BMC Anesthesiology

RESEARCH

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Erector spinae plane block versus transversus abdominis plane block with rectus sheath block for postoperative analgesia in laparoscopic hepatectomy: a randomized clinical trial

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Abstract

Background Postoperative pain after laparoscopic hepatectomy is common and can lead to increased opioid use, delayed recovery, and complications. Although transversus abdominis plane block (TAPB) with rectus sheath block (RSB) and erector spinae plane block (ESPB) have shown promise in abdominal surgeries, few comparative studies exist between the two techniques for laparoscopic hepatectomy. This study aims to compare the efficacy of bilateral ultrasound-guided ESPB versus subcostal TAPB with RSB for postoperative analgesia, addressing the gap in current research and optimizing pain management strategies for this procedure.

Methods Sixty patients scheduled for laparoscopic hepatectomy were randomly divided into two groups: E group received ultrasound-guided ESPB, while the TR group received subcostal TAPB with RSB. Morphine consumption at 24 h postoperatively was the primary outcome. Postoperative cumulative morphine consumption, the number of rescue analgesia, visual analog scale (VAS) scores at rest and during coughing, central venous pressure (CVP) values, Quality of Recovery Scale- 15 (QoR- 15) score, postoperative liver function, postoperative complications, duration of abdominal drain retention, and length of hospitalization were secondary outcomes.

Results Comparing the cumulative morphine consumption at 24 h postoperatively between groups, the difference was not statistically significant (E vs TR, 30.6 [24.2, 38.6] mg vs 36.0 [28.8, 43.4] mg, $p = 0.094$). Compared with the TR group, the E group had significantly lower cumulative morphine consumption at 1 and 2 h postoperatively, fewer cumulative number of rescue analgesia at 2, 4, 8, and 24 h postoperatively, and significantly lower VAS scores at rest and during coughing at 1, 2, and 4 h postoperatively and during coughing at 8 h postoperatively, and significantly higher QoR- 15 score than the TR group at 24 h postoperatively ($p < 0.05$).

Conclusions Ultrasound-guided bilateral ESPB provides better analgesia than TAPB with RSB in laparoscopic hepatectomy, reduces early postoperative morphine consumption, and promotes early postoperative recovery.

Trial registration On November 15, 2023, the trial was successfully registered on the ClinicalTrials.gov (NCT06133725).

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Keywords Ultrasound, Erector spinae plane block, Analgesia, Rectus sheath block, Transversus abdominis plane block, Hepatectomy

Background

Laparoscopic surgery is characterized by small incisions, less intraoperative bleeding, fewer postoperative complications, and rapid recovery [1], which is the recommended operation for liver surgery [2]. However, most patients still suffer from severe pain after laparoscopic hepatectomy, affecting the quality of postoperative recovery. Studies indicate that laparoscopic surgery can cause high pain intensity and opioid requirements in the short-term postoperative period, with peak pain typically occurring within 24 h after surgery [3–5], which is associated with high intra-abdominal pressure (≥ 12 mmHg) and prolonged operative time (> 3 h) [6]. Also, peritoneal stretching, organ damage, CO_2 pneumoperitoneum pressure, diaphragm stimulation, and ischemia can lead to severe pain [5]. Therefore, adequate postoperative analgesia is critical for patients undergoing laparoscopic hepatectomy.

Epidural analgesia (EA) is considered the gold standard for perioperative analgesics [7]. However, it is not recommended in hepatic surgery due to the risks of hypotension, bleeding, etc. [2]. Regional anesthesia has attracted much attention because of its ability to reduce opioid consumption and alleviate postoperative pain. Transversus abdominis plane block (TAPB) and rectus sheath block (RSB) can provide effective analgesia for abdominal surgery and are widely used in clinical practice. The combination of TAPB and RSB can provide adequate analgesia for the anterolateral and middle abdominal wall, reduce opioid consumption, and promote the early postoperative period in laparoscopic abdominal surgery [8–11]. Erector spinae plane block (ESPB), introduced in 2016 [12], is known for its extensive dermatomal coverage of T_1-L_3 and its effectiveness in perioperative and chronic pain management [13, 14]. Studies have shown that ESPB is a promising multimodal analgesia technique in laparoscopic major abdominal surgery [15].

However, limited comparative studies on ESPB and TAPB with RSB exist, so this study aimed to compare the effects of ultrasound-guided ESPB and TAPB with RSB on analgesia and postoperative recovery after laparoscopic hepatectomy.

Methods

Research participants

The randomized clinical trial received approval from the Ethics Committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (TJ-IRB20230951) and was subsequently at clinicaltrials.gov (Registration No: NCT06133725). The study was conducted by the Declaration of Helsinki and reported according to the CONSORT guidelines and was conducted at our hospital from January to October 2024, during which all participants signed informed consent.

On the day preceding the surgery, the anesthesiologist went to the ward to perform a preoperative evaluation of patients scheduled for laparoscopic hepatectomy, signed an informed consent, and screened the participants according to the study's criteria. The criteria for inclusion encompassed individuals aged 18 ~ 70 years, and an American Society of Anesthesiologists (ASA) classification of I-II, with body mass index (BMI) 19 ~ 28 $kg{\cdot}m^{-2}$, and elective laparoscopic hepatectomy. Unqualified patients were also excluded based on exclusion criteria, which included inability to perform nerve blocks, such as skin infection at the puncture site; routine use of opioid analgesics or with a history of opioid abuse; allergy to any of the medications used in the study; cognitive impairment; psychiatric or neurological disorders with motor or sensory deficits; coagulation disorders; severe pulmonary, cardiac, hepatic, or renal dysfunction; and the patient's previous participation in another clinical trial in the 3 months before enrollment.

Randomization and blinding

Patients were randomly assigned to the TR group and the E group using a computer-generated random number table, and the group information was kept in opaque envelopes by an anesthesia assistant who was not involved in this study. The E group received ultrasound-guided ESPB, while the TR group received subcostal TAPB with RSB. The regional anesthesiologist performed an appropriate nerve block according to the grouping in the envelope. The anesthesia manager, surgeons, and postoperative follow-up visitors were blinded to the group assignments. (Due to the differences in nerve block characteristics between groups in this study, patients may have been aware of the group assignments at the time of nerve block, but neither the postoperative followers nor the data analysts were aware of the grouping, thus minimizing bias.) During the preoperative visit, patients were instructed to manage pain with a patient-controlled intravenous analgesia (PCIA) device and to assess pain

levels at rest and during coughing using visual analog scores (VAS).

Ultrasound-guided ESPB

Before induction of anesthesia, patients were positioned in the prone orientation. Bilateral ESPB was performed at the T_7 vertebral level using an L15 - 4B high-frequency line-array ultrasound probe (Wisonic Navi s, Shenzhen, China). The probe was placed approximately 3 cm lateral to the midline of the spine, and a sagittal scan was performed to locate the erector spinae and the transverse process of the seventh thoracic vertebra. Using the in-plane needle insertion technique, advance the puncture needle until the needle tip contacts the transverse process. After confirming the correct position and ensuring no blood is aspirated, inject 20 ml of 0.375% ropivacaine. Repeat the process on the other side. When the medication displays linear spread below the erector spinae muscle, it indicates a successful ESPB.

Ultrasound-guided TAPB with RSB

Patients underwent bilateral subcostal TAPB in the supine position. Placing the L15 - 4B high-frequency line-array ultrasound probe (Wisonic Navi s, Shenzhen, China) transversely under the xiphoid process, the probe was tilted parallel to the rib margins and moved toward the vicinity of the midclavicular line to identify the transversus abdominis plane. After the needle tip reached the space between the internal oblique aponeurosis and the transversus abdominis muscle surface, and no blood was aspirated, 10 ml of 0.375% ropivacaine was injected. Under ultrasound guidance, the drug was observed to spread in the transversus abdominis plane, indicating a successful TAPB. Repeated on the other side.

In the supine position, bilateral RSB was performed at the level above the umbilicus. The L15 - 4B high-frequency linear array ultrasound probe was placed transversely on the abdomen. The probe was slid to locate the structures of the rectus abdominis muscle and its sheath. Using an in-plane needle insertion technique, after the needle tip reached the target area and no blood was aspirated, inject 10 ml of 0.375% ropivacaine. The drug diffused in a shuttle pattern when the rectus abdominis muscle dissociated from the posterior rectus abdominis sheath, indicating the success of the block. The other side was the same as above.

General anesthesia and surgical technique

Patients were transferred to the operating room 30 min earlier, and the electrocardiogram, blood pressure, pulse, and blood oxygen saturation were monitored. After local anesthesia, an internal jugular vein catheter puncture was performed under ultrasound guidance, and a sensor was connected to monitor and record the preoperative CVP. Subsequently, the E group underwent bilateral ESPB at the T_7 segment, performed by an experienced regional anesthesiologist. The TR group received bilateral subcostal TAPB with RSB. Subsequently, induction of anesthesia: methylprednisolone 5 mg, penehyclidine hydrochloride 0.5 mg, palonosetron 0.25 mg, dexamethasone 5 mg, sufentanil 0.5 $\mu g \cdot kg^{-1}$, etomidate 0.15–0.20 $mg \cdot kg^{-1}$, and cisatracurium 0.2 $mg \cdot kg^{-1}$. After 5 min of oxygen administration via a mask, tracheal intubation and mechanical ventilation were initiated. Ultrasound-guided radial artery catheterization was performed to monitor arterial blood pressure. Anesthesia maintenance: inhalation of 1.5% sevoflurane, and intravenous infusion of remifentanil 0.1–0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and dexmedetomidine 0.5 $\mu g \cdot kg^{-1} \cdot h^{-1}$. Depending on the tumor location, 4—5 trocar ports were made, with the intra-abdominal pressure maintained at approximately 12 mmHg. The resected tumor was removed through a 4 ~6 cm-long incision, followed by wound irrigation, thorough hemostasis, and placement of a drainage tube. 30 min before the end of the surgery, 5 μg of sufentanil was administered intravenously for analgesia. The tracheal tube was removed after the surgery when the patient was fully awake and had regular and adequate breathing (0 h postoperatively). Subsequently, the patient was transferred to the post-anesthesia care unit (PACU).

Postoperative care

When the patients entered the PACU for postoperative observation, the PCIA pump was connected: sufentanil 15 μg, butorphanol tartrate injection 15 mg, and palonosetron 0.3 mg diluted in 0.9% saline to 150 ml, the infusion dose was according to the body weight (1 $ml \cdot h^{-1}$, < 50 kg; 1.5 $ml \cdot h^{-1}$ for 50 ~60 kg; > 70 kg, 2 $ml \cdot h^{-1}$), with a lock time of 10 min. Postoperative pain intensity was assessed using the VAS (VAS, 0 cm = no pain; 10 cm = worst pain imaginable), and patients could press the PCIA pump as needed. In the PACU, if the VAS score at rest > 4, 2 mg of oxycodone was administered intravenously for rescue analgesia. After returning to the ward, if the patient had poor pain control or the patient requested (VAS score at rest > 4), diclofenac sodium suppository was given for rescue analgesia.

Information collection

The primary outcome was the cumulative morphine consumption at 24 h postoperatively, which included the dosage from the PCIA pump and the rescue analgesia oxycodone dosage, both converted into the equivalent dose of intravenous morphine. Morphine consumption at 1, 2, 4, and 8 h postoperatively, the number of rescue

analgesia and VAS scores at rest and during coughing at 1, 2, 4, 8, and 24 h, CVP values at 5, 10, 15, and 30 min after nerve block, patients' QoR- 15 scores preoperatively and at 24 h postoperatively, postoperative hepatic function [expressed as the ratio of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) elevated from baseline values], postoperative complications, duration of abdominal drain retention, and length of hospitalization were the secondary outcomes.

Statistical analysis

Sample size calculation

Using G*Power 3.1 to calculate the sample size based on the data from a pilot study (5 patients in the E Group and 5 in the TR Group). The results showed that the morphine consumption within 24 h post-operative was 32.88 ± 3.50 mg in the E group and 35.84 ± 3.05 mg in the TR group. To achieve a two-sided significance level of 0.05 and a power of 90%, 27 patients were required for each group with a 1:1 allocation ratio. Considering a drop-out rate of 10%, the total sample size needed was 60 participants.

Statistical analysis

Using SPSS 27.0 and GraphPad Prism 10.0 to implement statistical analysis and graphing. Normalcy was assessed for the data in this study using the Shapiro–Wilk test, the data with normal distribution were expressed as mean ± standard deviation (x ± s), and the independent-samples T-test was used for inter-group comparison. Conversely, non-normally distributed variables were expressed as median [interquartile range (IQR)], and comparison between groups using the Mann–Whitney U test. Disaggregated and counted data, including the frequency of rescue analgesia and postoperative adverse events, were presented as numbers (percentages). These data were subjected to statistical analysis utilizing the Pearson χ^2 test or Fisher exact probabilities test. Multiple

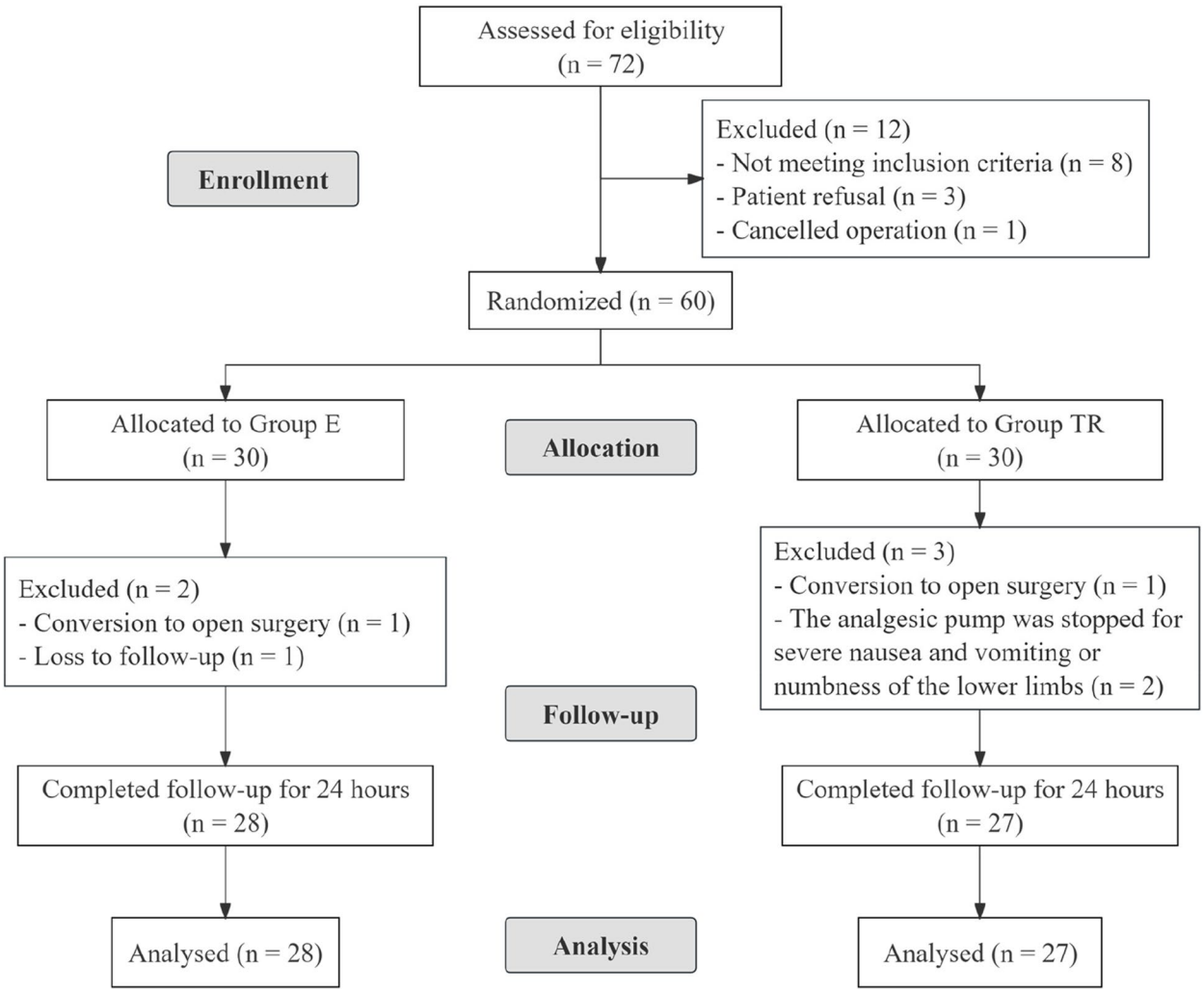

Fig. 1 Flow chart for participants enrolment and analysis

comparisons of all outcomes (VAS scores, cumulative morphine consumption, etc.) for repeated measures were performed using the Bonferroni correction. All analyses were performed using two-sided tests, with $P < 0.05$ indicating significance.

Results

Seventy-two patients scheduled for laparoscopic hepatectomy were included from January to October 2024, and 12 patients were excluded (8 patients did not meet the study criteria, 3 patients refused to participate, and surgical canceled in 1 patient), so the remaining 60 patients were randomly divided into groups E and TR. During the study period, 2 patients in the E group were excluded because of intraoperative conversion to open surgery or postoperative loss to follow-up. 3 patients in the TR group withdrew from the study because of intraoperative conversion to open surgery and postoperative pump discontinuation due to severe nausea and vomiting or numbness of the limbs. Finally, the study analyzed 55 patients after the exclusion of these patients ($n = 28$ in the E group, $n = 27$ in the TR group) (Fig. 1). There were no statistically significant differences in baseline characteristics and perioperative variables between groups (Table 1).

The average cumulative morphine consumption, including converted analgesic pump drugs and oxycodone, at 24 h postoperatively was 32.1 ± 11.3 mg in the E group and 37.7 ± 14.9 mg in the TR group, nevertheless, the statistical analysis revealed no significant difference between groups (E vs TR, 30.6 [24.2, 38.6] mg vs 36.0 [28.8, 43.4] mg, $p = 0.094$). In contrast, compared with the TR group, the E group exhibited a significantly reduced cumulative morphine consumption at both 1 and 2 h ($p < 0.05$) (Fig. 2).

A comparative analysis between the groups revealed that the cumulative number of rescue analgesia during 2, 4, 8, and 24 h post-surgery was notably diminished in the E group compared to the TR group, with statistical significance ($p < 0.05$). Although the cumulative number of rescue analgesia at 1 h postoperatively was lower in the E group, this difference did not attain statistical significance ($p > 0.05$) (Table 2).

Compared with the TR group, the resting VAS scores at 1, 2, and 4 h postoperatively in the E group were significantly lower ($p < 0.05$). There was no statistically significant difference in resting VAS scores between the groups at 8 and 24 h postoperatively ($p > 0.05$) (Fig. 3A). VAS scores at 1, 2, 4, and 8 h postoperatively for coughing were significantly lower in the E group ($p < 0.05$), but the difference between groups in coughing VAS scores at 24 h postoperatively was not statistically significant (E vs TR, 3 [2, 4] vs 3 [3, 4], $p = 0.260$) (Fig. 3B).

Table 1 Baseline and perioperative characteristics

Variable	Group E ($n = 28$)	Group TR ($n = 27$)	*P* value
Gender			
Male	10 (35.7%)	11 (40.7%)	0.701
Female	18 (64.3%)	16 (59.3%)	
Age (years)	49.1 ± 11.2	50.6 ± 14.4	0.671
Height (cm)	169.0 (160.3, 170.0)	162.0 (158.0, 170.0)	0.184
Weight (kg)	62.9 ± 10.9	64.1 ± 11.3	0.682
BMI ($kg \cdot m^{-2}$)	22.7 ± 2.9	23.7 ± 2.5	0.188
ASA class			
I	7 (25.0%)	6 (22.2%)	0.808
II	21 (75.0%)	21 (77.8%)	
Type of laparoscopic procedures			
Hepatic hemangioma	9 (32.1%)	10 (37.0%)	0.703
Liver cancer	19 (67.9%)	17 (63.0%)	
Surgery duration (min)	165.5 ± 58.8	169.1 ± 60.2	0.819
Anesthesia time (min)	213.1 ± 61.6	223.0 ± 64.3	0.563
Intraoperative parameters			
Total remifentanil (μg)	1084.3 ± 413.5	1165.9 ± 442.5	0.482
Total sufentanil (μg)	37.1 ± 5.1	37.9 ± 5.7	0.576
Dexmedetomidine (μg)	60.0 (42.5, 65.0)	60.0 (42.0, 66.0)	0.694
Preoperative QoR- 15 score (0—150)	140.4 ± 3.4	139.0 ± 2.9	0.096
Preoperative liver function			
AST (U/L)	24.0 (18.3, 27.8)	21.0 (18.0, 26.0)	0.336
ALT (U/L)	18.0 (11.3, 23.0)	15.0 (10.0, 24.0)	0.781

Data are expressed as number (%), mean ± standard deviation (x ± s), or median (IQR)

BMI body mass index, *ASA* American Society of Anesthesiologists, *QoR- 15* Quality of recovery- 15 questionnaire, *ALT* alanine transaminase, *AST* aspartate transaminase

No significant disparity was observed in the ratio of CVP values to basal values at each observation time point after nerve block between the two groups (Fig. 4). Meanwhile, due to a variety of factors, we measured the CVP values of only 14 patients.

No statistically significant difference was identified between groups in the ratio of elevated liver function indexes ALT and AST on postoperative days 1 and 3 compared with preoperative baseline values (Fig. 5).

Compared with the TR group, the QoR- 15 score exhibited a statistically significant increase in the E group at 24 h postoperatively (E vs TR; 100.8 ± 7.3 vs 95.2 ± 8.6, $p = 0.012$). However, the duration of abdominal drain retention and the hospital stay was not significantly different (Table 3). The occurrence of dizziness, nausea, and

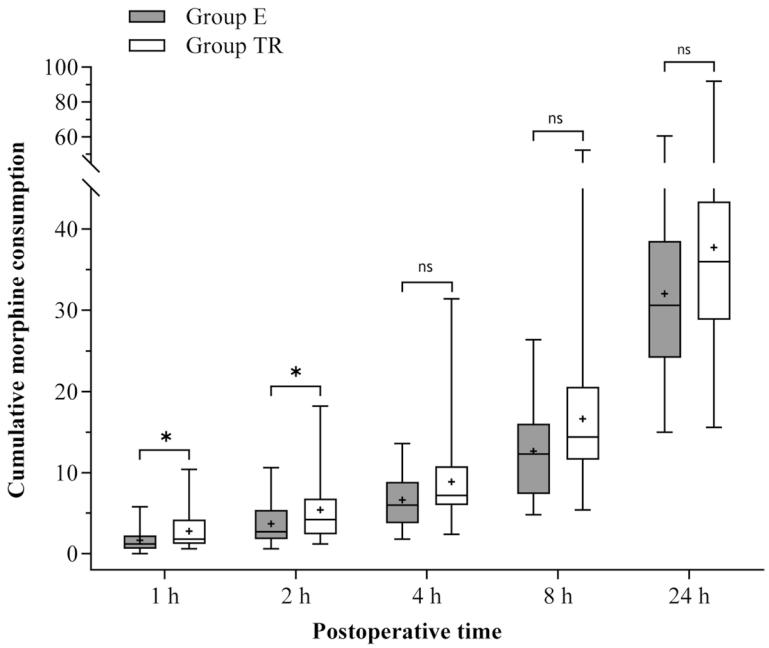

Fig. 2 Cumulative morphine consumption. Cumulative postoperative morphine consumption is represented by a box-and-line plot. The solid lines in the box indicates the median, the plus sign (+) indicates the mean, the box indicates interquartile ranges, and the whiskers indicate the minimum and maximum. *: $p < 0.05$; ns: $p > 0.05$

Table 2 Comparison of the number of cumulative rescue analgesia

Postoperative time	Group E ($n = 28$)	Group TR ($n = 27$)	*P* value
0–1 h	4 (14.3%)	9 (33.3%)	0.096
0–2 h	4 (14.3%)	12 (44.4%)	0.014*
0–4 h	5 (17.9%)	13 (48.1%)	0.017*
0–8 h	7 (25.0%)	14 (51.9%)	0.040*
0–24 h	7 (25.0%)	17 (63.0%)	0.005**

Values are presented as number (%)

* $p < 0.05$

** $p < 0.01$

vomiting was diminished in the E group, whereas the prevalence of shoulder pain was increased in comparison with the TR group, but there was no significant difference in postoperative adverse reactions between the two groups (Table 3). Two patients in the TR group were excluded because of withdrawal of analgesic pump, one patient developed lower limb numbness 4 h after surgery and recovered without sequelae 6 h after surgery, and the other patient developed severe nausea and vomiting after surgery. There were no complications related to constipation, pruritus, urinary retention and nerve block in both groups.

Discussion

The study revealed that compared with TAPB with RSB, bilateral ESPB could reduce the cumulative morphine consumption in the early postoperative period (0–2 h) after laparoscopic hepatectomy. Although the cumulative consumption of morphine in the E group decreased at 24 h postoperatively, the difference did not attain statistical significance. Furthermore, the number of rescue analgesia at 2, 4, 8, and 24 h postoperatively was significantly reduced, as well as the VAS scores for rest and cough during the initial 4 and 8 h post-surgery were notably reduced in the E group compared to the TR group ($p < 0.05$). Additionally, the QoR- 15 score was significantly higher at 24 h post-surgery. Therefore, the analgesic effect of bilateral ESPB is superior to that of TAPB with RSB, which can reduce the necessity for opioid analgesics in the early postoperative period and facilitate the patient's postoperative recovery.

It is possible that the analgesic mechanism of ESPB is through local anesthetic diffusion into the paravertebral space or epidural space, blocking the conduction of the ventral and dorsal branches of the spinal nerves, and may also block the traffic branch or sympathetic nerves to produce visceral analgesia [16]. TAPB has three approaches, and the subcostal and posterior approaches are recommended [17]. Subcostal TAPB mainly blocks T_7-T_9 and is suitable for abdominal incisions above the umbilical-abdominal wall. It can block

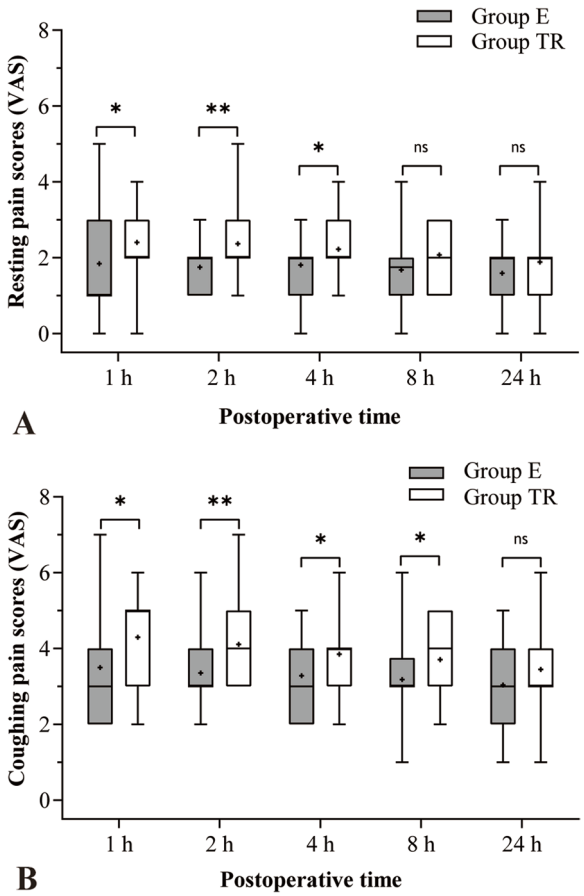

Fig. 3 VAS scores at rest (**A**) and coughing (**B**). VAS scores at different postoperative time points are represented by box-and-line plots. The solid line in the box indicates the median, the plus sign (+) indicates the mean, the box indicates the interquartile range, and the whisker bars indicate the minimum and maximum values. VAS, visual analogue scale; * $p < 0.05$; ** $p < 0.01$; ns: $p > 0.05$

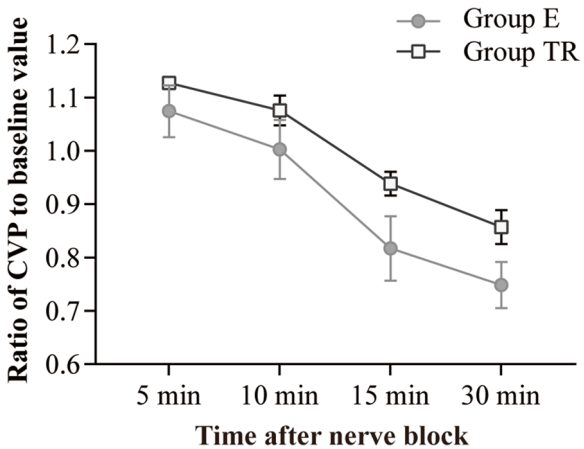

Fig. 4 Ratio of CVP to baseline value. The ratio of CVP change to baseline was plotted by line chart. CVP, central venous pressure

the nerves innervating the anterolateral abdominal wall but has a poor block effect near the midline incision. A meta-analysis demonstrated that TAPB and EA were equally effective, with a lower incidence of hypotension with TAPB [18], but TAPB provided only somatic analgesia. RSB is commonly employed to anesthetize the anterior cutaneous branch of the T_9-T_{11} intercostal nerve through the rectus abdominis muscle and is suitable for surgical analgesia through the median abdominal incision [19]. ESPB can significantly diminish postoperative pain scores, reduce opioid usage, and improve patient satisfaction during laparoscopic hepatectomy [20]. Bilateral TAPB with RSB has similar efficacy [21]. In a study of open partial hepatectomy, ESPB was found to reduce intraoperative and postoperative morphine consumption compared with subcostal TAPB and to reduce NRS scores up to 18 h postoperatively [22]. However, there is a lack of comparison between the two regional anesthesia techniques in laparoscopic hepatectomy.

This study found a significant reduction in cumulative morphine consumption during 1 and 2 h intervals following surgery in the E group ($p < 0.05$), while there was no significant difference between the groups at 24 h and other time points postoperatively. Within 8 h after laparoscopic hepatectomy, ESPB has a better analgesic effect than TAPB with RSB at rest and during coughing. We hypothesize that the reasons for the result include: First, even though patients had been taught how to use the PCIA pump before surgery, some patients may not be able to operate the PCIA pump effectively after surgery due to poor mental status or pain tolerance. Second, the rescue analgesic drug diclofenac sodium suppository could not be converted to the equivalent dose of morphine in the ward, and the implementation of rescue analgesia may have affected the use of the PCIA pump after surgery, thereby affecting the cumulative morphine consumption within 24 h postoperatively. Third, at the PACU, additional oxycodone for rescue analgesia was administered depending on the patient's pain or request, which can be translated into a morphine dose. Finally, pain generally peaked within the initial 2 h after the surgical procedure [23], consistent with this study's finding that rescue analgesia was significantly more frequent in the TR group at 2 h postoperatively. In a word, a combination of these factors may have contributed to these results. Studies have shown that ESPB sensory decline was about 9.7 h [24]. The VAS scores of patients in the E group were higher at 4 h postoperatively than at 2 h postoperatively, and some patients required rescue analgesia within 1 h postoperatively, which was in agreement with the results of ESPB in T_7 plane of healthy volunteers, and the duration of block

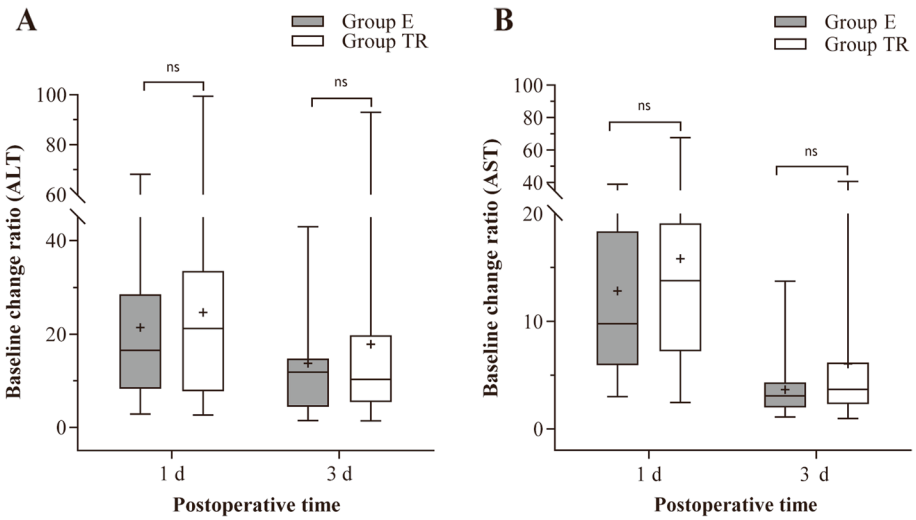

Fig. 5 Postoperative liver function parameters. Box line plots were used to plot the ratio of postoperative change in liver function from baseline. The solid line in the box indicates the median, the plus sign (+) represents the mean, the box indicates the interquartile range, and the whisker bars represent the minimum and maximum values. **A** postoperative ALT parameters; **B** postoperative AST parameters. ALT, alanine transaminase; AST, aspartate transaminase

Table 3 Postoperative recovery and adverse events

Variable	Group E ($n = 28$)	Group TR ($n = 27$)	*P* value
QoR- 15 score at 24 h postoperatively (0—150)	100.8 ± 7.3	95.2 ± 8.6	0.012*
Duration of abdominal drain retention (day)	4.0 (3.1, 5.9)	4.5 (3.5, 6.0)	0.406
Postoperative hospital stay (day)	6.2 ± 2.0	6.3 ± 1.6	0.839
Postoperative adverse reactions			
Nausea or vomiting	2 (7.1%)	3 (11.1%)	0.669
Dizziness	3 (10.7%)	6 (22.2%)	0.295
Respiratory depression	0 (0.0%)	1 (3.7%)	0.491
Postoperative Shoulder pain	6 (21.4%)	3 (11.1%)	0.469

Values are presented as mean ± standard deviation, median (interquartile range) or n (%). QoR- 15, Quality of recovery- 15 questionnaire

* $p < 0.05$

was about 6.6 h [25]. Similarly, the literature reported that the analgesia duration of TAPB after laparoscopic surgery (average 1.8 h) was about 7.0 h on average, while the analgesia duration of RSB was short, about 3.3 h [26]. However, in this study, 44.4% of patients in the TR group required rescue analgesia within 2 h postoperatively, which may be related to the operative time of laparoscopic hepatectomy (3.7 h), the duration and effectiveness of the nerve block and the varying degrees of pain in different surgeries.

Although ESPB can reduce the incidence of postoperative nausea and vomiting in patients undergoing partial hepatectomy [27], this study did not identify a statistically significant difference between groups. Firstly, it may be affected by the small sample size; our study was mainly calculated based on the cumulative morphine consumption at 24 h postoperatively. Secondly, it may be related to the fact that there was no significant difference in the cumulative consumption of morphine within 24 h postoperatively. Additionally, 2 patients withdrew from the study in the TR group after discontinuing the use of analgesic pumps because of severe postoperative nausea and vomiting, and limb numbness, which may have affected the statistics of adverse reactions. Finally, prophylactic antiemetic therapy with dexamethasone and palonosetron was administered. The investigation showed a higher incidence of postoperative shoulder pain in the E group compared to the TR

group, although the difference between groups was not statistically significant, which is similar to the findings of a systematic review [14]. Ultrasound-guided bilateral TAPB with 3 $mg{\cdot}kg^{-1}$ ropivacaine or ESPB with 150 mg ropivacaine in patients undergoing laparoscopic hepatectomy almost did not cause local anesthetic toxicity, and the average concentration peak appeared at 1 h after administration [28, 29]. However, in this study, one patient in the TR group developed lower limb numbness at 4 h after surgery, and then the analgesic pump was discontinued, which returned to normal 6 h after surgery without any sequelae. This may be related to long-term postoperative immobilization, surgical position, and anesthetic drugs.

This study has some limitations: 1-The plane of nerve block in patients was not detected, nor was the time of regression of the nerve block plane observed. Although we could confirm the block location under the guidance of ultrasound, we did not detect the plane of the nerve block, so we could not determine the exact block effect and analgesic plane, nor the duration of postoperative analgesia, which is not beneficial to explore the effectiveness and duration of nerve block in the two groups. 2-In this study, the rescue analgesics in the ward were non-opioid drugs, so they could not be calculated in the cumulative postoperative morphine consumption, which may affect the outcome of 24 h postoperative cumulative morphine consumption; 3-CVP measurement is affected by many factors such as positive end-expiratory pressure ventilation, body position, and pneumoperitoneal pressure [30–32]. The changes in CVP values at the corresponding time points after nerve block in all patients were not completely recorded in this study due to the influence of the operation time, operation, and anesthetic factors. 4-The study was conducted in a single center; 5-Patients' postoperative incisional pain and visceral pain scores were not measured separately. ESPB has both somatic and visceral analgesic effects [33], whereas TAPB and RSB only have a somatic analgesic effect and lack visceral analgesic effects, and visceral pain is more severe after laparoscopic hepatectomy. However, they were not measured separately in our study, which may affect the assessment of the corresponding analgesic effects of the nerve block, as many patients were unable to differentiate between incisional and visceral pain. 6-Peak pain in patients undergoing laparoscopic surgery is generally within 24 h postoperatively, so the subjects were followed up in this study only for 24 h postoperatively, which resulted in a follow-up period that was too short to adequately assess relevant aspects of postoperative recovery, such as the first time to get out of bed after surgery.

Conclusions

In conclusion, preoperative ultrasound-guided bilateral ESPB for postoperative analgesia in patients undergoing laparoscopic hepatectomy is superior to TAPB combined with RSB. It notably reduces opioid consumption in the initial postoperative phase, promotes recovery, and has no serious adverse effects. Ultrasound-guided bilateral ESPB for laparoscopic hepatectomy patients is a secure and efficacious analgesic strategy.

Abbreviations

ESPB	Erector spinae plane block
TAPB	Transversus abdominis plane block
RSB	Rectus sheath block
VAS	Visual analog scale
CVP	Central venous pressure
QoR- 15	Quality of recovery- 15 questionnaire
EA	Epidural analgesia
ASA	American Society of Anesthesiologists
BMI	Body mass index
PCIA	Patient-controlled intravenous analgesia
PACU	Post-anesthesia care unit
AST	Aspartate transaminase
ALT	Alanine transaminase
IQR	Interquartile range

Acknowledgements

Not applicable.

Authors' contributions

MKL, XM, and YZ conceived and designed the study. MKL, HW, and YXZ collected the data. XM and RNZ analyzed the data and interpretation of the experimental data. MKL and YZ wrote the manuscript. All authors read and approved the final manuscript.

Funding

No funding.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, China, on September 20, 2023 (Approval No. TJ-IRB20230951), and registration on clinicaltrials.gov was passed on November 15, 2023 (Registration No. NCT06133725). The trial was conducted by the 1964 Declaration of Helsinki, and informed consent was obtained from all patients who signed a written informed consent form before the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 14 January 2025 Accepted: 26 March 2025
Published online: 09 April 2025

References

1. Lee KF, Cheung YS, Chong CN, et al. Laparoscopic versus open hepatectomy for liver tumours: a case control study. Hong Kong Med J. 2007;13(6):442–8.
2. Joliat GR, Kobayashi K, Hasegawa K, et al. Guidelines for perioperative care for liver surgery: enhanced recovery after surgery (ERAS) society recommendations 2022. World J Surg. 2023;47(1):11–34. https://doi.org/10.1007/s00268-022-06732-5.
3. Ekstein P, Szold A, Sagie B, et al. Laparoscopic surgery may be associated with severe pain and high analgesia requirements in the immediate postoperative period. Ann Surg. 2006;243(1):41–6. https://doi.org/10.1097/01.sla.0000193806.81428.6f.
4. Small C, Laycock H. Acute postoperative pain management. Br J Surg. 2020;107(2):e70–80. https://doi.org/10.1002/bjs.11477.
5. Sjövall S, Kokki M, Kokki H. Laparoscopic surgery: a narrative review of pharmacotherapy in pain management. Drugs. 2015;75(16):1867–89. https://doi.org/10.1007/s40265-015-0482-y.
6. Kunapaisal T, Pattaravit N, Thongsuksai P. Factors associated with moderate to severe pain after laparoscopic surgery. J Health Sci Med Res. 2021. https://doi.org/10.31584/jhsmr.2021792.
7. Nimmo SM, Harrington LS. What is the role of epidural analgesia in abdominal surgery? BJA Educ. 2014;14(5):224–9. https://doi.org/10.1093/bjaceaccp/mkt062.
8. Tor IH, Çelik EC, Aydın ME. Analgesic effect of combined transversus abdominis plane block and rectus sheath block in laparoscopic cholecystectomy: prospective randomized study. Ain Shams J Anesthesiol. 2020;12(1). https://doi.org/10.1186/s42077-020-00108-4.
9. Yu S, Wen Y, Lin J, et al. Combined rectus sheath block with transverse abdominis plane block by one puncture for analgesia after laparoscopic upper abdominal surgery: a randomized controlled prospective study. BMC Anesthesiol. 2024;24(1):58. https://doi.org/10.1186/s12871-024-02444-6.
10. Liang M, Xv X, Ren C, et al. Effect of ultrasound-guided transversus abdominis plane block with rectus sheath block on patients undergoing laparoscopy-assisted radical resection of rectal cancer: a randomized, double-blind, placebo-controlled trial. BMC Anesthesiol. 2021;21(1):89. https://doi.org/10.1186/s12871-021-01295-9.
11. Zhu JL, Wang XT, Gong J, et al. The combination of transversus abdominis plane block and rectus sheath block reduced postoperative pain after splenectomy: a randomized trial. BMC Anesthesiol. 2020;20(1):22. https://doi.org/10.1186/s12871-020-0941-1.
12. Forero M, Adhikary SD, Lopez H, et al. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41(5):621–7. https://doi.org/10.1097/aap.0000000000000451.
13. Saadawi M, Layera S, Aliste J, et al. Erector spinae plane block: a narrative review with systematic analysis of the evidence pertaining to clinical indications and alternative truncal blocks. J Clin Anesth. 2021;68:110063. https://doi.org/10.1016/j.jclinane.2020.110063.
14. Bhushan S, Huang X, Su X, et al. Ultrasound-guided erector spinae plane block for postoperative analgesia in patients after liver surgery: a systematic review and meta-analysis on randomized comparative studies. Int J Surg. 2022;103:106689. https://doi.org/10.1016/j.ijsu.2022.106689.
15. Sia CJ, Wee S, Au-Yong AP, et al. Analgesia efficacy of erector spinae plane block in laparoscopic abdominal surgeries: a systemic review and meta-analysis. Int J Surg. 2024;110(7):4393–401. https://doi.org/10.1097/js9.0000000000001421.
16. Yang JH, Sun Y, Yang YR, et al. The analgesic mechanism and recent clinical application of erector spinae plane block: a narrative review. J Pain Res. 2024;17:3047–62. https://doi.org/10.2147/jpr.S468560.
17. Tran DQ, Bravo D, Leurcharusmee P, et al. Transversus abdominis plane block: a narrative review. Anesthesiology. 2019;131(5):1166–90. https://doi.org/10.1097/aln.0000000000002842.
18. Baeriswyl M, Zeiter F, Piubellini D, et al. The analgesic efficacy of transverse abdominis plane block versus epidural analgesia: a systematic review with meta-analysis. Medicine (Baltimore). 2018;97(26):e11261. https://doi.org/10.1097/md.0000000000011261.
19. Uppal V, Sancheti S, Kalagara H. Transversus Abdominis Plane (TAP) and rectus sheath blocks: a technical description and evidence review. Curr Anesthesiol Rep. 2019;9(4):479–87. https://doi.org/10.1007/s40140-019-00351-y.
20. Huang X, Wang J, Zhang J, et al. Ultrasound-guided erector spinae plane block improves analgesia after laparoscopic hepatectomy: a randomised controlled trial. Br J Anaesth. 2022;129(3):445–53. https://doi.org/10.1016/j.bja.2022.05.013.
21. Lu X, Yu P, Ou C, et al. The postoperative analgesic effect of ultrasound-guided bilateral transversus abdominis plane combined with rectus sheath blocks in laparoscopic hepatectomy: a randomized controlled study. Ther Clin Risk Manag. 2020;16:881–8. https://doi.org/10.2147/tcrm.S267735.
22. Mostafa M, Mousa MS, Hasanin A, et al. Erector spinae plane block versus subcostal transversus abdominis plane block in patients undergoing open liver resection surgery: a randomized controlled trial. Anaesth Crit Care Pain Med. 2023;42(1):101161. https://doi.org/10.1016/j.accpm.2022.101161.
23. Hayden P, Cowman S. Anaesthesia for laparoscopic surgery. BJA Educ. 2011;11(5):177–80. https://doi.org/10.1093/bjaceaccp/mkr027.
24. Zhang J, He Y, Wang S, et al. The erector spinae plane block causes only cutaneous sensory loss on ipsilateral posterior thorax: a prospective observational volunteer study. BMC Anesthesiol. 2020;20(1):88. https://doi.org/10.1186/s12871-020-01002-0.
25. Sørenstua M, Zantalis N, Raeder J, et al. Spread of local anesthetics after erector spinae plane block: an MRI study in healthy volunteers. Reg Anesth Pain Med. 2023;48(2):74–9. https://doi.org/10.1136/rapm-2022-104012.
26. Murouchi T, Iwasaki S, Yamakage M. Chronological changes in ropivacaine concentration and analgesic effects between transversus abdominis plane block and rectus sheath block. Reg Anesth Pain Med. 2015;40(5):568–71. https://doi.org/10.1097/aap.0000000000000288.
27. Hung KC, Chang LC, Chen IW. Erector spinae plane block reduces postoperative nausea and vomiting in liver surgery. Int J Surg. 2024;110(9):5987–8. https://doi.org/10.1097/js9.0000000000001707.
28. Zhang J, Liu T, Zhou H, et al. The safety and efficacy of ultrasound-guided bilateral dual transversus abdominis plane (BD-TAP) block in ERAS program of laparoscopic hepatectomy: a prospective, randomized, controlled, blinded, clinical study. Drug Des Devel Ther. 2020;14:2889–98. https://doi.org/10.2147/dddt.S255385.
29. Kang R, Lee S, Kim GS, et al. Comparison of analgesic efficacy of erector spinae plane block and posterior quadratus lumborum block in laparoscopic liver resection: a randomized controlled trial. J Pain Res. 2021;14:3791–800. https://doi.org/10.2147/jpr.S343366.
30. Ponduru S, Nanda A, Pakhare V, et al. The effect of different pressures of pneumoperitoneum on the dimensions of internal jugular vein - a prospective double-blind, randomised study. Indian J Anaesth. 2022;66(9):631–7. https://doi.org/10.4103/ija.ija_350_22.
31. Machanalli G, Bhalla AP, Baidya DK, et al. Sono-anatomical analysis of right internal jugular vein and carotid artery at different levels of positive end-expiratory pressure in anaesthetised paralysed patients. Indian J Anaesth. 2018;62(4):303–9. https://doi.org/10.4103/ija.IJA_716_17.
32. Ukere A, Meisner S, Greiwe G, et al. The influence of PEEP and positioning on central venous pressure and venous hepatic hemodynamics in patients undergoing liver resection. J Clin Monit Comput. 2017;31(6):1221–8. https://doi.org/10.1007/s10877-016-9970-1.
33. Kwon HM, Kim DH, Jeong SM, et al. Does erector spinae plane block have a visceral analgesic effect?: a randomized controlled trial. Sci Rep. 2020;10(1):8389. https://doi.org/10.1038/s41598-020-65172-0.

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