The Analgesic Efficacy of Postoperative Bilateral, Ultrasound-Guided, Posterior Transversus Abdominis Plane Block for Laparoscopic Colorectal Cancer Surgery: A Randomized, Prospective, Controlled Study

Yang Zhao
Affiliated hospital of North Sichuan Medical college
Han-Ying Zhang
Pidu District people's Hospital
Zong-Yi Yuan
Nanchong central hospital
Yi Han
Affiliated hospital of North Sichuan Medical College
Yi-Rong Chen
Affiliated hospital of Southwest Medical University
Qi-Lin Liu
Affiliated hospital of North Sichuan Medical college
Tao Zhu (739501155@qq.com)
Sichuan University West China Hospital

Research article

Keywords: TAP block, colorectal cancer surgery, analgesia technique, ropivacaine

Posted Date: December 21st, 2020

DOI: https://doi.org/10.21203/rs.3.rs-130940/v1

Version of Record: A version of this preprint was published at BMC Anesthesiology on April 6th, 2021. See the published version at https://doi.org/10.1186/s12871-021-01317-6.

Abstract

Background: The study aimed to observe whether a postoperative bilateral, ultrasound-guided, posterior transversus abdominis plane block offers more benefits than placebo in patients undergoing elective laparoscopic colorectal cancer surgery in the enhanced recovery after surgery program.

Methods: Patients scheduled to undergo elective laparoscopic surgery following the diagnosis of colorectal cancer were included in this study and randomized into Group TAP and Group Control. The patients received a postoperative bilateral, ultrasound-guided, posterior transversus abdominis plane block either 20 mL of 0.5% ropivacaine (Group TAP) per side or an equivalent volume of normal saline (Group Control). The primary outcome was the cumulative consumption of rescue tramadol within 24 h after the surgery. Secondary endpoints included numerical rating scale (NRS) pain scores at rest and movement at 2, 4, 6, 12, 24, 36, 48, and 72 h. The related side effects, time to the first request for rescue tramadol, patient satisfaction on postoperative analgesia, time to the intestinal function return, time to mobilization, and the length of hospital stay were recorded.

Results: In total, 92 patients were randomized, and 82 completed the trial. The posterior TAP block reduced numeric rating scale pain scores at rest and movement at 2, 4, 6, 12, and 24 h after surgery but showed similar scores at 48 or 72 h. The total rescue tramadol requirement within the first 24 h reduced in Group TAP. A higher level of satisfaction with postoperative analgesia was observed in Group TAP on day 1 which was similar on days 2 and 3, compared with the Group Control. There were no complications due to the TAP block. A few incidences of opioids related side effects and a lower percentage of patients needing rescue tramadol analgesia within 24 h were observed in Group TAP. The time to the first request for rescue analgesia was prolonged, and the time to mobilization and flatus was reduced with a shorter hospital stay in Group TAP.

Conclusions: A postoperative bilateral, ultrasound-guided, posterior transversus abdominis plane block resulted in better pain relief and a faster recovery in patients undergoing laparoscopic colorectal cancer surgery, without adverse effects.

Trial registration: The study was registered at http://www.chictr.org.cn (ChiCTR-IPR-17012650□12, Sep 2017).

Background

Perioperative analgesia is essential for patients undergoing elective colorectal surgery in the Enhanced recovery after surgery (ERAS) program. However, the postoperative pain of colorectal surgery was considered neuropathic that needed a multimodal approach of treatment to achieve effective pain control with fewer side effects [1, 2]. Transversus Abdominis Plane (TAP) Block was suggested as a necessary part of the analgesia approach to control postoperative pain in various abdominal and gynecological surgical procedures [3]. TAP technique includes injecting local anesthetics into a plane between the internal oblique (IO) and transversus abdominis (TA) muscles, which contain the thoracolumbar nerves

originating from T6 to L1 spinal roots that supply skin, muscle, and parietal peritoneum sensation to the anterolateral abdominal wall [4, 5]. Performing an ultrasound-guided block enhanced the accuracy and efficacy of injecting local anesthetics into TAP [6, 7].

Subcostal, lateral, and posterior are the three main approaches to TAP. The subcostal approach provides analgesia to the upper abdomen, whereas lateral and posterior reduce pain in the lower abdomen. Previous studies indicated that lateral TAP reduced the resting pain score within the first 6 h of laparoscopic colorectal surgery [8]. In contrast, posterior TAP could provide 12 - 36 h of postoperative analgesia for total abdominal hysterectomy or cesarean delivery surgery [9, 10]. However, there is limited evidence suggesting that posterior TAP could reduce opioid consumption and pain scores after laparoscopic colorectal cancer surgery compared with systemic opioids or placebo [2]. This study hypothesized that a postoperative bilateral, ultrasound-guided, posterior TAP offers more benefits to patients undergoing laparoscopic colorectal cancer surgery in terms of postoperative pain relief, analgesics consumption, related complications, and recovery, compared with placebo.

Methods

2.1 Patients

The randomized, double-blinded, prospective clinical trial study was registered in the Chinese registry of clinical trials at http://www.chictr.org.cn (ChiCTR-IPR-17012650，12, Sep 2017). The Research Ethics Committee of the Affiliated Hospital of North Sichuan Medical College approved the study（Approved No. 2017/049）. This study adhered to the applicable CONSORT guidelines. The study was carried out from January 2018 to December 2019 in the Affiliated Hospital of North Sichuan Medical College. Informed written consent was obtained from all the participants. Inclusion criteria were patients aged 18 –65 years without previous abdominal surgery; American Society of Anesthesiologists classification (ASA) I-III; ability to express pain; and undergoing elective laparoscopic colorectal cancer surgery. Exclusion criteria were: undergoing any surgery again after the elective laparoscopic colorectal cancer surgery until discharged; a history of an allergic reaction to local anesthetics or opioids; weighing less than 45 kg (to reduce the risk of anesthetic toxicity); a history of recent opioids exposure; body mass index (BMI) ≥30 kg/m^2; exposure to pain medication 24 h before surgery; inability to use patient-controlled intravenous analgesia（patients undergoing resections requiring perineal incisions.

2.2 Randomization and blinding

On the surgery day, consented patients were assigned randomly to Group TAP or Control (1:1) using a computer-generated list. The random number was 20170912 set by Qi-lin Liu. Allocation concealment was ensured by enclosing assignments in sealed, opaque, sequentially numbered envelopes opened by a nurse (Yi Han) only upon the patient's arrival in the operation room. The nurse prepared 0.5% ropivacaine or saline (40 mL) for all patients in the whole study period according to the allocation and did not

participate in any other related process. The allocation was blinded for all patients, surgeons, anesthesiologists, and follow-up observers until the end of the study.

2.3 sample size

The sample size was based on the 24 h rescue tramadol requirement of patients undergoing laparoscopic colorectal cancer surgery. For sample size calculation, a clinically important reduction in 24 h tramadol consumption was considered a 20% absolute reduction with a conservative assumption. We found that 24 h tramadol requirement was 110 ±34.2 mg in the control group of 10 subjects based on initial pilot studies. With a statistical power of 0.8 and a type 1 error rate of 0.05 to detect 20% improvement as conservative, a sample size of 38 patients per group was the minimum requirement to demonstrate difference using a two-tailed Student's *t*-test. Considering a possible dropout rate of 20%, we aimed to include 92 patients in this study.

2.4 Anaesthesia, surgery and postoperative analgesia

All patients received standard perioperative care. Patients were routinely monitored by electrocardiogram, non-invasive arterial blood pressure, arterial oxygen saturation, and end-tidal carbon dioxide monitoring and placed in the Trendelenburg position. General anesthesia was induced and maintained by the same procedure using intravenous midazolam (0.04 mg/kg), propofol (2.0 to 3.0 mg/kg), sufentanil (0.3μg/kg) in both groups. Endotracheal intubation was performed using IV administration of rocuronium (0.6 mg/kg). Sufentanil (10μg) and rocuronium (10 mg) were administered intravenously before the incision. Anesthesia was maintained with a combined IV–inhaled anesthesia: sevoflurane (2 - 4%) with oxygen 2 L/min, rocuronium (0.1 - 0.2 mg/kg/hour) was applied to maintain muscle relaxation, and remifentanil (0.1 μg/kg/min) was used to maintain intra-operative analgesia. Sevoflurane end-tidal concentrations were titrated to maintain bispectral index value at 40 to 60 for all patients. The infusion of IV atropine and ephedrine was used to maintain blood pressure and heart rate at the preoperative baseline range (the increase and decrease width did not exceed 20% of the baseline value). All patients were intravenously administered with 0.15μg/kg sufentanil, following with the patient-controlled intravenous anesthesia (PCIA) 30 min before surgery finished. The PCIA contained 100μg sufentanil and 98 mL saline; PCIA was set as follows: background infusion of 2μg/h sufentanil, a bolus dose of 2μg sufentanil, and lockout interval of 5 min [11].

The postoperative intravenous antiemetic regimen consisted of dexamethasone (5mg) administered at induction and ondansetron (4mg) after surgery. After the surgery, anesthesiologists performed ultrasound-guided bilateral posterior TAP block for all patients. After patients awakened, the tube was extubated, and they were transferred to the post-anesthesia care unit (PACU) for further monitoring. If the patient complained of a numerical rating score (NRS) higher than 3, a muscular injection of rescue tramadol was offered. Rescue antiemetics were also provided to patients complaining of nausea or vomiting. Early mobilization was encouraged since the patient transferred to the ward. Patients met the discharge criteria when they could have a soft diet, fully mobilized, and had an NRS score lower than 3.

2.5 Intervention

Before the extubation, all patients received ultrasound-guided bilateral posterior TAP block by an experienced anesthesiologist at the end of the surgery. The patient was kept in a semi-lateral position and received the posterior TAP block. An ultrasound probe was placed posterior to the mid-axillary line between the costal margin and the iliac crest [12](Fig. 1). When scanning posteriorly, transversus abdominis tails off and turns into the aponeurosis. Subsequently, a blunt-ended needle was injected at the TAP between the internal oblique and transversus abdominis, posterior to the mid-axillary line and near the aponeurosis. Real-time imaging allowed the anesthesiologist to observe the needle passage through the internal oblique and enter the TAP endpoint near the aponeurosis. Correct placement of the needle was confirmed upon injecting saline solution into the muscle plane, creating a spreading of the planes. After the confirmation, 40 mL 0.5% ropivacaine was injected (20 mL per side) in Group TAP and equivalent saline in Group Control. The successful injection was defined as the appearance of a hypoechoic ellipsoid with well-defined margins in the ultrasonic imaging.

2.6 Follow-up and outcomes

Patients were evaluated from PACU until discharge from the hospital by the same investigator blind to the randomization. The primary outcome was the cumulative consumption of rescue tramadol within 24 h after surgery. Secondary endpoints include : (1) the resting and movement NRS scores assessed at 2, 4, 6, 12, 24, 48, and 72 h, postoperatively. The side effects, such as nausea, vomiting, pruritus, sedation, and respiratory depression, were also recorded. (2) Time to the first requirement of rescue tramadol muscular injection. (3) Patient satisfaction on postoperative analgesia at 24, 48, and 72 h after surgery using a 5-point scale [13] (1 = very unsatisfied, 2 = unsatisfied, 3 = fair, 4 = satisfied, and 5 = very satisfied). (4) Time for the return of intestinal function. (5) Time to the first mobilization. (6) Length of hospital stay (number of nights spent in the hospital from the date of surgery to discharge).

2.7 Statistical analysis

The collected data was analyzed using SPSS 25.0 software (Statistical Program for Social Sciences, SPSS Inc, Chicago, Illinois, USA), with a 2-tailed p-value <0.05 considered statistically significant. Continuous variables were presented as means ±standard, or medians ± interquartile range (IQR), or absolute numbers. Categorical variables were presented as percentages. The two-sample Student *t*-test or the Mann–Whitney U-test was used for continuous variables, and the Chi-squared test compared differences in the qualitative data.

Results

One hundred twenty-six consecutive patients were assessed for eligibility between January 2018 and December 2019. Twenty-eight patients did not meet the inclusion criteria, and six patients refused to participate. The remaining 92 patients were randomized as allocated to Group TAP (n = 46) or Group Control (n = 46) to receive TAP intervention and a sham block, respectively. Ten procedures were

converted to open operations, 6 in Group TAP and 4 in Group Control. The posterior TAP block succeeded in 82 patients, with no lost follow-up. Therefore, 40 patients from Group TAP and 42 from Group Control were analyzed (Fig. 2). Both groups were similar in terms of sex, age, BMI, ASA, operation duration, co-morbidities, intra-operative analgesics, or extraction incision used (Table 1).

The median (interquartile range) cumulative consumption of rescue tramadol within 24 h was significantly lower in Group TAP 0 mg (0, 87.5), compared with Group Control 100 mg (100, 200), P<0.001 (Table 2).

A longer time to first tramadol muscular injection request was observed in Group TAP than Group Control (Fig. 3). The median (interquartile range) time to first request for tramadol was 50 min (30, 90) in the control group, compared with 1440 min (285, 1440.00) in patients who received a posterior TAP block (Table 2).

Postoperative NRS pain scores at rest and movement reduced after posterior TAP block at 2, 4, 6, 12, 24 h, but were similar at 48 and 72 h (Fig. 4 and Fig. 5).

The incidence of nausea and vomiting was lower in Group TAP than Group Control. No pruritus, sedation, and respiratory depression occurred in both groups (Table 3).

Table 4 shows patients' on analgesia postoperative satisfaction level. Patients' satisfaction was significantly higher in Group TAP at postoperative day 1 (p = 0.012) but similar at days 2 and 3, compared with Group Control.

The first time to get out of bed was significantly earlier in Group TAP than Group Control (27.90 ±7.78 vs. 33.93 ±0.60 h, p<0.001). Time to first passage of flatus was significantly earlier in Group TAP than Group Control (32.40 ±6.16 vs. 38.98 ±8.71 h, p<0.001) (Table 2). The mean length of hospital stay was significantly shorter in Group TAP than Group Control (3.43 ±0.50 vs. 3.93 ±0.60 days, p<0.001) (Table 2).

Discussion

In this study, a postoperative bilateral, ultrasound-guided, posterior TAP using 0.5% ropivacaine (20 mL per side) reduced resting and movement pain scores at 2, 4, 6, 12, and 24 h. Fewer cumulative consumption of rescue tramadol within 24 h and side effects, less rescue analgesia of tramadol muscular injection, accelerated bowel function recovery, and shorter hospital stay was observed in Group TAP with Group Control.

Postoperative analgesia is an essential part of perioperative anesthetic management and the Enhanced Recovery Program. After surgery, acute pain is a significant contributor to the increased hospital stay and patient dissatisfaction [14]. Pain derived from the abdominal wall incision was the main component experienced by patients after abdominal surgery [15]. Nowadays, TAP has been recommended as an essential component of multimodal analgesia techniques as it provides effective analgesia for abdominal surgical procedures, including colorectal surgery [16, 17]. TAP blocks the T6 - L1 spinal nerves'

neural branches dominating the anterolateral abdominal wall [18]. After the anterior rami of these nerves left their respective vertebral foramina, they pierced the anterior abdomen muscles. They reached the neuro-fascial plane between the internal oblique and transversus abdominis muscles. The sensory nerves branch first sends out a lateral cutaneous branch in the mid-axillary line and continues to move within the plane to supply the anterior skin [15]. The posterior TAP is located between the costal margin and the iliac crest. In the present study, the needle was inserted at the mid-axillary line. A large volume of local anesthetic drugs was deposited in the transverse abdominal plane by the mid-axillary line puncture that helped block the lateral cutaneous branches; thus, facilitating blockage of the entire anterior abdominal wall [15]. Similar research on cadavers and volunteers demonstrated that posterior TAPB provides analgesia effect from anterior-lateral abdominal area to post-axillary line [19, 20]. In addition, researchers reported that in the posterior TAP approach, local anesthetic entered para-vertebral space covering T4 to L1 in a retrograde fashion and potentially blocked a few degrees along with the thoracolumbar sympathetic system [21–23]. Due to the sympathetic nervous system's role in mediating pain after surgery, the posterior TAP approach could achieve a prolonged analgesic effect. Finally, the posterior TAP approach injection probably causes deposition of the local anesthetic in the aponeurosis. These local anesthetic effects probably intensify the posterior TAP approach [24, 25].

A previous study indicated that a preoperative bilateral, ultrasound-guided, lateral TAP blocks using 2 mg/kg levobupivacaine (40 mL) equally split between sides (up to a total maximum dose of 150 mg) decreased the pain scores only at 2, 4, and 6 h [26]. However, in our research, the postoperative bilateral, ultrasound-guided, posterior TAP produced 24 h analgesia in laparoscopic colorectal surgery. It indicates that posterior TAP tends to prolong postoperative analgesia. Thus, it is not surprising that posterior TAP block in our study could provide a reliable, satisfied, and durable analgesia effect for laparoscopic cancer surgery. Also, both preoperative and postoperative time is suitable for performing TAP. However, we chose postoperative over preoperative TAP, owing to its advantages, such as avoiding local anesthetic distribution within the muscle layers caused by the long head-down position and delaying the local anesthetics metabolization [26].

In this study, a local anesthetic, ropivacaine, was chosen due to its advantages, such as a lower potential for cardiovascular and central nervous system toxicity and a longer anesthesia duration. Sun et al. [27] reviewed nineteen Random Controlled Trials (1217 patients) to identify TAP's optimal ropivacaine concentration using a meta-analysis. They found that both 0.375% and 0.5% ropivacaine was a good choice for a TAP block. Both concentrations helped patients alleviate pain scores after surgery at 2 h, reduced opioid consumption at 24 h after surgery, and decreased the incidence of postoperative nausea and vomiting. The maximum sublethal-dose of ropivacaine was 200 mg, and local anesthetic poisoning was not reported [28]. In this study, to get a long analgesia duration, 0.5% ropivacaine 20 mL per side was considered.

Excessive perioperative opioid consumption increases the incidence of postoperative nausea and vomiting (PONV), sedation, pruritus, urinary retention, bowel dysfunction, respiratory depression, and delayed postoperative recovery [29–31]. The resting and movement NRS scores in Group TAP were lower

than Group Control at 2, 4, 6, 12, and 24 h after surgery. Early effective analgesia contributes to lower and delayed rescue analgesia requirement of tramadol muscular injection in Group TAP so that tramadol spare-effect occurred. In this study, the application of posterior TAP in Group TAP significantly reduced tramadol consumption and incidence of PONV 24 h after the surgery compared with the Group Control. Thus, in this trial, the reduction in PONV could be explained by the decrease in tramadol-related adverse effects. Early pain relief and fewer side effects allowed patients to get up and ambulate, associated with earlier mobilization, better bowel function recovery, shorter hospital stay, and better satisfaction [32].

TAP block is a superficial technique, where the target depth is usually between 1 and 3 cm, with a small but finite risk of complications [33]. Ultrasound-guided TAP block is a relatively safe intervention with hardly any adverse outcomes [15, 34, 35]. The semi-lateral position helps abdominal organs fall far away from the needle trajectory and make the posterior TAP safer. So, ultrasound-guided posterior TAP block is considered a safe technique for postoperative analgesia.

Conclusions

This prospective, randomized, double-blinded trial showed that postoperative bilateral, ultrasound-guided, posterior transversus abdominis plane block using 0.5% ropivacaine 20 mL per side decreased pain scores at rest and movement at 2, 4, 6, 12, and 24 h. Besides, the cumulative consumption of rescue tramadol within 24 h after surgery was reduced. A delayed and lower requirement of tramadol muscular injection accelerated bowel function recovery, and shorter hospital stay was observed compared with placebo, without an increase in adverse events.

Abbreviations

TAP: transversus abdominis plane; NRS: numerical rating scale; ERAS: Enhanced recovery after surgery; IO: internal oblique; TA: transversus abdominis; ASA: American Society of Anesthesiologists classification; BMI: body mass index; PCIA: patient-controlled intravenous anesthesia; PACU: post-anesthesia care unit; IQR: interquartile range; PONV: postoperative nausea and vomiting;

Declarations

Ethics approval and consent to participate

The randomized, double-blinded, prospective clinical trial study was registered in the Chinese registry of clinical trials at http://www.chictr.org.cn (ChiCTR-IPR-17012650，12, Sep 2017). The Research Ethics Committee of the Affiliated Hospital of North Sichuan Medical College approved the study（Approved No. 2017/049）. This study adhered to the applicable CONSORT guidelines. The study was carried out from January 2018 to December 2019. The first participant enrolled on 4th January 2018. Informed written consent was obtained from all the participants.

Consent for publication

Not applicable

Availability of data and materials

Data had been uploaded successfully to the Chinese registry of clinical trials at http://www.chictr.org.cn. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

Funding

This research was funded by the project of Affiliated hospital North Sichuan Medical College (grant no. (2016)163, belongs to Yang Zhao). The funding supported the publishing cost of the study. Disclosure: None.

Authors' contributions:

T.-Z. and Y.Z are responsible for the idea and design of the study.

Y.Z. performed the TAP technique and drafted the manuscript.

H.-Y.Z. and Y.-R.C did data collection and analysis.

L.-Q.L did the randomization and controlled the research quality.

Y.-H. prepared ropivacaine or saline for TAP.

Z.-Y. Y analyzed the data, draw the tables and figures.

T.-Z. revised the article.

All authors read and approved the final manuscript.

Authors' information

Tao Zhu: professor, Ph.D. , doctoral supervisor, vice chief of the department of anesthesiology, West China Hospital of Sichuan University, Chengdu, 610041, Sichuan, P.R. China. Major in anesthesiology, perioperative organ protection, mechanism of anesthetic drugs, and perioperative information management. Published over 30 SCI papers as first author or corresponding author.

Acknowledgments

Not applicable.

References

1. Karthikesalingam A, Walsh SR, Markar SR, Sadat U, Tang TY, Malata CM: **Continuous wound infusion of local anesthetic agents following colorectal surgery: systematic review and meta-analysis**. *World J Gastroenterol* 2008, **14**:5301–5305.
2. Nygren J, Thacker J, Carli F, Fearon KC, Norderval S, Lobo DN, Ljungqvist O, Soop M, Ramirez J: **Guidelines for perioperative care in elective rectal/pelvic surgery: Enhanced Recovery After Surgery (ERAS(®)) Society recommendations**. *World J Surg* 2013, **37**:285–305.
3. Bonnet F, Berger J, Aveline C: **Transversus abdominis plane block: what is its role in postoperative analgesia**. *Br J Anaesth* 2009, **103**:468–470.
4. 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**:325–333.
5. Karaman T, Ozsoy AZ, Karaman S, Dogru S, Tapar H, Sahin A, Dogru H, Suren M: **[The effects of transversus abdominis plane block on analgesic and anesthetic consumption during total abdominal hysterectomy: a randomized controlled study]**. *Rev Bras Anestesiol* 2018, **68**:285–291.
6. Walter EJ, Smith P, Albertyn R, Uncles DR: **Ultrasound imaging for transversus abdominis blocks**. *Anaesthesia* 2008, **63**:211.
7. Joshi GP, Bonnet F, Kehlet H, PROSPECT collaboration: **Evidence-based postoperative pain management after laparoscopic colorectal surgery**. *Colorectal Dis* 2013, **15**:146–155.
8. Abdallah FW, Laffey JG, Halpern SH, Brull R: **Duration of analgesic effectiveness after the posterior and lateral transversus abdominis plane block techniques for transverse lower abdominal incisions: a meta-analysis**. *Br J Anaesth* 2013, **111**:721–735.
9. McDonnell JG, Curley G, Carney J, Benton A, Costello J, Maharaj CH, Laffey JG: **The analgesic efficacy of transversus abdominis plane block after cesarean delivery: a randomized controlled trial**. *Anesth Analg* 2008, **106**:186–191, table of contents.
10. Carney J, McDonnell JG, Ochana A, Bhinder R, Laffey JG: **The transversus abdominis plane block provides effective postoperative analgesia in patients undergoing total abdominal hysterectomy**. *Anesth Analg* 2008, **107**:2056–2060.
11. Gao Y, Deng X, Yuan H, Leng Y, Zhang T, Xu X, Tian S, Fang J, Ouyang W, Wu X: **Patient-Controlled Intravenous Analgesia with Combination of Dexmedetomidine and Sufentanil on Patients after Abdominal Operation: A Prospective, Randomized, Controlled, Blinded, Multicenter Clinical Study**. *Clin J Pain* 2018, **34**:155–161.
12. Hsiao-Chien T, Takayuki Y, Tai-Yuan C, Yang SF, Chang CC, Yao HY, Tai YT, Lin JA, Chen KY: **Transversus Abdominis Plane Block: An Updated Review of Anatomy and Techniques**. *Biomed Res Int* 2017, **2017**:1–12.

13. Tawfik MM, Mohamed YM, Elbadrawi RE, Abdelkhalek M, Mogahed MM, Ezz HM: **Transversus Abdominis Plane Block Versus Wound Infiltration for Analgesia After Cesarean Delivery: A Randomized Controlled Trial**. *Anesth Analg* 2017, **124**:1291–1297.
14. Mhuircheartaigh RJ, Moore RA, McQuay HJ: **Analysis of individual patient data from clinical trials: epidural morphine for postoperative pain**. *Br J Anaesth* 2009, **103**:874–881.
15. McDonnell JG, O'Donnell B, Curley G, Heffernan A, Power C, Laffey JG: **The analgesic efficacy of transversus abdominis plane block after abdominal surgery: a prospective randomized controlled trial**. *Anesth Analg* 2007, **104**:193–197.
16. Ventham NT, O'Neill S, Johns N, Brady RR, Fearon KC: **Evaluation of novel local anesthetic wound infiltration techniques for postoperative pain following colorectal resection surgery: a meta-analysis**. *Dis Colon Rectum* 2014, **57**:237–250.
17. Hain E, Maggiori L, Prost À la Denise J, Panis Y: **Transversus abdominis plane (TAP) block in laparoscopic colorectal surgery improves postoperative pain management: a meta-analysis**. *Colorectal Dis* 2018, **20**:279–287.
18. Tsai HC, Yoshida T, Chuang TY, Yang SF, Chang CC, Yao HY, Tai YT, Lin JA, Chen KY: **Transversus Abdominis Plane Block: An Updated Review of Anatomy and Techniques**. *Biomed Res Int* 2017, **2017**:8284363.
19. Tran TM, Ivanusic JJ, Hebbard P, Barrington MJ: **Determination of spread of injectate after ultrasound-guided transversus abdominis plane block: a cadaveric study**. *Br J Anaesth* 2009, **102**:123–127.
20. Støving K, Rothe C, Rosenstock CV, Aasvang EK, Lundstrøm LH, Lange KH: **Cutaneous Sensory Block Area, Muscle-Relaxing Effect, and Block Duration of the Transversus Abdominis Plane Block: A Randomized, Blinded, and Placebo-Controlled Study in Healthy Volunteers**. *Reg Anesth Pain Med* 2015, **40**:355–362.
21. Aveline C, Hetet HL, Roux AL, Vautier P, Cognet F, Vinet E, Tison C, Bonnet F: **Comparison between ultrasound-guided transversus abdominis plane and conventional ilioinguinal/iliohypogastric nerve blocks for day-case open inguinal hernia repair**. *Bja British Journal of Anaesthesia* 2011, **106**:380–386.
22. Carney J, Finnerty O, Rauf J, Bergin D, Laffey JG, Donnell JGM: **Studies on the spread of local anesthetic solution in transversus abdominis plane blocks**. *Anaesthesia* 2011, **66**:1023–1030.
23. Olivia, Finnerty, John, G, McDonnell: **Transversus abdominis plane block**. *Curr Opin Anaesthesiol* 2012.
24. Latzke D, Marhofer P, Kettner SC, Koppatz K, Turnheim K, Lackner E, Sauermann R, Müller M, Zeitlinger M: **Pharmacokinetics of the local anesthetic ropivacaine after transversus abdominis plane block in healthy volunteers**. *Eur J Clin Pharmacol* 2012, **68**:419–425.
25. Hessian EC, Evans BE, Woods JA, Taylor DJ, Kinkel E, Bjorksten AR: **Plasma ropivacaine concentrations during bilateral transversus abdominis plane infusions**. *Br J Anaesth* 2013, **111**:488–495.

26. Walter CJ, Maxwell-Armstrong C, Pinkney TD, Conaghan PJ, Bedforth N, Gornall CB, Acheson AG: **A randomised controlled trial of the efficacy of ultrasound-guided transversus abdominis plane (TAP) block in laparoscopic colorectal surgery**. *Surg Endosc* 2013, **27**:2366–2372.
27. Sun N, Wang S, Ma P, Liu S, Shao A, Xiong L: **Postoperative Analgesia by a Transversus Abdominis Plane Block Using Different Concentrations of Ropivacaine for Abdominal Surgery: A Meta-Analysis**. *Clin J Pain* 2017, **33**:853–863.
28. Hebbard PD, Barrington MJ, Vasey C: **Ultrasound-guided continuous oblique subcostal transversus abdominis plane blockade: description of anatomy and clinical technique**. *Reg Anesth Pain Med* 2010, **35**:436–441.
29. White PF, Kehlet H, Neal JM, Schricker T, Carr DB, Carli F, Fast-Track Surgery Study Group: **The role of the anesthesiologist in fast-track surgery: from multimodal analgesia to perioperative medical care**. *Anesth Analg* 2007, **104**:1380–1396, table of contents.
30. Shirakami G, Teratani Y, Segawa H, Matsuura S, Shichino T, Fukuda K: **Omission of fentanyl during sevoflurane anesthesia decreases the incidences of postoperative nausea and vomiting and accelerates post-anesthesia recovery in major breast cancer surgery**. *J Anesth* 2006, **20**:188–195.
31. Walder B, Schafer M, Henzi I, Tramèr MR: **Efficacy and safety of patient-controlled opioid analgesia for acute postoperative pain. A quantitative systematic review**. *Acta Anaesthesiol Scand* 2001, **45**:795–804.
32. Keller DS, Ermlich BO, Schiltz N, Champagne BJ, Reynolds HL Jr, Stein SL, Delaney CP: **The effect of transversus abdominis plane blocks on postoperative pain in laparoscopic colorectal surgery: a prospective, randomized, double-blind trial**. *Dis Colon Rectum* 2014, **57**:1290–1297.
33. Lee TH, Barrington MJ, Tran TM, Wong D, Hebbard PD: **Comparison of extent of sensory block following posterior and subcostal approaches to ultrasound-guided transversus abdominis plane block**. *Anaesth Intensive Care* 2010, **38**:452–460.
34. El-Dawlatly AA, Turkistani A, Kettner SC, Machata AM, Delvi MB, Thallaj A, Kapral S, Marhofer P: **Ultrasound-guided transversus abdominis plane block: description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy**. *Br J Anaesth* 2009, **102**:763–767.
35. Niraj G, Searle A, Mathews M, Misra V, Baban M, Kiani S, Wong M: **Analgesic efficacy of ultrasound-guided transversus abdominis plane block in patients undergoing open appendicectomy**. *Br J Anaesth* 2009, **103**:601–605.
36. Li X, Xu ZZ, Li XY, Jiang TT, Lin ZM, Wang DX: **The analgesic efficacy of ultrasound-guided transversus abdominis plane block for retroperitoneoscopic renal surgery: a randomized controlled study**. *BMC Anesthesiol* 2019, **19**:186.

Tables

Table 1 Demographic and intraoperative characteristics

variables	Group T (n=40)	Group C (n=42)	P value
Mean age , year	51.43±7.39	52.14±8.40	0.683
Gender, male:female	18□22	22□20	0.504
BMI (kg/m2)	23.64±2.69	23.75±2.61	0.848
ASA I / II / III	8/28/4	7/33/2	0.903
Operation time□min□	162.73±33.35	164.33±30.42	0.820
Type of operation			0.995
Right hemicolectomy	16 (40)	16 (38)	/
Left hemicolectomy	12 (30)	13 (31)	/
Anterior resection	6 (15)	7 (17)	/
Sigmoid colectomy	6 (15)	6 (14)	/
Intraoperative sufentanil usage (ug)	37.71±4.22	37.64±4.29	0.941
Intraoperative remifentanil usage (mg)	0.97±0.29	0.97±0.26	0.979

Note: Data are presented as mean ± SD or the number of cases or no. (%) of patients.

ASA=American Society of Anesthesiologists, BMI=body mass index, Group T = transversus abdominis plane block , Group C = Control.

Table 2 Comparison of clinical outcomes between the groups

	Group T (n=40)	Group C (n=42)	P value
Tramadol consumption within 24 h after surgery (mg) *	0 (0 , 87.5)	100 (100 , 200)	<0.001
Time to first requirement of rescue tramadol mascular injection (min)*	1440(285,1440.00)	50(30, 90)	<0.001
time to flatus (h)	32.40±6.16	38.98±8.71	<0.001
time to mobilization (h)	27.90±7.78	33.93±8.18	0.001
length of hospital stay (d)	3.43±0.50	3.93±0.60	<0.001

Data are presented as mean ± SD , unless otherwise indicated

*Data are presented as median and quartiles , and analysed by Kaplan-Meier analysis

Group T = transversus abdominis plane block , Group C = Control.

Table 3 Comparison of postoperative side effects between the groups.

Groups	Nausea		Vomitting		Pruritus		Sedation		Respiratory depression	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Group T (n=40)	11	29	3	37	0	40	0	40	0	40
Group C (n=42)	32	10	17	25	0	42	0	42	0	42
P value	□0.001		□0.001		/		/		/	

Data are presented as the number of case.

Group T = transversus abdominis plane block , Group C=Control..

Table4 Comparison of satisfaction on postoperative analgesia at different times between the groups

	Group T (n=40)	Group C (n=42)	P value
24h after surgery	4 (3,4)	3(3,4)	0.002
48h after surgery	4(4,4)	4(4,4)	0.702
72h after surgery	4(4,4)	4(3,4)	0.551

Data are presented as median and quartiles , and analysed by Kaplan-Meier analysis.

Assessed satisfaction using a 5-point scale (1 = very unsatisfied, 2 = unsatisfied, 3 = fair, 4 = satisfied, and 5 = very satisfied) .

Group T= TAPB, Group C = Control.

Figures

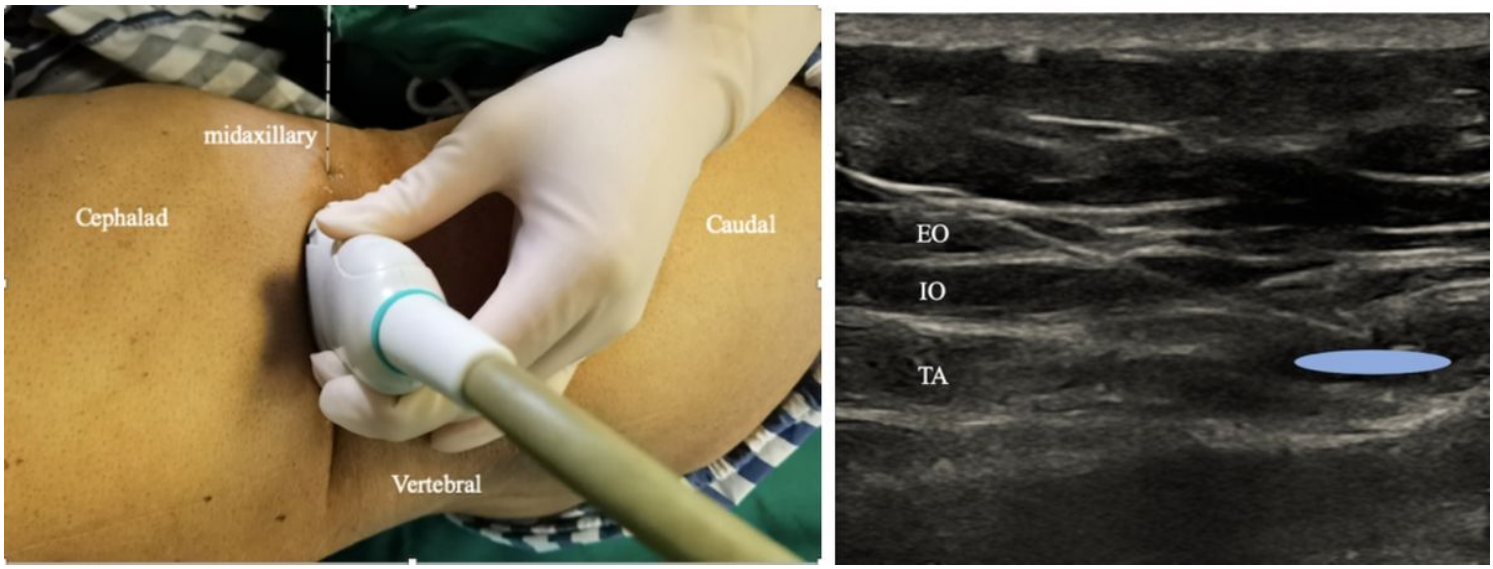

Figure 1

Posterior approach of transversus abdominis plane (TAP) block. (a) The patient was kept in semi-lateral position , the probe position and needle trajectory were displayed . The probe is placed posterior to the midaxillary line between the costal margin and the iliac crest. The needle is inserted in plane. (b) Corresponding ultrasound images. Posterior approach located in the end of transversus abdominis plane where TAP transmigrate into aponeurosis. The injection site is at the TAP between internal oblique and transversus abdominis posterior to the midaxillary line and near the aponeurosis. White dashed line: needle trajectory. Light blue area: the deposition site of local anesthetic. TA: transversus abdominis; IO: internal oblique; EO: external oblique.

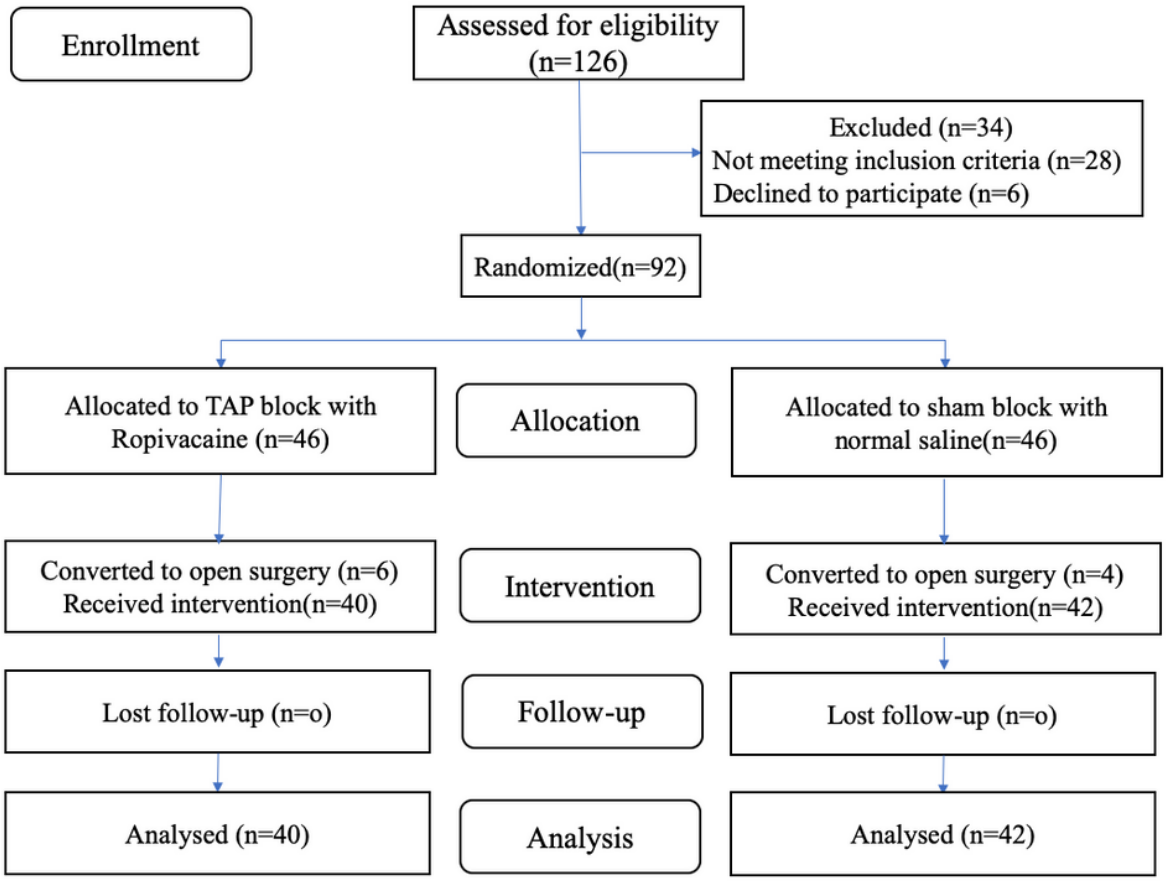

Figure 2

Consort flow study diagram TAP: transversus abdominis plane

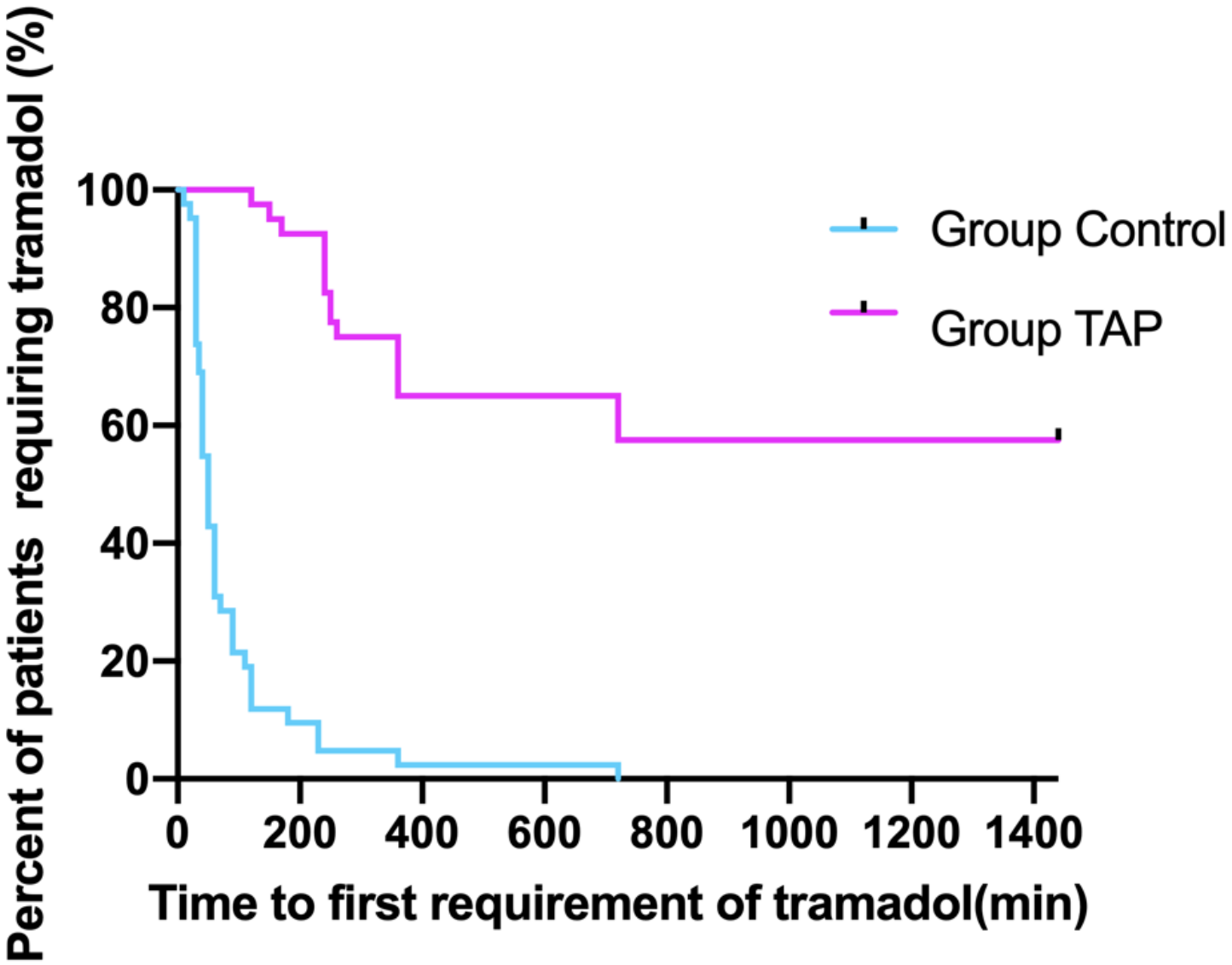

Figure 3

Kaplan-Meier curve depicting time to first tramadol requirement during postoperative 24-h follow-up among two groups. Group TAP = transversus abdominis plane block , P□0.001.

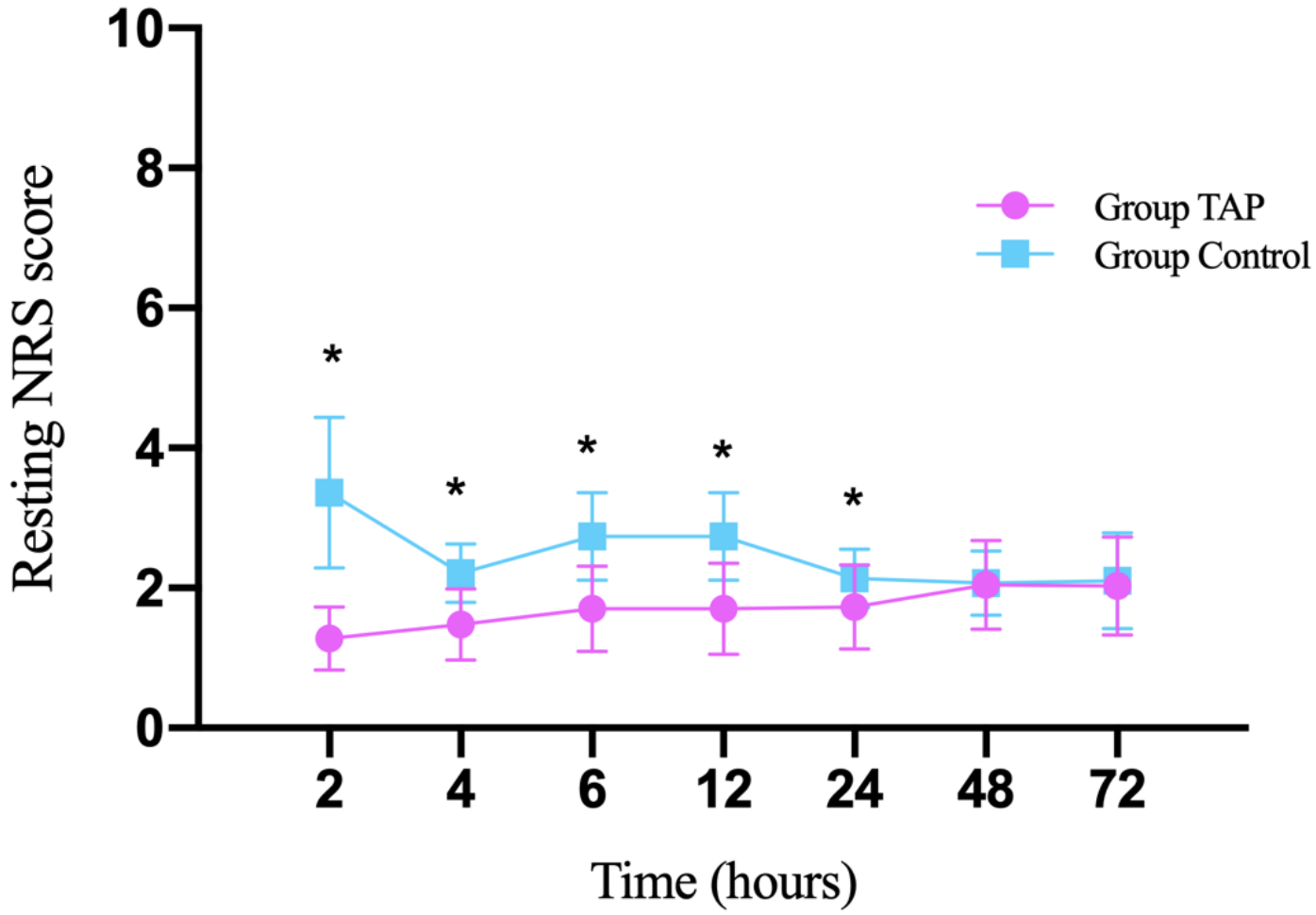

Figure 4

Comparison of resting NRS scores at different times after surgery between the groups Mean postoperative resting NRS scores assessed by using an 11-point numerical rating scale (0 = no pain and 10 = the worst possible pain) at different times after surgery in each group . *Indicates NRS score significantly difference (P < 0.001, t-test) between two groups. Group TAP = transversus abdominis plane block .

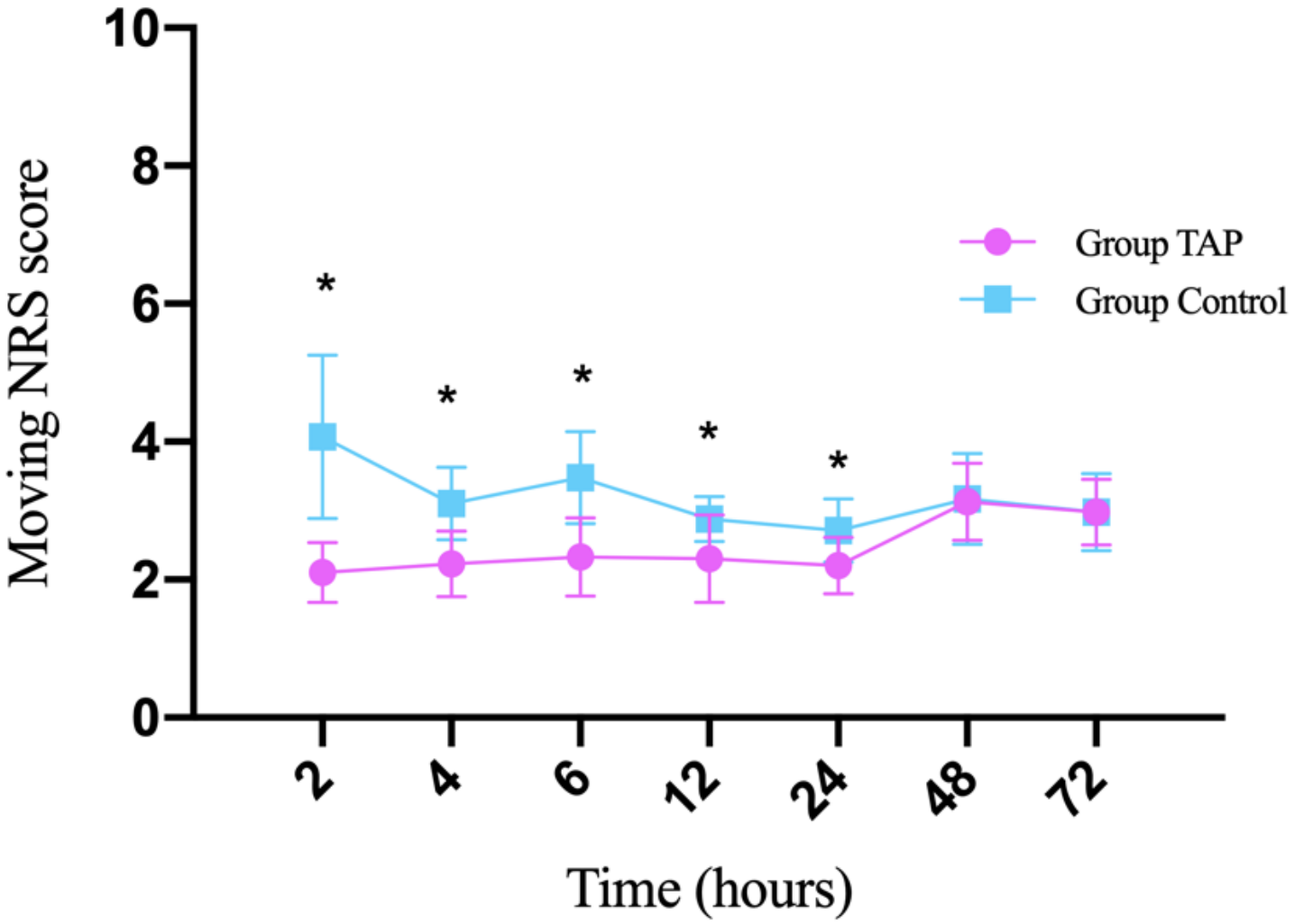

Figure 5

Comparison of moving NRS scores at different times after surgery between the groups Mean postoperative moving NRS scores assessed by using an 11-point numerical rating scale (0 = no pain and 10 = the worst possible pain) at different times after surgery in each group . *Indicates NRS score significantly difference (P < 0.001, t-test) between two groups. Group T = transversus abdominis plane block.