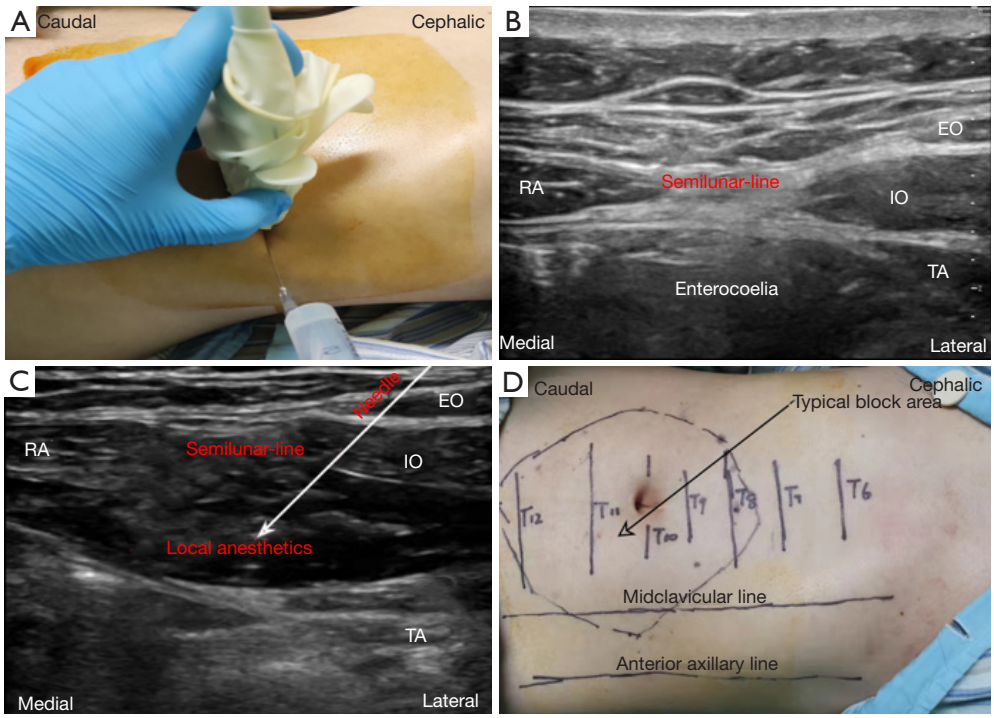
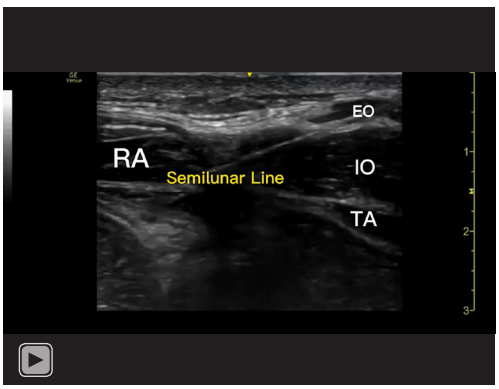


Figure 1 The details of umbilical paramedian semilunaris approach for TAP block technique. (A) Diagram of ultrasound probe placement; (B) ultrasound images of semilunar line approach for abdominal fascial plane block; (C) after completion of the block LA spread medially along the posterior rectus sheath and laterally along the transverse abdominal plane; (D) typical block area determined using alcohol skin sensation test. RA, rectus abdominis muscle; EO, external oblique muscle; IO, internal oblique muscle; TA, transversus abdominis muscle; TAP, transversus abdominis plane; LA, local anesthetic.



Video 1 Details of ultrasound-guided linea semilunar block.

premedication was used and patients were continuously monitored with noninvasive blood pressure monitoring (NIBP), heart rate, and oxygen saturation (SpO_2) after arriving at the holding area of the operating theater. Prior to performing the ultrasound-guided block, the patient was placed in the supine position (*Figure 1A*). A high-frequency ultrasound probe (5–13 MHz) was initially placed lateral to the umbilicus to show the rectus sheath, then moved laterally to visualize the EO, IO and TA, and the semilunar line as the connection between the RA and these three muscles (*Figure 1B*). A 22-gauge, 80-mm needle was inserted in an in-plane approach from lateral to medial aiming towards the bottom of the semilunar line. After negative aspiration, 20 mL of 0.25% ropivacaine was injected at the bottom of the semilunar line (*Figure 1C*). The anesthetic spread laterally and medially is shown in *Video 1*.

Outcomes and Assessment of sensory block and analgesic effect

The primary endpoint was the blocking range. At 10 min after administering the block, an investigator assessed temperature sensation of the anterior abdominal wall with alcohol swabs. All checks followed a clockwise order:

starting from the xiphoid, moving along the left subcostal line to the left anterior axillary line to the anterior superior iliac spine, moving down along the left inguinal ligament to the left cubic symphysis, then the right cubic symphysis to the right inguinal ligament, moving up along the right anterior superior iliac spine to the right anterior axillary line, along the right subcostal line back to the xiphos. The sensation of all check points was compared with the sensation of the umbilicus. If the sensations were similar, it signified that the area was blocked, and the check points moved a further 2 cm apart, until the sensations were different. Otherwise, the check points were moved 2 cm closer, until the skin temperature sensations were similar. By this method we were able to draw a circle around the typical area of cutaneous sensory block (*Figure 1D*). Each check point was tested three times; that is, every 10 min after the block up to 30 min.

All patients had appropriate general anesthesia for their operation with propofol 1–2 mg/kg, sulfentanyl 0.05 μg/kg and muscle relaxant for endotracheal intubation. Remifentanyl and sevoflurane were used to maintain anesthesia during the operation. All patients were moved to the postanesthetic care unit before returning to their wards or to the intensive care unit with patient controlled intravenous analgesia (PCIA) using 1 μg/mL sufentanil (150 mL). The PCIA was set to a continuous infusion rate of 3 mL/h, a bolus of 2 mL and lock-out time of 15 min. Other endpoints studied include: (I) the total amount of PCIA used during the first 24 h after surgery; (II) the 4 to 24 h pain score postoperatively, which was assessed by dedicated nurses every 2 h after surgery at the bedside using a visual analog score (VAS; 0 indicates no pain, 10 for most severe pain). If the patient was asleep, the score was regarded as less than 2. If the patient's VAS score exceeded 4, remedial analgesia was performed with flurbiprofen [50 mg intravenous (IV)]; (III) the time of the first remedial analgesia, which was recorded, was defined as the effective block time; (IV) the complications such as hematoma, nausea, vomiting, and LA toxicity (blurred vision, hearing impairment, sleep disturbances, dizziness, muscle twitching and arrhythmia).

Statistical analysis

For continuous variables, data are presented as mean ± standard deviation (SD) or median [interquartile range (IQR)] depending on the distribution of the data. For all categorical variables, frequency/percentage was calculated. Estimate effective block durations using the Kaplan-Meier method. All statistical analyzes were performed using PRISM version 7.0 (GraphPad Software, La Jolla, CA, USA) and SPSS version 22.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 39 patients were evaluated for study participation. Thirty-three patients who met the inclusion criteria were enlisted in the study. Two of these patients were excluded because the ultrasound-guided block could not be administered due to inaccessible apparatus. The recruitment pathway is presented in *Figure 2*. The basic characteristics were: age, 63.2±4.7 years; body mass index (BMI), 24.0±3.0; sex, 14 (45%) male and 17 (55%) female; and ASA grade, I 7 (23%) and II 24 (77%). The greatest and lowest median [IQR] VAS pain scores postoperatively were 4 [4–5] of 10 h and 2 [1–2] of 4 h. After gastrointestinal surgery, the first bowel movement occurred 3.7±1.1 days later. There were four patients with nausea and vomiting, but no adverse reactions due to LA poisoning were observed (*Table 1*).

All patients received an umbilical semilunar block under ultrasound guidance according to the study protocol. The extent of average cutaneous sensory block ranges from 3.46 cm superiorly to the xiphoid, 1.74 cm inferiorly to the suprasymphysial, 2.02 cm lateral to the left midclavicular line and 2.19 cm lateral to the right midclavicular line (*Table 2*). *Figure 3A* shows the trend in median VAS pain scores from 4 to 24h postoperatively, and the highest and lowest median [IQR] VAS pain score were 4 [4–5] at 10 h and 2 [1–2] at 4 h. *Figure 3B* shows the Kaplan-Meier survival plot for the duration of effective block; the median time of the block was 8.0 (6.8, 9.2) h.

Discussion

Our study demonstrated that the umbilical approach to semilunar line block provided fast-onset, safe and effective analgesia for abdominal surgery. The anterior abdominal wall block area is a mix of rectus sheath block and classic TAP block. The duration of the block was ~8 h with a large volume, yet low concentration of LA.

Traditionally, postoperative analgesia for abdominal surgery has been dominated by epidural analgesia, but TAP blocks are increasingly being used. Several clinical studies

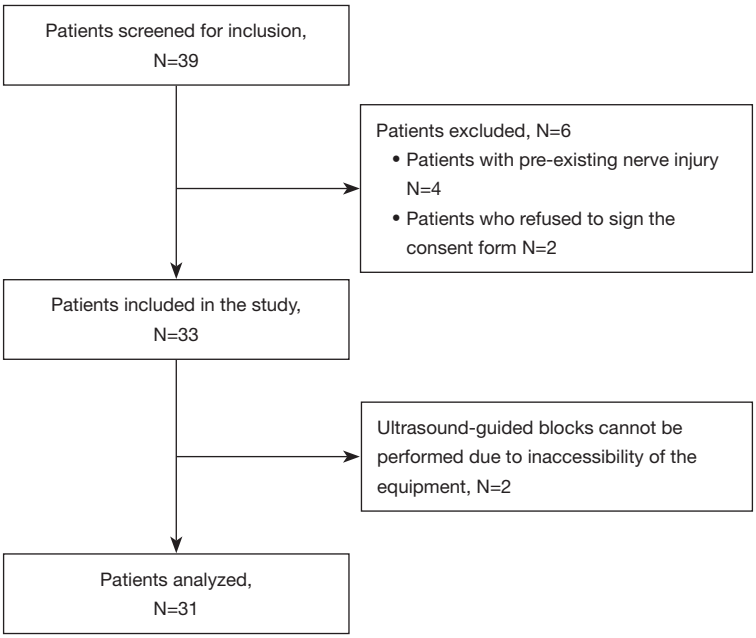


Figure 2 Flow of participants in the study.

Table 1 Characteristics of patients and surgeries

Characteristics	Operations (n=31)
Sex (male), n (%)	14 (45.1)
Age (years), mean ± SD	63.2±4.7
BMI (kg/m^2), mean ± SD	24.0±3.0
ASA physical status, n (%)	
1	7 (22.6)
2	24 (77.4)
Reason for surgery, n (%)	
Gastric carcinoma	4 (12.9)
Colon cancer	12 (38.7)
Rectal cancer	15 (48.4)
Duration of surgery (min), median [IQR]	125.0 [120.0, 157.5]
Total amount of sufentanyl (μg), mean ± SD	48.5±6.6
Nausea and vomiting, n	4
Total amount of opioid during first 24 h after surgery (μg), mean ± SD	102.2±9.2
Time to first remedial analgesia (h), mean ± SD	11.0±5.3
Patients with VAS >4 within 2 h after surgery, n	0
Time to bowl movement (days), mean ± SD	3.7±1.1

SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiology; IQR, interquartile range; VAS, visual analog score.

Table 2 Extent of cutaneous sensory block

Markers of body surface	Extent of sensory block (cm)
Below the xiphoid	3.46±0.59
Suprasymphysial	1.74±0.37
Midclavicular line (left)	2.02±1.24
Midclavicular line (right)	2.19±1.25

Data are presented as mean ± SD. SD, standard deviation.

have shown that TAP blocks of various approaches (i.e., lateral, subcostal, posterior) can successfully anesthetize the anterior or lateral abdominal wall and reduce postoperative pain, thereby reducing postoperative opioid use (1,7,8). Notwithstanding, there is some controversy about the efficacy of TAP blocks. Ghisi *et al.* (9) and Oh *et al.* (10) discovered that ultrasound-guided lateral TAP blocks did not diminish the use of opioids following total laparoscopic hysterectomy or colorectal cancer surgery. In addition, Juhl *et al.* revealed in a trial of volunteers that single-injection lateral TAP blocks induce only tiny areas of acceptable cutaneous sensory anesthesia, with large variability in the anterior abdomen wall and moderate-to-poor repeatability (11). Rozen *et al.* stated that if the TAP injection is not placed beneath this unique fascia, the block may only affect the nerves that penetrate a portion

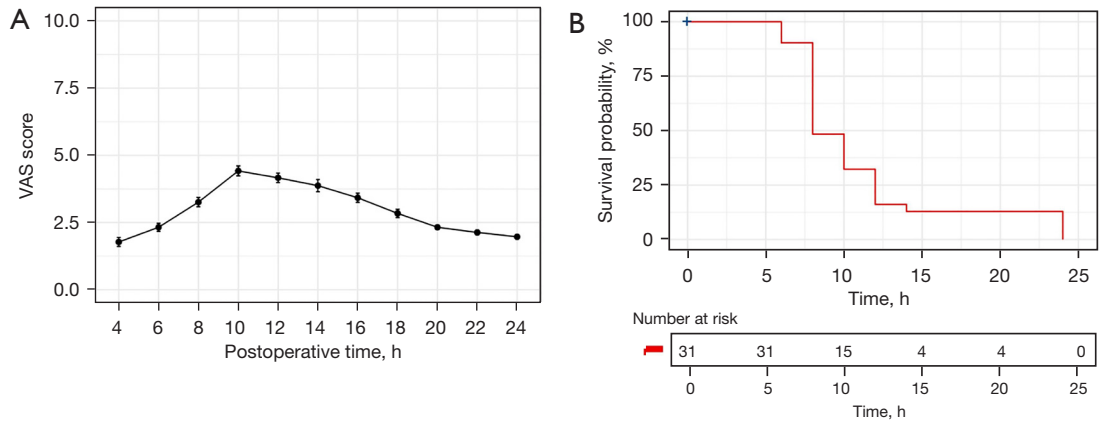


Figure 3 The diagram of postoperative VAS pain score and effective block time. (A) Postoperative 4–24 h median VAS score trend graph; (B) Kaplan-Meier survival plot for the duration of effective block and median time of the block. VAS, visual analog scale.

of the fascia layer (12). Thus, the rectus sheath block was introduced for abdominal surgery. However, the spread of anesthetic is blocked by the semilunar line, whereas with our technique the anesthetic spreads both laterally and medially, combining the effects of both TAP and rectus sheath blocks.

Our approach to the semilunar line differed from that described in a previous study (13). Chen *et al.* (13,14) reported a subcostal approach to a semilunar line block. The association between the TA muscles and the semilunar line varies at different levels. At the subcostal level, the semilunar is right above the TA, whereas between T7 and T11, the semilunar is at the same level as the TA and rectus sheath, rendering a more even spread of anesthetic laterally and medially, resulting in the combination of the rectus sheath and TAP blocks.

There are some limitations to this approach. First, it needs a large volume of LA, so a low concentration must be used to avoid potential toxicity. Second, the block duration is shorter than other peripheral nerve blocks in which anesthetic is injected next to a nerve or nerve plexus. However, due to the fast onset and a surgical incision avoiding the semilunar line, it is possible to use this method as a postoperative rescue method. Third, our approach cannot reach the lateral abdominal area in which even existing TAP approaches cannot perfectly block (15). The analgesia with this approach is less effective for some procedures requiring subcostal margin incision (e.g., gallbladder surgery or liver surgery). To reach that area, the lateral cutaneous branches of intercostal nerves (T6–T12) should be blocked.

Conclusions

In conclusion, an umbilical level semilunar line block is a safe, fast-onset and effective TAP block with broader analgesia for abdominal surgery. It is easy to perform and can be used both preoperatively and postoperatively.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-23-245/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-245/coif). 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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The trial was approved by the Ethics Committee of Shanghai Jiaotong University Affiliated Sixth People's Hospital (No. 2021-253). Written informed

consent was given by participants before recruitment.

References

1. Tran DQ, Bravo D, Leurcharusmee P, Neal JM. Transversus Abdominis Plane Block: A Narrative Review. Anesthesiology 2019;131:1166-90.
2. Bashandy GM, Elkholy AH. Reducing postoperative opioid consumption by adding an ultrasound-guided rectus sheath block to multimodal analgesia for abdominal cancer surgery with midline incision. Anesth Pain Med 2014;4:e18263.
3. Dal Moro F, Aiello L, Pavarin P, Zattoni F. Ultrasound-guided transversus abdominis plane block (US-TAPb) for robot-assisted radical prostatectomy: a novel '4-point' technique-results of a prospective, randomized study. J Robot Surg 2019;13:147-51.
4. Urits I, Ostling PS, Novitch MB, Burns JC, Charipova K, Gress KL, Kaye RJ, Eng MR, Cornett EM, Kaye AD. Truncal regional nerve blocks in clinical anesthesia practice. Best Pract Res Clin Anaesthesiol 2019;33:559-71.
5. Pachera P, Pavan PG, Todros S, Cavinato C, Fontanella CG, Natali AN. A numerical investigation of the healthy abdominal wall structures. J Biomech 2016;49:1818-23.
6. Chin KJ, McDonnell JG, Carvalho B, Sharkey A, Pawa A, Gadsden J. Essentials of Our Current Understanding: Abdominal Wall Blocks. Reg Anesth Pain Med 2017;42:133-83.
7. Hong KY, Kim DK, Park HJ, Sim WS, Wi WG, Lee WY, Kim HC, Lee JY. Analgesic Efficacy of Preemptive Transversus Abdominis Plane Block in Patients Undergoing Laparoscopic Colorectal Cancer Surgery. J Clin Med 2020;9:1577.
8. Faiz SHR, Alebouyeh MR, Derakhshan P, Imani F, Rahimzadeh P, Ghaderi Ashtiani M. Comparison of ultrasound-guided posterior transversus abdominis plane block and lateral transversus abdominis plane block for postoperative pain management in patients undergoing cesarean section: a randomized double-blind clinical trial study. J Pain Res 2017;11:5-9.
9. Ghisi D, Fanelli A, Vianello F, Gardini M, Mensi G, La Colla L, Danelli G. Transversus Abdominis Plane Block for Postoperative Analgesia in Patients Undergoing Total Laparoscopic Hysterectomy: A Randomized, Controlled, Observer-Blinded Trial. Anesth Analg 2016;123:488-92.
10. Oh TK, Yim J, Kim J, Eom W, Lee SA, Park SC, Oh JH, Park JW, Park B, Kim DH. Effects of preoperative ultrasound-guided transversus abdominis plane block on pain after laparoscopic surgery for colorectal cancer: a double-blind randomized controlled trial. Surg Endosc 2017;31:127-34.
11. Juhl CS, Rothe C, Støving K, Aasvang EK, Rosenstock CV, Lange KHW, Lundstrøm LH. Intraindividual variation of the transversus abdominis plane block: an exploratory study in healthy volunteers. Reg Anesth Pain Med 2020;45:419-23.
12. Rozen WM, Tran TM, Ashton MW, Barrington MJ, Ivanusic JJ, Taylor GI. Refining the course of the thoracolumbar nerves: a new understanding of the innervation of the anterior abdominal wall. Clin Anat 2008;21:325-33.
13. Chen Q, Jiang JH, Yang B. Modified thoracoabdominal sensory nerves block through subcostal exterior semilunaris approach (SE-TAP) provide broader analgesia for abdominal surgery. J Clin Anesth 2021;68:110077.
14. Chen Q, Liang C, Liang J, Qiu J, Yang B. An Image Study on Local Anesthetic Spread in Healthy Volunteers Receiving Subcostal Exterior Semilunaris Transversus Abdominis Plane (SE-TAP) Block. J Pain Res 2021;14:2013-9.
15. Xu C, Wang D, Gao X, Zhou Q, Chen Y. A novel approach to transversus abdominis plane block for analgesia in subcostal margin incision surgery. J Clin Anesth 2022;80:110832.

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