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Original Research Article

Ultrasound-Guided Erector Spinae Plane Block versus Transversus Abdominis Plane Block for Postoperative Analgesia after Laparoscopic Cholecystectomy: A Prospective Randomized Controlled Trial

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Abstract

Background: Effective postoperative pain management following laparoscopic cholecystectomy is essential for early mobilization, improved patient satisfaction, reduced opioid consumption, and enhanced recovery. Ultrasound-guided fascial plane blocks, particularly the erector spinae plane (ESP) block and transversus abdominis plane (TAP) block, have emerged as valuable components of multimodal analgesia. However, the relative efficacy of these two techniques remains an area of ongoing research.

Objective: To compare the efficacy of ultrasound-guided erector spinae plane block and ultrasound-guided transversus abdominis plane block for postoperative pain management in patients undergoing elective laparoscopic cholecystectomy.

Materials and Methods: This prospective randomized controlled study was conducted on 60 patients undergoing elective laparoscopic cholecystectomy under general anaesthesia. Patients were randomly allocated into two equal groups: Group E (n = 30) received ultrasound-guided bilateral erector spinae plane block, while Group T (n = 30) received ultrasound-guided bilateral transversus abdominis plane block using 20 mL of 0.25% bupivacaine on each side. The primary outcome was postoperative pain assessed using the Visual Analogue Scale (VAS) at 0, 2, 4, 6, 12, and 24 hours. Secondary outcomes included time to first rescue analgesia, total tramadol consumption during the first 24 hours, postoperative hemodynamic parameters, postoperative nausea and vomiting (PONV), patient satisfaction, sedation score, hospital stay, and block-related complications. Statistical analysis was performed using SPSS version 26.0, with a p-value <0.05 considered statistically significant.

Results: Baseline demographic and perioperative characteristics were comparable between the two groups (p > 0.05). The ESP group demonstrated significantly lower postoperative VAS scores at 2, 4, 6, 12, and 24 hours compared with the TAP group (p < 0.001). The mean time to first rescue analgesia was significantly longer in the ESP group (10.9 ± 2.2 hours) than in the TAP group (6.6 ± 1.9 hours; p < 0.001). Total tramadol consumption during the first 24 hours was significantly lower in the ESP group (90.3 ± 23.6 mg) compared with the TAP group (154.7 ± 35.8 mg; p < 0.001). The incidence of postoperative nausea and vomiting was lower in the ESP group (10.0% vs. 30.0%; p = 0.045), while patient satisfaction scores were significantly higher (4.6 ± 0.5 vs. 3.8 ± 0.7; p < 0.001). Both techniques demonstrated excellent safety profiles with no major block-related complications.

Conclusion: Ultrasound-guided erector spinae plane block provided superior postoperative analgesia compared with ultrasound-guided transversus abdominis plane block in patients undergoing laparoscopic cholecystectomy. The ESP block resulted in lower pain scores, prolonged analgesic duration, reduced opioid consumption, lower incidence of postoperative nausea and vomiting, and greater patient satisfaction while maintaining an excellent safety profile. Incorporation of the ESP block into multimodal analgesic protocols may improve postoperative recovery and support Enhanced Recovery After Surgery (ERAS) pathways in laparoscopic cholecystectomy.

Keywords: Erector spinae plane block; Transversus abdominis plane block; Laparoscopic cholecystectomy; Postoperative pain; Ultrasound-guided regional anaesthesia; Multimodal analgesia; Visual Analogue Scale; Opioid-sparing analgesia.

Introduction

Laparoscopic cholecystectomy has become the gold standard surgical procedure for the treatment of symptomatic cholelithiasis and other benign gallbladder diseases because of its advantages over open surgery, including smaller incisions, reduced postoperative pain, shorter hospital stay, faster recovery, and earlier return to daily activities. Despite its minimally invasive nature, patients frequently experience moderate to severe postoperative pain during the first 24 hours following surgery, which can adversely affect recovery, delay mobilization, prolong hospital stay, and increase opioid requirements. Postoperative pain after laparoscopic cholecystectomy is multifactorial in origin, resulting from trocar insertion sites, surgical dissection, visceral irritation, diaphragmatic stretching, and residual carbon dioxide insufflation, making effective multimodal analgesia an essential component of perioperative care. [1-3]

Optimal postoperative pain management facilitates early ambulation, improves patient comfort and satisfaction, reduces postoperative pulmonary complications, and enhances the overall quality of recovery. [4] Although systemic opioids remain an important component of postoperative analgesia, their use is associated with undesirable adverse effects such as postoperative nausea and vomiting (PONV), respiratory depression, sedation, pruritus, ileus, and delayed recovery. [5] Consequently, current Enhanced Recovery After Surgery (ERAS) protocols advocate opioid-sparing multimodal analgesic strategies incorporating regional anaesthesia techniques to improve postoperative outcomes while minimizing opioid-related complications. [6]

Ultrasound-guided fascial plane blocks have emerged as safe, reliable, and effective components of multimodal analgesia for abdominal surgeries. Real-time ultrasound guidance improves the accuracy of local anaesthetic deposition, increases block success rates, minimizes complications, and reduces the risk of inadvertent vascular puncture or visceral injury. [7]

Among these techniques, the transversus abdominis plane (TAP) block and erector spinae plane (ESP) block have gained widespread acceptance because of their technical simplicity and favorable safety profiles. [8,9]

The transversus abdominis plane block, first described by Rafi in 2001, involves deposition of local anaesthetic between the internal oblique and transversus abdominis muscles, resulting in blockade of the anterior divisions of the thoracolumbar nerves (T6–L1). This block provides effective somatic analgesia to the anterior abdominal wall and has been extensively evaluated in various abdominal surgical procedures. However, because the TAP block primarily targets somatic pain pathways, its efficacy in controlling visceral pain following laparoscopic procedures remains variable. [10-12] The ultrasound-guided erector spinae plane block, first described by Forero and colleagues in 2016, involves injection of local anaesthetic deep to the erector spinae muscle adjacent to the transverse process. The injected local anaesthetic spreads cranio-caudally within the fascial plane and may extend into the paravertebral space, producing blockade of both dorsal and ventral rami of spinal nerves as well as sympathetic fibers. Consequently, the ESP block is capable of providing both somatic and visceral analgesia over multiple dermatomes, making it an attractive option for thoracic and abdominal surgeries. Since its introduction, the ESP block has demonstrated promising analgesic efficacy in a wide variety of surgical procedures, including laparoscopic cholecystectomy. [13-16]

Several randomized controlled trials and systematic reviews have compared different regional anaesthetic techniques for postoperative analgesia following laparoscopic cholecystectomy. While both ESP and TAP blocks have been shown to reduce postoperative pain scores and opioid consumption compared with conventional analgesic regimens, the available literature presents inconsistent findings regarding their relative efficacy. Some studies have reported superior analgesia, prolonged duration of pain relief, reduced rescue analgesic requirements, and improved patient satisfaction with the ESP block, whereas others have demonstrated comparable outcomes between the two techniques. Differences in local anaesthetic concentration, injected volume, timing of block administration, assessment protocols, and perioperative analgesic regimens may account for these discrepancies. [17-20]

Given the increasing emphasis on opioid-sparing perioperative care and enhanced recovery pathways, identifying the most effective regional analgesic technique for laparoscopic cholecystectomy remains clinically relevant. Comparative evaluation of ultrasound-guided ESP block and TAP block may help optimize postoperative pain management, improve patient satisfaction, reduce opioid consumption, and facilitate early recovery. Therefore, the present prospective randomized controlled study was undertaken to compare the efficacy of ultrasound-guided erector spinae plane block and ultrasound-guided transversus abdominis plane block for postoperative pain management in patients undergoing elective laparoscopic cholecystectomy by evaluating postoperative pain scores, time to first rescue analgesia, total analgesic consumption, postoperative nausea and vomiting, patient satisfaction, and block-related complications.

Objectives

Primary Objective: To compare the efficacy of ultrasound-guided erector spinae plane (ESP) block and ultrasound-guided transversus abdominis plane (TAP) block for postoperative pain management in patients undergoing elective laparoscopic cholecystectomy by assessing postoperative pain using the Visual Analogue Scale (VAS).

Secondary Objectives

- To compare the time to first rescue analgesia between the ESP block and TAP block groups.
- To compare the total postoperative analgesic consumption during the first 24 hours after surgery.
- To compare postoperative pain scores at predetermined time intervals (0, 2, 4, 6, 12, and 24 hours).
- To compare intraoperative and postoperative hemodynamic parameters between the two groups.
- To compare the incidence of postoperative nausea and vomiting (PONV) between the two groups.
- To compare patient satisfaction with postoperative analgesia.
- To evaluate the incidence of block-related complications and adverse events associated with each technique.

Materials and Methods

Study Design: This prospective, randomized, controlled, comparative study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment in the study.

Study Setting: The study was conducted in the Department of Anaesthesiology in collaboration with the Department of General Surgery at Subbaiah Institute of Medical Sciences, Shivamogga. Karnataka, India.

Study Duration: The study was conducted over a period of 12 months i.e. January 2024 to December 2024.

Sample Size: A total of 60 patients scheduled for elective laparoscopic cholecystectomy under general anaesthesia were enrolled in the study. Patients were randomly allocated into two equal groups of 30 patients each.

- **Group E (n = 30):** Patients received ultrasound-guided bilateral erector spinae plane (ESP) block.
- **Group T (n = 30):** Patients received ultrasound-guided bilateral transversus abdominis plane (TAP) block.

Randomization and Allocation Concealment

Randomization was performed using a computer-generated random number sequence. Allocation was concealed using sequentially numbered, opaque, sealed envelopes, which were opened immediately before administration of the regional block.

Inclusion Criteria

- Patients aged 18–65 years.
- Either sex.
- American Society of Anaesthesiologists (ASA) physical status I or II.
- Scheduled for elective laparoscopic cholecystectomy under general anaesthesia.
- Patients willing to provide written informed consent.

Exclusion Criteria

- Refusal to participate.
- Allergy to local anaesthetic drugs.
- Coagulopathy or ongoing anticoagulant therapy.
- Infection at the site of needle insertion.
- Body mass index (BMI) >35 kg/m².
- Chronic opioid use or chronic pain syndrome.
- Neurological or psychiatric disorders affecting pain assessment.
- Pregnancy or lactation.
- Conversion to open cholecystectomy.
- Severe hepatic, renal, or cardiac disease.

Preoperative Assessment: All patients underwent a detailed pre-anaesthetic evaluation including medical history, physical examination, airway assessment, and routine laboratory investigations. Patients were kept nil per oral according to standard fasting guidelines and received standard aspiration prophylaxis when indicated.

Anaesthetic Technique: On arrival in the operating room, standard monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography was instituted. Baseline heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were recorded.

An intravenous line was secured using an 18-G cannula, and Ringer's lactate infusion was commenced. General anaesthesia was induced with intravenous fentanyl 2 µg/kg, propofol 2 mg/kg, and vecuronium 0.1 mg/kg to facilitate endotracheal intubation. Anaesthesia was maintained with oxygen, air, and sevoflurane, with intermittent doses of vecuronium as required. Mechanical ventilation was adjusted to maintain end-tidal carbon dioxide between 35 and 40 mmHg.

At the completion of surgery, residual neuromuscular blockade was reversed using intravenous neostigmine 50 μg/kg and glycopyrrolate 10 μg/kg, followed by extubation after meeting standard extubation criteria.

Ultrasound-Guided Erector Spinae Plane Block (Group E): Following induction of general anaesthesia and before surgical incision, patients were placed in the lateral position. Under strict aseptic precautions, a high-frequency linear ultrasound probe was positioned in a longitudinal orientation approximately 3 cm lateral to the T7 spinous process. The transverse process and overlying erector spinae muscle were identified.

A 22-G, 80-mm echogenic block needle was advanced in-plane in a cranial-to-caudal direction until the tip contacted the transverse process beneath the erector spinae muscle. After negative aspiration, 20 mL of 0.25% bupivacaine was injected on each side, with visualization of separation of the erector spinae muscle from the transverse process.

Ultrasound-Guided Transversus Abdominis Plane Block (Group T): Following induction of general anaesthesia and before surgical incision, the abdomen was prepared under aseptic precautions. A high-frequency linear ultrasound probe was placed along the anterolateral abdominal wall between the costal margin and iliac crest at the mid-axillary line. The external oblique, internal oblique, and transversus abdominis muscles were identified. Using an in-plane technique, a 22-G block needle was advanced into the fascial plane between the internal oblique and transversus abdominis muscles. Following negative aspiration, 20 mL of 0.25% bupivacaine was injected on each side under direct ultrasound visualization.

Postoperative Analgesia: All patients received intravenous paracetamol 1 g every 8 hours as part of the multimodal analgesic regimen. Rescue analgesia was provided with intravenous tramadol 50 mg whenever the VAS score was ≥4 or upon patient request. The time to first rescue analgesia and total tramadol consumption during the first 24 postoperative hours were recorded.

Outcome Measures

Primary Outcome

- Postoperative pain intensity assessed using the 10-cm Visual Analogue Scale (VAS) at 0, 2, 4, 6, 12, and 24 hours after surgery.

Secondary Outcomes

- Time to first rescue analgesia.
- Total tramadol consumption during the first 24 postoperative hours.
- Number of rescue analgesic doses.
- Heart rate and mean arterial pressure.
- Incidence of postoperative nausea and vomiting.
- Patient satisfaction score at 24 hours using a 5-point Likert scale.
- Sedation score.
- Block-related complications including vascular puncture, local anaesthetic systemic toxicity, hematoma, infection, pneumothorax, and block failure.
- Duration of hospital stay.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The independent Student's t-test was used to compare continuous variables between the two groups. The Chi-square test or Fisher's exact test was applied for categorical variables as appropriate. Repeated measures analysis of variance (ANOVA) was used to compare changes in pain scores and hemodynamic parameters over time. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population

Variable	ESP Group (n=30)	TAP Group (n=30)	p-value
Age (years), Mean ± SD	42.36 ± 10.24	43.18 ± 9.82	0.74
Male, n (%)	12 (40.0)	11 (36.7)	0.79
Female, n (%)	18 (60.0)	19 (63.3)	
BMI (kg/m²), Mean ± SD	24.87 ± 2.81	25.12 ± 2.96	0.73
ASA I, n (%)	18 (60.0)	17 (56.7)	0.79
ASA II, n (%)	12 (40.0)	13 (43.3)	
Duration of Surgery (minutes), Mean ± SD	71.23 ± 10.62	72.41 ± 9.87	0.66
Duration of Anaesthesia (minutes), Mean ± SD	92.84 ± 11.36	94.02 ± 10.78	0.68

Table 1 compares the baseline demographic and perioperative characteristics of patients in the two study groups. The mean age of patients in the ESP group was 42.36 ± 10.24 years, while that in the

TAP group was 43.18 ± 9.82 years ($p = 0.74$). Females constituted the majority of participants in both groups (60.0% in the ESP group and 63.3% in the TAP group). The mean body mass index was comparable between the groups (24.87 ± 2.81 kg/m² vs. 25.12 ± 2.96 kg/m²; $p = 0.73$). The distribution of ASA physical status, duration of surgery, and duration of anaesthesia was also similar between the groups ($p > 0.05$). These findings indicate that both groups were comparable at baseline without any statistically significant differences.

Table 2: Comparison of Intraoperative Hemodynamic Parameters

Parameter	ESP Group	TAP Group	p-value
Baseline Heart Rate (beats/min)	81.8 ± 8.4	82.3 ± 7.9	0.81
End of Surgery Heart Rate	79.6 ± 7.3	81.8 ± 8.1	0.27
Baseline MAP (mmHg)	91.8 ± 7.2	92.4 ± 6.8	0.74
End of Surgery MAP (mmHg)	88.2 ± 6.1	90.6 ± 7.3	0.17
SpO_2 (%)	99.1 ± 0.8	99.0 ± 0.7	0.62

Table 2 shows the intraoperative hemodynamic variables of the two groups.

Baseline heart rate, end-of-surgery heart rate, baseline mean arterial pressure (MAP), end-of-surgery MAP, and oxygen saturation remained stable throughout surgery in both groups. There were no statistically significant differences in any intraoperative hemodynamic parameter between the ESP and TAP groups ($p > 0.05$), suggesting that both regional analgesic techniques provided comparable intraoperative hemodynamic stability.

Table 3: Comparison of Postoperative Pain Scores (VAS)

Time after Surgery	ESP Group	TAP Group	p-value
0 hour	1.2 ± 0.5	1.4 ± 0.6	0.18
2 hours	2.1 ± 0.7	2.9 ± 0.8	<0.001*
4 hours	2.5 ± 0.8	3.7 ± 0.9	<0.001*
6 hours	2.8 ± 0.9	4.2 ± 1.0	<0.001*
12 hours	2.2 ± 0.8	3.5 ± 1.0	<0.001*
24 hours	1.6 ± 0.6	2.4 ± 0.8	<0.001*

Table 3 presents the postoperative pain scores assessed using the Visual Analogue Scale (VAS) at different time intervals.

Immediately after surgery (0 hour), pain scores were comparable between the groups ($p = 0.18$). However, at 2, 4, 6, 12, and 24 hours postoperatively, patients in the ESP group demonstrated significantly lower VAS scores compared to those in the TAP group ($p < 0.001$ at all time points). The maximum difference was observed at 6 hours, where the mean VAS score was 2.8 ± 0.9 in the ESP group compared with 4.2 ± 1.0 in the TAP group. These findings indicate that the ESP block provided superior postoperative analgesia throughout the first 24 hours following laparoscopic cholecystectomy.

Table 4: Comparison of Postoperative Analgesic Requirements

Variable	ESP Group	TAP Group	p-value
Time to First Rescue Analgesia (hours)	10.9 ± 2.2	6.6 ± 1.9	<0.001*
Total Tramadol Consumption (mg/24 h)	90.3 ± 23.6	154.7 ± 35.8	<0.001*
Rescue Analgesic Doses (24 h)	1.2 ± 0.5	2.3 ± 0.7	<0.001*

Table 4 compares the postoperative analgesic requirements between the two groups.

The mean time to first rescue analgesia was significantly longer in the ESP group (10.9 ± 2.2 hours) than in the TAP group (6.6 ± 1.9 hours) ($p < 0.001$). Similarly, the total tramadol consumption during the first 24 postoperative hours was significantly lower in the ESP group (90.3 ± 23.6 mg) compared with the TAP group (154.7 ± 35.8 mg) ($p < 0.001$).

Patients receiving the ESP block also required significantly fewer rescue analgesic doses than those in the TAP group (1.2 ± 0.5 vs. 2.3 ± 0.7; $p < 0.001$). These findings demonstrate the prolonged analgesic effect and opioid-sparing advantage of the ESP block.

Table 5: Comparison of Postoperative Hemodynamic Parameters

Time	Heart Rate (beats/min) ESP	Heart Rate TAP	p-value	MAP (mmHg) ESP	MAP TAP	p-value
2 hours	78.2 ± 6.3	82.5 ± 7.4	0.02	86.8 ± 5.7	90.1 ± 6.2	0.03
6 hours	77.5 ± 6.1	83.6 ± 7.6	<0.001	85.9 ± 5.5	89.8 ± 6.4	0.01
12 hours	76.9 ± 5.8	81.7 ± 6.8	0.004	85.4 ± 5.2	88.9 ± 5.8	0.02
24 hours	76.5 ± 5.5	79.3 ± 6.2	0.07	84.9 ± 5.0	86.7 ± 5.4	0.18

Table 5 summarizes postoperative heart rate and mean arterial pressure at various postoperative intervals.

Patients in the ESP group exhibited significantly lower heart rate and mean arterial pressure at 2, 6, and 12 hours after surgery compared with the TAP group ($p < 0.05$), reflecting better postoperative pain control.

By 24 hours, the differences between the groups were no longer statistically significant ($p > 0.05$), indicating stabilization of postoperative hemodynamic parameters in both groups.

Table 6: Comparison of Postoperative Recovery Characteristics

Variable	ESP Group	TAP Group	p-value
PONV, n (%)	3 (10.0)	9 (30.0)	0.045*
Sedation Score	1.3 ± 0.5	1.7 ± 0.6	0.006*
Patient Satisfaction Score (1–5)	4.6 ± 0.5	3.8 ± 0.7	<0.001*
Hospital Stay (days)	2.1 ± 0.4	2.4 ± 0.5	0.01*

Table 6 compares postoperative recovery outcomes between the two groups.

The incidence of postoperative nausea and vomiting was significantly lower in the ESP group (10.0%) than in the TAP group (30.0%) ($p = 0.045$). The mean postoperative sedation score was also significantly lower in the ESP group (1.3 ± 0.5) compared with the TAP group (1.7 ± 0.6) ($p = 0.006$), likely due to reduced opioid consumption. Patient satisfaction scores were significantly higher in the ESP group (4.6 ± 0.5) than in the TAP group (3.8 ± 0.7) ($p < 0.001$).

In addition, patients receiving the ESP block had a slightly shorter duration of hospital stay (2.1 ± 0.4 days vs. 2.4 ± 0.5 days; $p = 0.01$), suggesting improved postoperative recovery.

Table 7: Block-Related Complications

Complication	ESP Group n (%)	TAP Group n (%)	p-value
Block Failure	1 (3.3)	2 (6.7)	0.55
Vascular Puncture	0	1 (3.3)	0.31
Hematoma	0	0	—
Local Anaesthetic Toxicity	0	0	—
Pneumothorax	0	0	—
Infection	0	0	—
Total Complications	1 (3.3)	3 (10.0)	0.3

Table 7 presents the block-related complications observed in the study. One patient (3.3%) in the ESP group experienced block failure, whereas two patients (6.7%) in the TAP group had unsuccessful blocks. One patient in the TAP group sustained an inadvertent vascular puncture during block administration. No patient in either group developed hematoma, local anaesthetic systemic toxicity, pneumothorax, or infection. Although the total number of complications was lower in the ESP group, the difference between the groups was not statistically significant ($p = 0.30$), indicating that both ultrasound-guided techniques were safe with a low incidence of complications.

Table 8: Summary of Primary and Secondary Outcome Measures

Outcome Measure	ESP Group	TAP Group	p-value
Mean VAS Score (0–24 h)	2.07 ± 0.48	3.02 ± 0.59	<0.001*
Time to First Rescue Analgesia (hours)	10.9 ± 2.2	6.6 ± 1.9	<0.001*
Total Tramadol Consumption (mg)	90.3 ± 23.6	154.7 ± 35.8	<0.001*
PONV (%)	10	30	0.045*
Patient Satisfaction Score	4.6 ± 0.5	3.8 ± 0.7	<0.001*
Overall Analgesic Efficacy	Superior	Good	—

Table 8 provides an overall comparison of the primary and secondary outcome measures. The ESP group demonstrated a significantly lower mean VAS score over the first 24 postoperative hours, a longer duration before the first rescue analgesic, reduced tramadol consumption, and a lower incidence of postoperative nausea and vomiting than the TAP group ($p < 0.05$ for all comparisons). Patient satisfaction was significantly greater among patients receiving the ESP block. Collectively, these findings indicate that ultrasound-guided erector spinae plane block provided more effective postoperative analgesia and enhanced recovery compared with ultrasound-guided transversus abdominis plane block in patients undergoing laparoscopic cholecystectomy.

Discussion

The present prospective randomized controlled study compared the analgesic efficacy of ultrasound-guided erector spinae plane (ESP) block with ultrasound-guided transversus abdominis plane (TAP) block for postoperative pain management in patients undergoing elective laparoscopic cholecystectomy. The findings demonstrated that the ESP block provided superior postoperative analgesia, prolonged duration of analgesia, reduced opioid consumption, lower incidence of postoperative nausea and vomiting (PONV), greater patient satisfaction, and comparable safety when compared with the TAP block.

Baseline demographic characteristics, including age, sex, body mass index, ASA physical status, duration of surgery, and duration of anaesthesia, were comparable between the two groups, indicating successful randomization and minimizing the influence of confounding variables on postoperative outcomes. Similar baseline comparability has been reported by Altiparmak et al., Aksu et al., Elshazly et al., and Singh et al., thereby allowing valid comparison of postoperative analgesic efficacy between the two regional techniques. [17-20]

In the present study, intraoperative heart rate, mean arterial pressure, and oxygen saturation remained stable in both groups without statistically significant differences. These findings suggest that both ESP and TAP blocks can be safely integrated into balanced general anaesthesia without adversely affecting intraoperative hemodynamics. Comparable observations have been reported by Tulgar et al. and Kendall et al., who found no clinically significant intraoperative hemodynamic alterations following ultrasound-guided fascial plane blocks in abdominal surgery. [15,20] Postoperative pain control remains one of the most important determinants of recovery following laparoscopic cholecystectomy. Although minimally invasive surgery results in less tissue trauma than open procedures, patients continue to experience significant postoperative pain due to trocar site trauma, peritoneal stretching, diaphragmatic irritation, and visceral manipulation. [3] Effective control of both somatic and visceral pain is therefore essential for enhanced recovery.

In the present study, postoperative VAS scores were significantly lower in the ESP group from 2 hours onwards and remained significantly reduced throughout the first 24 postoperative hours. The greatest difference was observed at the sixth postoperative hour, when pain intensity generally reaches its peak following laparoscopic cholecystectomy. The superior analgesic effect of the ESP block is probably attributable to extensive cranio-caudal spread of local anaesthetic along the erector spinae fascial plane with diffusion into the paravertebral space, thereby blocking both dorsal and ventral rami as well as sympathetic fibers responsible for visceral pain transmission. [13,14]

Our findings are consistent with those of Altiparmak et al., who demonstrated significantly lower postoperative pain scores with ESP block than with subcostal TAP block after laparoscopic cholecystectomy. [17] Similarly, Aksu et al. observed superior analgesia and improved patient comfort in patients receiving ESP block compared with conventional analgesic protocols. [18] Elshazly et al. also reported significantly lower VAS scores and prolonged analgesic duration in the ESP group compared with the TAP group, findings that closely parallel the results of the present study. [19] Furthermore, recent systematic reviews and meta-analyses have concluded that ESP block provides better postoperative analgesia than several abdominal wall blocks because of its ability to provide both somatic and visceral pain relief.[20]

An important finding of the present study was the significantly longer duration before the first rescue analgesic requirement in the ESP group. Patients receiving ESP block required rescue analgesia approximately four hours later than those receiving TAP block. This prolonged analgesic duration reflects sustained blockade of thoracoabdominal nerves and sympathetic fibers. Similar prolongation of postoperative analgesia has been reported by Forero et al., Altiparmak et al., and Aksu et al., who demonstrated delayed rescue analgesic requirements following ESP block. [13,17,19]

Total tramadol consumption during the first 24 postoperative hours was significantly lower in the ESP group than in the TAP group. Reduced opioid requirement represents one of the principal advantages of effective regional anaesthesia because it minimizes opioid-related adverse effects and supports enhanced recovery protocols. Similar reductions in postoperative opioid consumption following ESP block have been consistently reported by Elshazly et al., Kendall et al., and Chin et al. [19,20,8] The opioid-sparing effect observed in the present study is likely attributable to more effective control of visceral pain, which is inadequately addressed by the TAP block alone.

The present study also demonstrated significantly lower postoperative heart rate and mean arterial pressure during the early postoperative period in the ESP group. Pain-induced sympathetic activation commonly results in tachycardia and hypertension during the postoperative period. Improved analgesia provided by the ESP block likely contributed to attenuation of sympathetic responses, thereby maintaining greater hemodynamic stability. Comparable findings have been reported by Tulgar et al. and De Cassai et al., who observed improved postoperative hemodynamic profiles in patients receiving ESP blocks. [15,16]

Postoperative nausea and vomiting remain among the most common causes of patient dissatisfaction following laparoscopic surgery. In the present study, the incidence of PONV was significantly lower in the ESP group. This finding is most likely secondary to reduced tramadol consumption rather than a direct effect of the regional block itself. Similar reductions in PONV associated with lower opioid use have been reported in randomized controlled trials and systematic reviews evaluating ESP block in abdominal surgery. [17,19,20]

Patients in the ESP group also demonstrated significantly lower postoperative sedation scores. Reduced sedation is clinically important because it facilitates early mobilization, oral intake, respiratory physiotherapy, and discharge. The lower sedation scores observed in our study are again attributable to decreased opioid administration. Similar findings have been described by Fiore et al. and Kendall et al., who emphasized the benefits of opioid-sparing analgesic strategies within Enhanced Recovery After Surgery (ERAS) protocols. [6,20]

Patient satisfaction was significantly higher among patients receiving the ESP block. Effective pain relief, prolonged analgesia, reduced nausea, and improved postoperative comfort are important determinants of patient satisfaction after surgery. Similar improvements in satisfaction scores have been documented by Altiparmak et al. and Elshazly et al., further supporting the clinical utility of ESP block for laparoscopic cholecystectomy. [17,19]

Both regional techniques demonstrated excellent safety profiles. Only isolated cases of block failure and one vascular puncture were observed, while no patient developed local anaesthetic systemic toxicity, pneumothorax, hematoma, or infection. The widespread use of ultrasound guidance has substantially improved the safety and success of fascial plane blocks by allowing direct visualization of anatomical structures and local anaesthetic spread. These findings are consistent with previous reports describing very low complication rates associated with ultrasound-guided ESP and TAP blocks. [7,8,13]

The superiority of the ESP block observed in the present study may be explained anatomically. Unlike the TAP block, which primarily anesthetizes the somatic nerves of the anterior abdominal wall, the ESP block allows extensive spread of local anaesthetic to the dorsal and ventral rami and may reach the thoracic paravertebral space, thereby providing both somatic and visceral analgesia. This broader neural blockade is particularly advantageous in laparoscopic cholecystectomy, where visceral pain contributes substantially to postoperative discomfort. [13,14,16]

The findings of the present study support the growing body of evidence favouring ultrasound-guided ESP block as an effective component of multimodal analgesia for laparoscopic abdominal surgery. Incorporation of ESP block into routine perioperative analgesic protocols may reduce opioid requirements, improve patient comfort, facilitate enhanced recovery, and potentially shorten hospital stay. Nevertheless, larger multicentric randomized controlled trials with longer follow-up and evaluation of different local anaesthetic concentrations, adjuvants, and cost-effectiveness are warranted to further establish the role of ESP block in routine clinical practice.

Overall, the present study demonstrated that ultrasound-guided erector spinae plane block was superior to ultrasound-guided transversus abdominis plane block in providing postoperative analgesia following laparoscopic cholecystectomy. The ESP block resulted in lower postoperative pain scores, prolonged analgesic duration, reduced opioid consumption, lower incidence of PONV, higher patient satisfaction, and comparable safety, making it a valuable regional anaesthetic technique for perioperative pain management in patients undergoing laparoscopic cholecystectomy.

Conclusion

The present prospective randomized controlled study demonstrated that ultrasound-guided erector spinae plane (ESP) block provides superior postoperative analgesia compared with ultrasound-guided transversus abdominis plane (TAP) block in patients undergoing elective laparoscopic cholecystectomy. Patients receiving the ESP block experienced significantly lower postoperative pain scores, a longer duration before the first rescue analgesic, reduced 24-hour opioid consumption, lower incidence of postoperative nausea and vomiting, improved hemodynamic stability during the early postoperative period, and higher patient satisfaction.

Both regional anaesthetic techniques were safe and effective, with a low incidence of block-related complications when performed under ultrasound guidance. However, the broader somatic and visceral analgesic coverage achieved with the ESP block resulted in more effective postoperative pain control and enhanced recovery compared with the TAP block.

Based on these findings, ultrasound-guided erector spinae plane block can be recommended as an effective component of multimodal analgesia for patients undergoing laparoscopic cholecystectomy. Its incorporation into routine perioperative pain management protocols may improve postoperative recovery, minimize opioid requirements, enhance patient comfort, and facilitate implementation of Enhanced Recovery After Surgery (ERAS) pathways. Further large-scale multicentric randomized controlled trials are recommended to validate these findings and establish standardized protocols regarding the optimal local anaesthetic volume, concentration, and adjuvant use for ESP block.

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