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Original Article

Anaesthesia Section

Ultrasound-guided Erector Spinae Plane Block versus Oblique Subcostal Transversus Abdominis Plane Block for Postoperative Analgesia in Laparoscopic Cholecystectomy: A Prospective Observational Study

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ABSTRACT

Introduction: Postoperative pain following laparoscopic cholecystectomy is multifactorial and requires effective management to enhance recovery and reduce opioid consumption. Ultrasound-guided regional techniques like Erector Spinae Plane Block (ESPB) and Oblique Subcostal Transversus Abdominis Plane (OSTAP) block are increasingly used for postoperative analgesia.

Aim: To compare the analgesic efficacy of ESPB and OSTAP block in patients undergoing laparoscopic cholecystectomy.

Materials and Methods: The present prospective observational study was conducted in the Department of Anaesthesia at SKIMS Medical College and Hospital, Srinagar, Jammu and Kashmir, India, from June 2024 to December 2025. A total of 56 patients undergoing elective laparoscopic cholecystectomy under general anaesthesia were enrolled into two equal groups: Group O received bilateral OSTAP block, and Group E received bilateral ESPB. Postoperative pain was assessed using the Numerical Rating Scale (NRS) at predefined intervals up to 24 hours. Time to first rescue analgesia, total analgesic consumption, haemodynamic parameters and complications were also evaluated. The p-value <0.05 was considered statistically significant.

Results: The mean age was 41.89±12.50 years in the OSTAP group and 38.86±12.75 years in the ESPB group (p-value >0.05). OSTAP group had four males and 24 females while ESPB group which had 10 males and 18 females (p-value >0.05). Mean Body Mass Index (BMI) was 22.58±1.20 kg/m^2 in the OSTAP group and 22.69±1.00 kg/m^2 in the ESPB group (p-value >0.05). OSTAP group had 11 American Society of Anaesthesiologists (ASA) I and 17 ASA II patients whereas ESPB group had 12 ASA I and 16 ASA II patients (p-value >0.05). The ESPB group demonstrated significantly lower NRS scores after extubation, in the recovery, at one hour, nine hours, 12 hours, and 24 hours postoperatively (p-value <0.05). The time to first rescue analgesia was significantly longer in the ESPB group than OSTAP group (p-value <0.001). Total analgesic consumption was significantly lower in the ESPB group (p-value <0.001). Mean heart rate, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Oxygen Saturation (SpO_2) were comparable between groups (p-value >0.05). No complications were observed.

Conclusion: ESPB provides superior and prolonged postoperative analgesia with reduced opioid requirement compared to OSTAP block, making it a more effective component of multimodal analgesia for laparoscopic cholecystectomy.

Keywords: Gall bladder surgery, Nerve block, Postoperative pain, Ultrasonography

INTRODUCTION

Laparoscopic cholecystectomy is the gold-standard treatment for symptomatic cholelithiasis and other benign gallbladder disorders and is one of the most frequently performed surgical procedures worldwide. Compared to open surgery, it offers several advantages, including reduced tissue trauma, smaller incisions, less postoperative pain, shorter hospital stay, faster recovery, and earlier return to routine activities [1]. Despite these benefits, postoperative pain remains a major clinical concern with many patients experiencing moderate-to- severe pain during the first 24 hours after surgery. Effective pain control is essential to improve patient comfort, facilitate early mobilisation, enhance recovery and enable timely discharge [2].

Pain following laparoscopic cholecystectomy is multifactorial in nature. Somatic pain arises from trocar insertion sites and abdominal wall trauma, whereas visceral pain results from gallbladder bed dissection, peritoneal inflammation, and intra-abdominal manipulation. Diaphragmatic irritation from residual carbon dioxide pneumoperitoneum commonly produces referred shoulder-tip pain [3]. The co-existence of these pain components makes postoperative anaesthesia challenging. Inadequately controlled pain can impair respiratory function, delay ambulation, prolong hospitalisation, increase healthcare costs, and negatively impact patient recovery.

Conventional postoperative analgesia relies on systemic opioids, Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), and paracetamol. Although opioids provide effective pain relief, their use is associated with adverse effects, including respiratory depression, sedation, postoperative nausea and vomiting, urinary retention, ileus, and the potential risk of persistent opioid use [4]. Consequently, Enhanced Recovery After Surgery (ERAS) protocols advocate multimodal analgesia to improve pain control while minimising opioid consumption [5].

Ultrasound-guided regional anaesthesia has become an important component of multimodal analgesia because it provides targeted neural blockade with fewer systemic side effects. Among the available techniques, the Transversus Abdominis Plane (TAP) block is widely used for abdominal surgery. The OSTAP block, first described by Hebbard PD et al., is a modification designed specifically for upper abdominal procedures. By facilitating longitudinal spread of local anaesthetic along the subcostal margin, it provides sensory coverage from approximately T6 to L1 dermatomes and effectively reduces somatic pain arising from the anterior abdominal wall [6]. Several studies have demonstrated reduced postoperative pain scores and opioid consumption with OSTAP block following laparoscopic cholecystectomy and other upper abdominal surgeries [6-9]. However, because the block primarily targets the thoracoabdominal nerves of the abdominal wall, its ability to control visceral pain is limited.

The ESPB, first described by Forero M et al., has emerged as a promising regional anaesthesia technique for thoracic and abdominal surgery [10]. The block involves injection of local anaesthetic deep to the erector spinae muscle and superficial to the transverse process. Cadaveric and radiological studies suggest spread of injectate to the paravertebral and epidural spaces, producing blockade of both somatic and sympathetic nerve fibres. This mechanism may provide analgesia for both somatic and visceral pain. Clinical studies have demonstrated effective postoperative analgesia and reduced opioid requirements with ESP block in thoracic, spinal, urological, and abdominal procedures [11,12].

Several comparative studies have evaluated ESP and TAP-based blocks in laparoscopic cholecystectomy. Engineer SR et al., reported lower postoperative pain scores and reduced analgesic requirements with ESP block compared with OSTAP block [7]. Similarly, Gupta A et al., demonstrated prolonged analgesia and lower rescue analgesic consumption with ESP block than subcostal TAP block [13]. A recent systematic review and meta-analysis by Liheng L et al., also suggested that ESP block provides superior postoperative analgesia and greater opioid-sparing effects than TAP block in abdominal surgery [14].

Despite these encouraging findings, the available evidence remains limited and heterogeneous [9,14-17]. Differences in study design, sample size, local anaesthetic concentration and volume, timing of block administration, and outcome measures have produced inconsistent results across studies [7-9,13-20]. Moreover, relatively few randomised studies have directly compared ESP and OSTAP blocks specifically in patients undergoing laparoscopic cholecystectomy, and consensus regarding the optimal regional analgesic technique remains lacking [7,9,13,15-17].

Given the growing emphasis on opioid-sparing strategies and the increasing use of ultrasound-guided fascial plane blocks, further comparative evaluation of these techniques is clinically relevant. Therefore, the present study was undertaken to compare the analgesic efficacy of ultrasound-guided ESPB and OSTAP block in patients undergoing elective laparoscopic cholecystectomy. The primary objective was to evaluate postoperative pain scores and duration of analgesia, while secondary objectives included assessment of rescue analgesic requirements and overall analgesic effectiveness.

MATERIALS AND METHODS

The present prospective observational study was conducted in the Department of Anaesthesia, SKIMS Medical College and Hospital, Srinagar, Jammu and Kashmir, India, over a period of 18 months from June 2024 to December 2025. The study was conducted after obtaining approval from the Institutional Ethics Committee (Approval No: 108/2024). Written informed consent was obtained from all participants.

Sample size calculation: The sample size was calculated based on a previous study by Engineer SR et al., [7]. The calculation was performed using the following formula:

$$n = 2\times\frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2\times(\sigma_d)^2}{(\mu_d)^2}$$

Where, $Z_{1-\alpha/2}$= value of Z at 95% confidence level= 1.96

$Z_{1-\beta}$=1.28 (at 90% power)

$(\sigma_d)^2= S^2_1+S^2_2/2$

σ_d=pooled standard deviation

$(\sigma_d)^2=S^2_1+S^2_2/2=40.5^2+51.4^2/2=1640.25+2641.96/2=4282.21/2=2141.105$

S_1 and S_2 were the standard deviations of tramadol consumption (in milligrams) per patient in 24 hours between the two groups (40.5 and 51.4, respectively)

μ_d=Expected mean difference=42.

Substituting the values:

$$n=\frac{2\times(1.96+1.28)^2\times2141.105}{42^2}=\frac{44952.927696}{1764}=25.48$$

The calculated sample size was 26 patients per group, giving a total of 52 patients. To account for possible dropouts and incomplete data, a total of 60 patients were initially enrolled, of which 56 patients completed the study and were included in the final analysis.

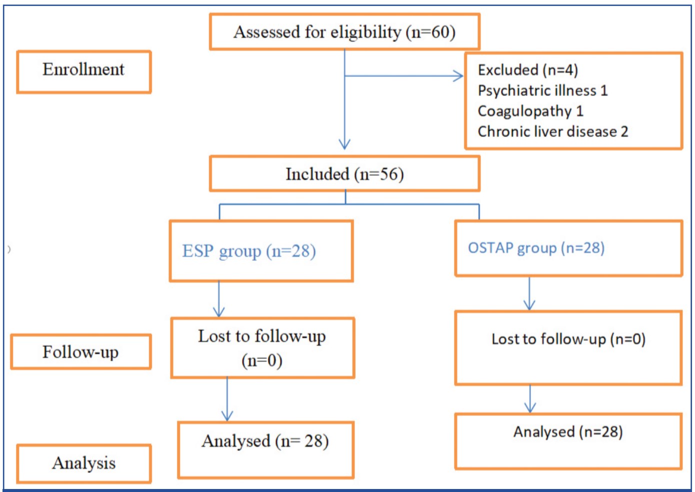
Inclusion criteria: Patients aged 20-60 years, belonging to ASA physical status I or II, scheduled for elective laparoscopic cholecystectomy under general anaesthesia were included in the study.

Exclusion criteria: Patients with obesity (BMI >30 kg/m²), liver disease, pregnancy, neurological or psychiatric illness, coagulopathy, anticoagulant therapy, or known drug allergies were excluded from the study.

Study Procedure

All patients underwent preanaesthetic evaluation, and informed written consent was obtained. Patients were educated regarding the NRS for pain assessment. In the operating room, standard monitoring was instituted, and general anaesthesia was induced using fentanyl (2 μg/kg), propofol (2 mg/kg), and atracurium (0.5 mg/kg), followed by endotracheal intubation. Anaesthesia was maintained with oxygen, nitrous oxide, and sevoflurane. Intravenous paracetamol 1 g was administered intraoperatively, and no local anaesthetic infiltration was performed at surgical sites. Both the ESPB and the OSTAP block are performed at our institution as part of standard, routine clinical care. The choice of which block a patient received was entirely dependent on the preference of the attending anaesthesiologist on duty and routine clinical activity. Data were gathered by observing and analysing the outcomes of these routine clinical practices after the blocks were administered.

Patients were enrolled into two groups O and E with equal number of patients (n=28). Group O received bilateral ultrasound-guided OSTAP block, and Group E received bilateral ultrasound-guided ESPB at the T9 level. In both groups, 20 mL of 0.2% ropivacaine was administered on each side in accordance with the study by Hebbard PD et al., and Patloo FA et al., [6,8]. The block was performed under ultrasound guidance using aseptic precautions after induction of anaesthesia and before surgical incision [Table-Fig-1].



[Table/Fig-1]: Participant flow diagram.

At the end of surgery, neuromuscular blockade was reversed and patients were extubated and shifted to recovery. Postoperative pain was assessed using the NRS at predefined intervals up to 24 hours. Rescue analgesia with intravenous tramadol was administered for NRS ≥3, with additional diclofenac for severe pain (NRS ≥7). The time to first rescue analgesia and total analgesic consumption over 24 hours were recorded. Patients were monitored for haemodynamic parameters (BP, HR), SpO_2 and complications such as haematoma, pneumothorax, local anaesthetic toxicity, or motor weakness.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software, version 25.0. Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequency and percentage. Intergroup comparisons of continuous variables were carried out using the independent t-test. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

The age distribution of patients was comparable between the two groups, with no statistically significant difference (p-value=0.310). Although the ESPB group had a relatively higher proportion of male patients compared to the OSTAP group, the difference was not statistically significant (p-value=0.061). The mean BMI was comparable between the OSTAP and ESPB groups (p-value=0.500). Similarly, ASA physical status distribution did not differ significantly between the two groups (p-value=0.500) [Table/Fig-2].

Variables		OSTAP group	ESPB group	p-value
Age (years)	Mean±SD	41.89±12.50	38.86±12.75	0.310
Gender	Male n (%)	4 (14.3)	10 (35.7)	0.061
	Female n (%)	24 (85.7)	18 (64.3)	
BMI (Kg/m²)	Mean±SD	22.58±1.20	22.69±1.00	0.500
ASA Grade	I n (%)	11 (39.3)	12 (42.9)	0.500
	II n (%)	17 (60.7)	16 (57.1)	

[Table/Fig-2]: Intergroup comparison of mean age, gender, mean BMI and ASA grade.
Age, BMI: independent t-test; Gender, ASA grade: Chi-square test

The ESPB group demonstrated significantly lower NRS scores at multiple time points, including immediately after extubation in the recovery room, at one hour, nine hours, 12 hours and 24 hours postoperatively (p-value <0.05). The difference in NRS score was not statistically significant at three hours (p-value=0.237) and a transient increase in pain score was observed at six hours (p-value <0.001) [Table/Fig-3].

Time point	OSTAP Group Mean±SD	ESPB Group Mean±SD	t-value	p-value
Immediately after extubation	1.96±0.13	1.82±0.24	2.729	0.009*
RR	2.09±0.20	1.91±0.20	3.426	0.001*
1 hour	2.70±0.39	2.14±0.23	6.433	<0.001*
3 hours	2.73±0.52	2.59±0.36	1.197	0.237
6 hours	2.63±0.55	3.20±0.55	-3.870	<0.001*
9 hours	3.54±0.84	2.75±0.75	3.693	0.001*
12 hours	3.82±0.72	2.77±0.82	5.093	<0.001*
24 hours	2.23±0.48	1.80±0.57	3.052	0.004*

[Table/Fig-3]: Intergroup comparison of postoperative Numerical Rating Scale (NRS) score.
RR: Recovery room *Statistically significant; Independent t-test; At 6 hours, NRS score was significantly higher in the ESPB group than the OSTAP group (p<0.001)

Mean SBP, DBP, HR, and SpO_2, were comparable between the two groups at all measured time points, with no statistically significant differences observed [Table/Fig-4].

Parameter	Time point	OSTAP Group Mean±SD	ESPB Group Mean±SD	p-value
SBP	RR	124.3±6.8	121.7±7.1	0.18
	1 hour	123.5±6.5	120.8±6.9	0.16
	3 hours	122.8±6.2	120.2±6.5	0.15
	6 hours	122.1±6.0	119.6±6.4	0.17
	9 hours	121.7±5.9	119.0±6.2	0.14
	12 hours	121.0±5.7	118.6±6.0	0.16
	24 hours	120.4±5.6	118.0±5.8	0.18
DBP	RR	78.6±4.9	76.9±5.2	0.21
	1 hour	77.9±4.6	76.3±4.9	0.23
	3 hours	77.3±4.4	75.8±4.7	0.24
	6 hours	76.8±4.3	75.2±4.6	0.22
	9 hours	76.3±4.2	74.9±4.4	0.25
	12 hours	75.8±4.1	74.4±4.3	0.23
	24 hours	75.2±4.0	73.9±4.1	0.24
HR	RR	86.4±5.3	83.8±5.1	0.12
	1 hour	85.9±5.0	83.1±4.7	0.10
	3 hours	84.7±4.8	82.5±4.6	0.14
	6 hours	83.9±4.7	81.6±4.5	0.13
	9 hours	83.1±4.5	81.0±4.3	0.15
	12 hours	82.5±4.4	80.7±4.2	0.19
	24 hours	81.9±4.3	80.2±4.1	0.20
SpO_2	RR	98.2±0.7	97.9±0.8	0.19
	1 hour	98.3±0.6	98.0±0.7	0.17
	3 hours	98.4±0.6	98.1±0.6	0.18
	6 hours	98.5±0.5	98.2±0.6	0.16
	9 hours	98.6±0.5	98.3±0.6	0.18
	12 hours	98.6±0.5	98.4±0.5	0.21
	24 hours	98.7±0.4	98.5±0.5	0.22

[Table/Fig-4]: Intergroup comparison of postoperative SBP, DBP, HR and SpO_2.
RR: Recovery room; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HR: Heart rate; SpO_2: oxygen saturation; Statistical test used: Independent t-test

The time to first request for rescue analgesia was significantly longer in the ESPB group compared to the OSTAP group (p-value <0.001). Total analgesic consumption over 24 hours was significantly lower in the ESPB group compared to the OSTAP group (p-value <0.001) [Table/Fig-5].

Variables	OSTAP Group Mean±SD	ESPB Group Mean±SD	t-value	p-value
Time to first request of analgesia (hours)	3.14±1.74	7.50±1.91	-8.919	<0.001*
Total analgesia consumption in 24 hours (mg)	123.21±25.39	83.04±11.89	7.582	<0.001*

[Table/Fig-5]: Intergroup comparison of time to first request of analgesia and total analgesia consumption.
*Statistically significant; Independent (unpaired) t-test

The distribution of total analgesic requirements differed significantly between the groups (p-value <0.001), with patients in the ESPB group requiring fewer additional doses of analgesics compared to the OSTAP group [Table/Fig-6]. No undesirable side effects or complications were observed in either group.

Tramadol requirement	OSTAP group	ESPB group
50 mg + 50 mg	0	9 (100%)
75 mg	5 (20.8%)	19 (79.2%)
75 mg + 50 mg	15 (100.0%)	0
75 mg + 75 mg	8 (100.0%)	0

[Table/Fig-6]: Intergroup comparison of distribution of total analgesic requirement.
Fisher's exact test; p<0.001; Percentages denote the proportion of all patients receiving each analgesic dose regimen who belonged to the respective group (row percentages)

DISCUSSION

The present study demonstrated that ultrasound-guided ESPB provided better pain relief compared with OSTAP block in patients undergoing laparoscopic cholecystectomy. Patients receiving ESPB had significantly lower postoperative NRS pain scores at multiple assessment points, including immediately after extubation in the recovery room, and at 1, 9, 12, and 24 hours postoperatively. Also, ESPB significantly prolonged the time to first rescue analgesia and reduced total analgesic consumption during the first 24 postoperative hours. Both groups showed comparable perioperative haemodynamic parameters, and no block-related complications were observed. These findings indicate that ESPB may provide more effective and sustained analgesia than OSTAP block and may represent an important component of multimodal analgesia for laparoscopic cholecystectomy.

The baseline demographic and clinical characteristics, including age, gender distribution, BMI, and ASA physical status, were comparable between the two groups. Similar findings have been reported in previous comparative studies evaluating ESPB and TAP-based techniques. Khalil MS et al., observed no significant differences in demographic variables between ESPB and OSTAP groups undergoing laparoscopic cholecystectomy [15]. Engineer et al., also reported comparable age, BMI, and ASA status between patients receiving ESPB and OSTAP blocks [7]. Similarly, Altıparmak B et al., demonstrated similar baseline characteristics between ESPB and TAP block groups in laparoscopic cholecystectomy patients [9].

The present study showed significantly lower NRS scores in the ESPB group at several postoperative time points, suggesting improved and prolonged pain control. Ozdemir H et al., and Dharani M et al., also reported significantly reduced NRS scores with ESPB compared with OSTAP block [16,17]. Engineer SR et al., also found improved postoperative pain control with ESPB compared with OSTAP block [7]. These findings are consistent with the present results and support the superiority of ESPB in providing prolonged postoperative analgesia.

The improved analgesic efficacy of ESPB may be related to its anatomical mechanism and wider spread of local anaesthetic. OSTAP block mainly targets thoracoabdominal nerves within the transversus abdominis fascial plane and provides somatic analgesia for abdominal wall incisions. However, postoperative pain following laparoscopic cholecystectomy includes both somatic and visceral components due to abdominal wall trauma, gallbladder manipulation, peritoneal irritation, and pneumoperitoneum. ESPB involves injection of local anaesthetic deep to the erector spinae muscle with potential extension towards the paravertebral region, resulting in blockade of dorsal and ventral rami and possible modulation of sympathetic pathways. Forero M et al., proposed this mechanism based on clinical observations [10]. Subsequent studies by Tulgar S et al., and Ma J et al., highlighted the increasing role of ESPB in abdominal surgery because of its wide analgesic coverage and opioid-sparing potential [18,19]. Kwon HM et al., further investigated the possible visceral analgesic effect of ESPB and suggested that its analgesic mechanism may extend beyond superficial abdominal wall blockade, although the exact contribution of visceral pathway inhibition remains under investigation [20]. These findings provide a physiological explanation for the improved pain outcomes observed with ESPB in the present study.

The duration of effective analgesia was significantly longer in the ESPB group. The time to first rescue analgesia was more than twice as long in patients receiving ESPB compared with OSTAP block, indicating clinically meaningful prolongation of pain relief. Similar observations have been reported previously. Engineer SR et al., demonstrated a significantly delayed requirement for rescue analgesia with ESPB compared with OSTAP block in laparoscopic cholecystectomy [7]. Gupta A et al., also reported prolonged analgesic duration with ESPB compared with TAP block, with delayed requirement of postoperative analgesics [13]. Altıparmak B et al., observed improved duration of analgesia and reduced rescue medication requirement with ESPB in laparoscopic cholecystectomy patients [9].

A significant reduction in total analgesic consumption was observed with ESPB in the present study. The ESPB group required significantly lower cumulative tramadol consumption during the first 24 postoperative hours, while higher-dose rescue analgesic regimens were predominantly observed among patients receiving OSTAP block. Previous studies have reported similar opioid-sparing effects. Engineer SR et al., demonstrated significantly lower tramadol consumption in ESPB-treated patients compared with those receiving OSTAP block [7]. Gupta A et al., and Ma J et al., observed similar results in their studies [13,19].

Postoperative haemodynamic parameters, including SBP, DBP, HR, and SpO_2 remained comparable between the two groups throughout the observation period. Similar results have been reported by Khalil MS et al., who found no significant differences in haemodynamic parameters between ESPB and OSTAP groups after laparoscopic cholecystectomy [15]. Engineer SR et al., and Ozdemir H et al., also reported comparable cardiovascular stability between ESPB and TAP-based techniques [7,16]. These findings indicate that the improved analgesic efficacy of ESPB does not occur at the expense of haemodynamic instability and supports its safety as part of multimodal perioperative analgesia.

Regarding safety outcomes, both ESPB and OSTAP blocks were associated with a favourable safety profile, with no complications such as pneumothorax, haematoma, local anaesthetic systemic toxicity, or motor weakness observed in either group. Previous literature has similarly demonstrated the safety of ultrasound-guided fascial plane blocks. Tulgar S et al., reviewed the clinical applications and potential complications of ESPB and emphasised that ultrasound guidance improves procedural safety [18]. The absence of adverse events in the present study further supports the feasibility of these techniques when performed by trained practitioners under appropriate monitoring.

Although previous literature has established the role of both ESPB and OSTAP block in laparoscopic cholecystectomy, uncertainty regarding the optimal regional technique remains because of variations in study design, block level, local anaesthetic dose, and outcome assessment. Existing studies have mainly focused on pain scores and opioid consumption, whereas the present study provides a broader evaluation incorporating serial NRS measurements, duration of analgesia, total analgesic requirement, rescue analgesic dose distribution, haemodynamic parameters, and safety outcomes [7,9,13,15-17]. The findings add to the existing literature by demonstrating that ESPB provides prolonged analgesia, reduces opioid requirement, and maintains haemodynamic stability compared with OSTAP block. Therefore, ESPB may be considered a useful component of multimodal analgesia strategies for patients undergoing laparoscopic cholecystectomy.

Limitation(s)

The observational nature of the study and absence of randomisation may introduce potential bias.

CONCLUSION(S)

The present study demonstrated that the ESPB provides superior and longer-lasting postoperative analgesia compared to the OSTAP block in patients undergoing laparoscopic cholecystectomy. ESPB was associated with lower pain scores, prolonged analgesic duration, and reduced opioid requirement, without compromising safety. These findings suggest that ESPB may be considered an important component of multimodal analgesia in laparoscopic cholecystectomy.

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