



Original Research Article

ULTRASOUND-GUIDED ERECTOR SPINAE PLANE BLOCK VERSUS
TRANSVERSUS ABDOMINIS PLANE BLOCK FOR POSTOPERATIVE
ANALGESIA IN LAPAROSCOPIC CHOLECYSTECTOMY: A PROSPECTIVE
DOUBLE-BLINDED RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

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Background: Effective postoperative pain management following laparoscopic cholecystectomy is essential for early recovery, reduced opioid consumption, and improved patient satisfaction. Although the transversus abdominis plane (TAP) block provides effective somatic analgesia, its effect on visceral pain is limited. The erector spinae plane (ESP) block has emerged as a promising regional analgesic technique because of its potential to provide both somatic and visceral analgesia. This study compared the analgesic efficacy of ultrasound-guided bilateral ESP block and bilateral TAP block in patients undergoing elective laparoscopic cholecystectomy.

Methods: This prospective, randomized, double-blinded controlled study included 90 patients aged 18–60 years with American Society of Anesthesiologists (ASA) physical status I–II undergoing elective laparoscopic cholecystectomy under general anesthesia. Patients were randomly allocated into two equal groups (45 each). Group ESP received ultrasound-guided bilateral erector spinae plane block at the T8 level, while Group TAP received ultrasound-guided bilateral transversus abdominis plane block using an identical volume and concentration of 0.25% bupivacaine. Postoperative pain was assessed using the Numeric Rating Scale (NRS) at predetermined intervals. Time to first rescue analgesia, total tramadol consumption during the first 24 hours, postoperative nausea and vomiting (PONV), and block-related complications were also evaluated.

Results: Baseline demographic and perioperative characteristics were comparable between the two groups. Pain scores were similar during the initial postoperative period but were significantly lower in the ESP group between 6 and 10 hours after surgery. The ESP block also provided a significantly longer duration of analgesia (11.7 ± 2.0 vs. 9.3 ± 2.3 hours) and reduced 24-hour tramadol consumption (150 ± 35 mg vs. 210 ± 40 mg) compared with the TAP block ($p < 0.05$). The incidence of postoperative nausea and vomiting was comparable between groups, and no block-related complications or local anesthetic-related adverse events were observed.

Conclusion: Ultrasound-guided bilateral erector spinae plane block provides superior postoperative analgesia compared with bilateral transversus abdominis plane block following laparoscopic cholecystectomy. It prolongs the duration of analgesia, reduces postoperative opioid requirements, and maintains an excellent safety profile. Incorporation of ESP block into multimodal analgesic protocols may facilitate enhanced postoperative recovery following laparoscopic cholecystectomy.

Keywords: Erector spinae plane block; Transversus abdominis plane block; Laparoscopic cholecystectomy; Postoperative analgesia; Regional anaesthesia; Ultrasound-guided nerve block; Multimodal analgesia; Tramadol consumption; Randomized controlled trial.

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the standard surgical treatment for symptomatic gallstone disease because of its minimally invasive approach, shorter hospital stay, faster recovery, lower postoperative morbidity, and improved cosmetic outcomes compared

with open cholecystectomy.^[1] Despite these advantages, postoperative pain remains a significant concern and may delay mobilization, prolong recovery, increase opioid consumption, and reduce patient satisfaction. Therefore, effective postoperative analgesia is a key component of perioperative care and Enhanced Recovery After Surgery (ERAS) protocols.^[2,3]

Pain following LC is multifactorial, comprising somatic pain from trocar insertion, visceral pain resulting from gallbladder dissection and peritoneal stretching, and referred shoulder pain caused by diaphragmatic irritation from residual carbon dioxide pneumoperitoneum.^[4] Visceral pain is often the predominant component and is less responsive to conventional analgesic techniques than somatic pain. Consequently, optimal postoperative pain management should address both somatic and visceral nociceptive pathways to facilitate early recovery and improve postoperative outcomes.^[5,6]

Although opioid analgesics remain effective for postoperative pain control, their use is associated with adverse effects including postoperative nausea and vomiting, sedation, respiratory depression, constipation, urinary retention, and delayed recovery.^[7–9] These limitations have encouraged the adoption of multimodal analgesic strategies incorporating ultrasound-guided regional anesthesia techniques to reduce opioid requirements while maintaining effective analgesia.^[10,11] The transversus abdominis plane (TAP) block is an established regional analgesic technique for abdominal surgery that provides effective somatic analgesia by blocking the thoracolumbar nerves within the fascial plane between the internal oblique and transversus abdominis muscles.^[12,13] However, because its analgesic effect is primarily limited to the anterior abdominal wall, TAP block offers limited control of visceral pain following upper abdominal procedures such as laparoscopic cholecystectomy.^[14,15]

The ultrasound-guided erector spinae plane (ESP) block has recently emerged as a promising fascial plane block capable of providing both somatic and visceral analgesia through the spread of local anesthetic into the paravertebral region, affecting the dorsal and ventral rami as well as sympathetic fibers.^[16–18] Previous randomized trials and systematic reviews have demonstrated favorable postoperative analgesia with reduced opioid consumption and opioid-related adverse effects following ESP block in thoracic and abdominal surgeries.^[19,20] However, direct comparisons between ultrasound-guided ESP block and TAP block in patients undergoing laparoscopic cholecystectomy remain limited.

Therefore, this prospective randomized double-blinded controlled study was undertaken to compare the postoperative analgesic efficacy of ultrasound-guided bilateral erector spinae plane block and bilateral transversus abdominis plane block in patients undergoing elective laparoscopic cholecystectomy. The study primarily evaluated postoperative pain scores, time to first rescue analgesia, and 24-hour tramadol consumption, while secondary outcomes included postoperative nausea and vomiting and block-related complications.

MATERIAL AND METHODS

Study design and setting

This prospective, randomized, double-blind, parallel-group controlled trial was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after approval from the Institutional Ethics Committee.

The study adhered to the principles of the Declaration of Helsinki and Good Clinical Practice guidelines, and written informed consent was obtained from all participants before enrolment.

Study population

A total of 90 patients aged 18–60 years with American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective laparoscopic cholecystectomy under general anaesthesia were enrolled. Patients were randomly allocated into two equal groups:

- **Group ESP (n=45):** Ultrasound-guided bilateral erector spinae plane block.
- **Group TAP (n=45):** Ultrasound-guided bilateral transversus abdominis plane block.

Eligibility criteria

Inclusion criteria

- Patients aged 18–60 years.
- ASA physical status I or II.
- Body mass index (BMI) of 18–30 kg/m².
- Elective laparoscopic cholecystectomy under general anaesthesia.
- Written informed consent.

Exclusion criteria

- Refusal to participate.
- Coagulopathy or bleeding disorders.
- Local infection at the proposed block site.
- Known hypersensitivity to local anaesthetics.
- Chronic opioid use.
- Pre-existing neurological disorders.
- Pregnancy.

Sample size

The sample size was calculated to detect a minimum clinically significant difference of one point in the postoperative Numeric Rating Scale (NRS) pain score between the two groups with 80% power and a two-sided significance level of 5%, resulting in a required sample size of 45 patients per group (90 patients in total).

Randomization and blinding

Patients were randomized in a 1:1 ratio using a computer-generated randomization sequence with allocation concealment through sequentially numbered opaque sealed envelopes. The anaesthesiologist performing the regional block was not involved in postoperative assessment. Both the patients and the outcome assessor were blinded to group allocation throughout the study.

Anaesthetic protocol and block technique

Standard ASA monitoring, including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography, was applied to all patients. General anaesthesia was induced with intravenous fentanyl (2 µg/kg), propofol (2 mg/kg), and vecuronium to facilitate endotracheal intubation and maintained with inhalational anaesthetic agents and intermittent vecuronium as required.

Following completion of surgery and before tracheal extubation, ultrasound-guided bilateral regional blocks were performed under strict aseptic precautions using a high-frequency linear transducer.

Group ESP: Patients received an ultrasound-guided bilateral erector spinae plane block at the T8 level. A 22-gauge block needle was advanced using the in-plane technique until the transverse process was contacted, and

10 mL of 0.25% bupivacaine was injected on each side after negative aspiration (total volume 20 mL).

Group TAP: Patients received an ultrasound-guided bilateral transversus abdominis plane block by depositing 10 mL of 0.25% bupivacaine between the internal oblique and transversus abdominis muscles on each side under ultrasound guidance (total volume 20 mL).

Outcome assessment

Postoperative pain was assessed using the 11-point Numeric Rating Scale (NRS; 0 = no pain, 10 = worst imaginable pain) at 2-hour intervals for 14 hours. Intravenous tramadol (50 mg) was administered as rescue analgesia when the NRS score was ≥ 4 .

The **primary outcomes** were postoperative pain scores, time to first rescue analgesia, and total tramadol

consumption during the first 24 hours. **Secondary outcomes** included the incidence of postoperative nausea and vomiting (PONV), block-related complications, and overall postoperative analgesic efficacy.

Statistical analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics software. Continuous variables were expressed as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Continuous variables were compared using the independent Student's *t*-test, while categorical variables were analysed using the Chi-square test or Fisher's exact test, as appropriate. A two-tailed *P* value <0.05 was considered statistically significant.

RESULTS

A total of 90 patients undergoing elective laparoscopic cholecystectomy were randomized equally into the ESP and TAP groups (45 patients each). Baseline demographic and perioperative characteristics were comparable between the groups, with no statistically significant differences in age, sex, body mass index, ASA physical status, or duration of surgery. Postoperative pain scores were similar during the first 4 hours after surgery; however, patients receiving ultrasound-guided ESP block experienced significantly lower pain scores between 6 and 10 hours compared with the TAP group. The ESP block also provided a longer duration of analgesia, reduced 24-hour tramadol consumption, and fewer rescue analgesic requirements. Although the incidence of postoperative nausea and vomiting was lower in the ESP group, the difference was not statistically significant. Both regional techniques demonstrated excellent safety profiles without major block-related complications, while patient satisfaction was significantly higher among patients receiving the ESP block.

Table 1. Baseline demographic and clinical characteristics

The baseline demographic and clinical characteristics were comparable between the ESP and TAP groups.

Parameter	ESP Group (n=45)	TAP Group (n=45)	P value
Age (years), mean $\pm$ SD	42.6 $\pm$ 10.8	41.9 $\pm$ 11.3	0.762
Sex, Male/Female, n (%)	21 (46.7)/24 (53.3)	19 (42.2)/26 (57.8)	0.658
Body mass index (kg/m ²), mean $\pm$ SD	24.8 $\pm$ 2.6	25.1 $\pm$ 2.4	0.571
ASA physical status I/II, n (%)	27 (60.0)/18 (40.0)	25 (55.6)/20 (44.4)	0.671
Duration of surgery (min), mean $\pm$ SD	52.4 $\pm$ 9.6	50.8 $\pm$ 8.9	0.412

Table 2. Comparison of postoperative NRS pain scores at rest

Postoperative pain scores were significantly lower in the ESP group between 6 and 10 hours after surgery.

Time (hours)	ESP Group (n=45)	TAP Group (n=45)	P value
2	1.8 $\pm$ 0.5	1.9 $\pm$ 0.6	0.421
4	2.0 $\pm$ 0.6	2.1 $\pm$ 0.6	0.398
6	2.1 $\pm$ 0.6	3.2 $\pm$ 0.8	<0.001
8	1.9 $\pm$ 0.5	3.4 $\pm$ 0.9	<0.001
10	2.0 $\pm$ 0.6	3.0 $\pm$ 0.8	<0.001
12	2.4 $\pm$ 0.7	2.6 $\pm$ 0.7	0.184
14	2.6 $\pm$ 0.6	2.8 $\pm$ 0.7	0.152

Table 3. Comparison of postoperative rescue analgesia and tramadol consumption

Patients receiving ESP block had a significantly longer time to first rescue analgesia and lower postoperative tramadol consumption.

Parameter	ESP Group (n=45)	TAP Group (n=45)	P value
Time to first rescue analgesia (h), mean $\pm$ SD	11.7 $\pm$ 2.0	9.3 $\pm$ 2.3	<0.001
Median time (IQR), h	11.5 (10.2–13.1)	9.0 (7.8–10.9)	<0.001
Total tramadol consumption (mg), mean $\pm$ SD	150 $\pm$ 35	210 $\pm$ 40	<0.001
Number of rescue doses, mean $\pm$ SD	2.1 $\pm$ 0.7	3.4 $\pm$ 0.9	<0.001
Patients requiring >3 rescue doses, n (%)	5 (11.1)	17 (37.8)	0.002

Table 4. Comparison of postoperative nausea, vomiting, and block-related complications
Both regional techniques demonstrated excellent safety profiles without major block-related complications.

Parameter	ESP Group (n=45)	TAP Group (n=45)	P value
Postoperative nausea and vomiting, n (%)	6 (13.3)	10 (22.2)	0.180
Antiemetic requirement, n (%)	5 (11.1)	9 (20.0)	0.211
Local anaesthetic systemic toxicity	0	0	—
Pneumothorax	0	0	—
Haematoma	0	0	—
Infection at injection site	0	0	—
Inadvertent vascular puncture	1 (2.2)	1 (2.2)	1.000

Table 5. Comparison of patient satisfaction with postoperative analgesia
Patients receiving ESP block reported significantly higher satisfaction with postoperative analgesia than those receiving TAP block.

Satisfaction level	ESP Group (n=45), n (%)	TAP Group (n=45), n (%)
Excellent (5)	22 (48.9)	10 (22.2)
Good (4)	18 (40.0)	20 (44.4)
Fair (3)	4 (8.9)	11 (24.4)
Poor (2)	1 (2.2)	4 (8.9)
Very Poor (1)	0	0
Mean satisfaction score (mean ± SD)	4.36 ± 0.70	3.80 ± 0.90
P value	<0.001	

Tables Summary

Tables Summary

Table 1 demonstrated that the ESP and TAP groups were comparable with respect to baseline demographic and perioperative characteristics, confirming successful randomization.

Table 2 showed significantly lower postoperative NRS pain scores in the ESP group between 6 and 10 hours after surgery, whereas pain scores during the early (2–4 hours) and late (12–14 hours) postoperative periods were comparable between the groups.

Table 3 demonstrated that ultrasound-guided ESP block significantly prolonged the time to first rescue analgesia, reduced 24-hour tramadol consumption, and decreased the number of rescue analgesic doses compared with TAP block.

Table 4 showed comparable safety profiles between both regional analgesic techniques. Although the incidence of postoperative nausea and vomiting was lower in the ESP group, the difference was not statistically significant, and no major block-related complications were observed in either group.

Table 5 demonstrated significantly higher patient satisfaction with postoperative analgesia in the ESP group, reflecting superior pain control and overall postoperative recovery compared with the TAP block group.

Overall, the tables summary consistently demonstrate that ultrasound-guided bilateral erector spinae plane block provides superior postoperative analgesia, greater opioid-sparing effects, and improved patient satisfaction compared with bilateral transversus abdominis plane block, while maintaining a comparable safety profile following laparoscopic cholecystectomy.

DISCUSSION

The present prospective, randomized, double-blind controlled study demonstrated that ultrasound-guided

bilateral erector spinae plane (ESP) block provided superior postoperative analgesia compared with transversus abdominis plane (TAP) block in patients undergoing laparoscopic cholecystectomy.^[1-3] Patients receiving ESP block experienced significantly lower pain scores between 6 and 10 hours after surgery, prolonged time to first rescue analgesia, reduced 24-hour tramadol consumption, and higher patient satisfaction without an increase in block-related complications.^[4,5]

The superior analgesic efficacy of the ESP block is attributed to its anatomical mechanism. Injection of local anaesthetic beneath the erector spinae muscle allows extensive cranio-caudal spread with anterior diffusion into the paravertebral space, resulting in blockade of the dorsal and ventral rami as well as sympathetic fibers. Consequently, the ESP block provides both somatic and visceral analgesia.^[6,7] In contrast, the TAP block primarily blocks the thoracolumbar nerves supplying the anterior abdominal wall and therefore provides effective somatic analgesia but limited visceral pain control, explaining the comparatively higher postoperative pain scores and opioid requirements observed in the TAP group.^[8-10]

The findings of the present study are consistent with previous randomized trials and systematic reviews demonstrating that ESP block provides superior postoperative analgesia and greater opioid-sparing effects than conventional regional analgesic techniques following upper abdominal surgery.^[11,12] Although some studies have reported comparable outcomes between ESP and TAP blocks, these differences are likely related to variations in study design, local anaesthetic regimen, block technique, and surgical population.^[13]

An important clinical finding was the significant reduction in postoperative tramadol consumption in the ESP group. Reduced opioid requirements may minimize opioid-related adverse effects such as postoperative nausea and vomiting, excessive sedation, respiratory depression, and delayed recovery, thereby supporting enhanced recovery pathways.^[14-17] Although the

incidence of postoperative nausea and vomiting was lower in the ESP group, the difference was not statistically significant.

The ESP block also demonstrated an excellent safety profile, with no major block-related complications or local anaesthetic systemic toxicity observed in either group. Its simple ultrasound-guided technique, reliable anatomical landmarks, and ability to provide effective somatic and visceral analgesia make it an attractive component of multimodal analgesia protocols for laparoscopic cholecystectomy and other upper abdominal procedures.^[18–20]

Overall, the findings support the incorporation of ultrasound-guided ESP block into multimodal perioperative analgesic strategies, as it provides prolonged analgesia, reduces postoperative opioid requirements, improves patient satisfaction, and maintains a favorable safety profile following laparoscopic cholecystectomy.

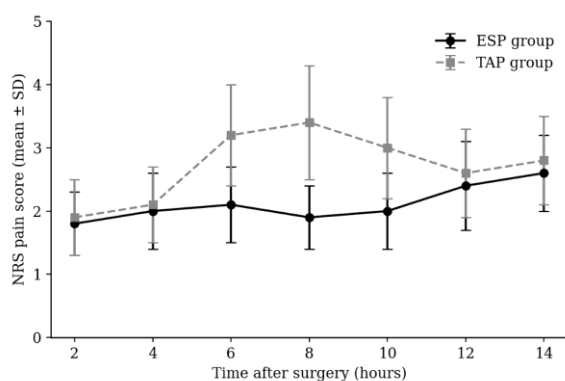


Figure 1: Comparison of Postoperative NRS Pain Scores at Rest Between the ESP and TAP Groups

Figure 1: A line graph illustrating the average Numeric Rating Scale (NRS) pain levels at rest ($\pm$ SD) at 2, 4, 6, 8, 10, 12 and 14 hours post-operatively in the ESP group (black, solid) and TAP group (grey, dashed). The pain levels were similar at 2 and 4 hours, and were significantly lower for the ESP group at 6, 8 and 10 hours ($P < 0.001$) before becoming similar again at the 12 and 14 hour mark.

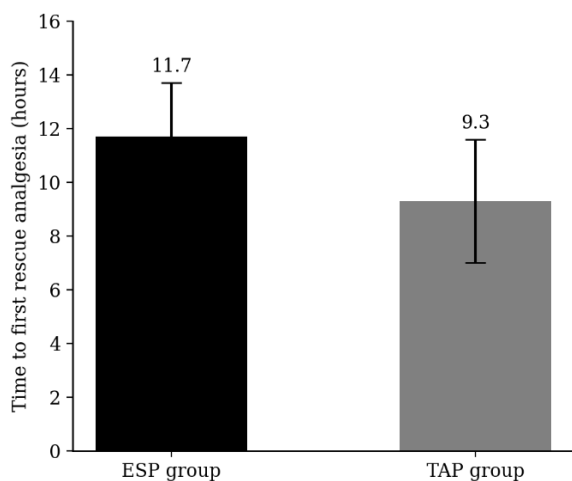


Figure 2: Time to First Rescue Analgesia in the ESP and TAP Groups

Figure 2: Mean time ($\pm$ SD, hours) to first rescue analgesic request in the ESP and TAP groups. The rescue analgesic request time was significantly later in the ESP group as compared to the TAP group (11.7 ± 2.0 h vs 9.3 ± 2.3 h; $P < 0.001$).

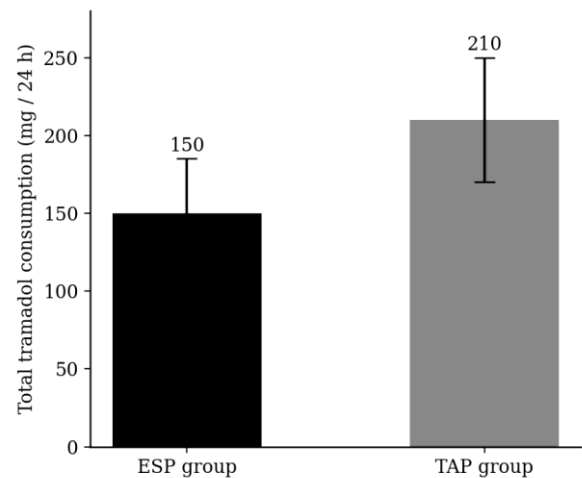


Figure 3: Total 24-Hour Tramadol Consumption in the ESP and TAP Groups

Figure 3: Bar graph illustrating the comparison of the total tramadol usage ($\pm$ SD (mg)) during first 24 hours postoperative among the experimental group (ESP) and control group (TAP). There was a significantly lower usage of tramadol for patients in the ESP group when compared to patients in the TAP group (150 ± 35 mg vs 210 ± 40 mg; $P < 0.001$), indicating a reduction of about 28 to 30% in the number of opioids used.

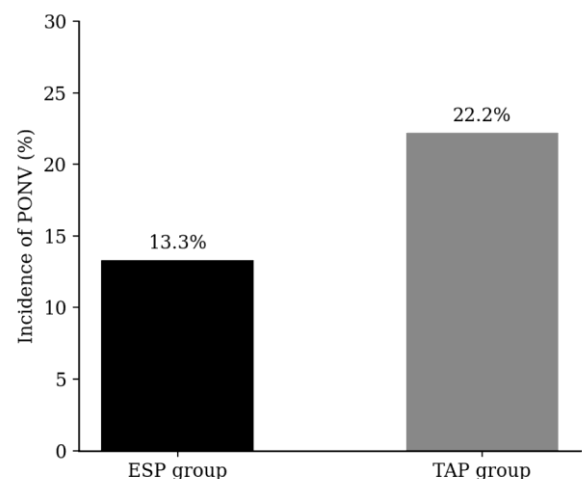


Figure 4: Incidence of Postoperative Nausea and Vomiting in the ESP and TAP Groups

Figure 4: Bar graph indicating the rates of postoperative nausea and vomiting (PONV, %) between two groups: ESP and TAP. Though the incidence was less for the ESP group than TAP (13.3% vs 22.2%), it was not statistically significant ($P = 0.18$).

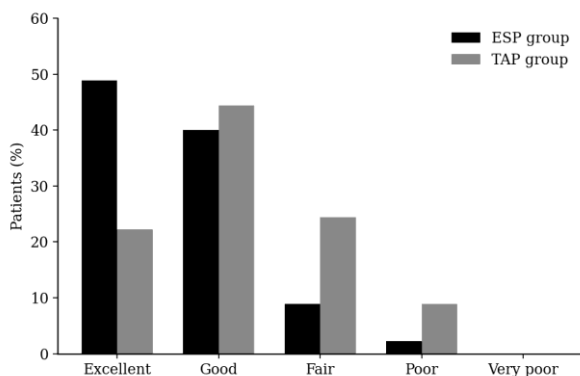


Figure 5: Distribution of Patient Satisfaction Scores with Postoperative Analgesia

Figure 5: Grouped bar chart illustrating the proportion of patient-reported satisfaction ratings (5-point Likert scale) regarding postoperative analgesia in ESP (black) and TAP (grey). A higher proportion of the patients in ESP rated their analgesia as 'excellent' when compared to the TAP patients.

Figures Summary

Taken together, the data demonstrate that the ESP block has exhibited significant clinical and statistical benefits in the reduction of postoperative pain throughout the intermediate recovery period, the delay in the need for rescue analgesia, and the reduction of 24-hour opioid consumption when compared to the TAP block. However, despite the fact that there was no statistical significance between the two groups concerning PONV incidence, the consistent numerical trend that favours the ESP group as well as the increased patient satisfaction scores provides additional support for the superior analgesic efficacy of the ESP block compared to the TAP block for laparoscopic cholecystectomy.

CONCLUSION

Patients undergoing laparoscopic cholecystectomy experienced longer and more efficacious postoperative analgesia by receiving an ultrasound-guided bilateral erector spinae plane block than by receiving a bilateral transversus abdominis plane block. The erector spinae plane block is capable of reducing pain scores in the intermediate postoperative phase, delaying the time to the first use of rescue pain relief, and limiting the amount of opioids used in the first 24 hours. There were no increased adverse effects from the erector spinae plane block. These findings favor the use of the erector spinae plane block in multimodal analgesia because it improves pain control after laparoscopic cholecystectomy, decreases complications from opioid therapy, and improves recovery.

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