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Original Research Article

Erector Spinae Block vs. Subcostal TAP Block for Postoperative Analgesia in Open Cholecystectomy - A Randomised Trial

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Abstract:

Trial Design: A prospective, randomized, single-blind, comparative trial was conducted with 100 patients scheduled for elective open cholecystectomy. Patients were randomly allocated to two groups: Group A received a landmark-guided subcostal TAP (Transversus Abdominis Plane) block, and Group B received a landmark-guided ESP (Erector Spinae Plane) block, both using 20 ml of 0.25% ropivacaine prior to induction of anaesthesia.

Methods: Randomization was performed using a computer-generated sequence and sealed envelope technique. The primary outcomes were duration to first request for rescue analgesia, total postoperative rescue analgesic consumption, mean VAS (Visual Analogue Scale) pain scores at multiple time points, perioperative hemodynamic changes, and patient and surgeon satisfaction (5-point Likert scale). Blinded data collection ensured outcome assessment objectivity. Adverse event rates were also recorded.

Results: Both groups were similar in demographic and surgical parameters. The ESP block group demonstrated significantly lower mean postoperative VAS scores at all recorded intervals, longer duration to first rescue analgesic, and reduced total consumption of rescue analgesic compared to the TAP group (mean paracetamol consumption 1.5 ± 0.57 g for ESP vs. 2.04 ± 0.82 g for TAP; $p = 0.0003$). Mean patient satisfaction scores favored ESP (4.52 ± 0.50 vs. 4.32 ± 0.46). Hemodynamic variables were largely comparable except for lower systolic and mean arterial pressures at select postoperative intervals in ESP group. The incidence of adverse events (e.g., nausea, vomiting, headache) did not significantly differ between groups.

Conclusions: In open cholecystectomy, landmark-guided ESP block with ropivacaine 0.25% offers superior and prolonged postoperative analgesia, reduces rescue analgesic use, and provides better patient satisfaction compared with subcostal TAP block, with minimal differences in adverse events. ESP block is thus a practical and effective alternative in settings lacking ultrasound facilities.

Keywords: Erector Spinae Plane Block, Subcostal Transversus Abdominis Plane, Postoperative Analgesia, Randomised Controlled Trial, Ropivacaine 0.25%.

Introduction

Pain is a multidimensional and subjective experience, defined by the International Association for the Study of Pain (IASP) 2023 as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage".[1] In the pre-operative context, pain from surgical tissue injury-both intra-operative and post-operative-remains a major determinant of recovery, and inadequate management is associated with increased morbidity, delayed wound healing, progression to chronic pain, prolonged hospitalisation, and greater healthcare costs.[2-4] Surgical pain following abdominal procedures is predominantly nociceptive, resulting from activation of peripheral nociceptors in response to tissue injury.[5] Effective postoperative analgesia may be achieved through multiple modalities, including systemic, neuraxial, and regional techniques,[6] with regional blocks increasingly preferred in abdominal and thoracic surgeries for their opioid-sparing benefits.[7]

Several interfascial plane blocks have been developed for abdominal surgery, including the RSB (Rectus Sheath Block), the TAP (Transversus Abdominis Plane) block introduced in 2001, its oblique subcostal modification (OSTAP), and the more recent ESP (Erector Spinae Plane) block.[8]

Thoracic epidural analgesia has also been employed for open cholecystectomy.[9] Pain after open cholecystectomy arises from both somatic and visceral components,[10] making the choice of regional block particularly relevant. Although TAP block primarily targets somatic nerves from T6–L1,[11] ESP block-first described by Forero et al. in 2016[12] has been shown to spread to dorsal rami, ventral rami, and rami communicantes of thoracic and abdominal spinal nerves,[13] potentially offering combined visceral and somatic analgesia. Early clinical reports have demonstrated its successful use in abdominal surgeries, including cholecystectomy. [14,15]

Despite the advantages of ultrasound guidance in improving block accuracy and safety,[16] landmark-guided regional techniques continue to be widely practiced, especially in resource-limited environments where ultrasound availability and trained personnel remain limited.[17] Given that open cholecystectomy produces more severe postoperative pain than laparoscopic surgery,[18] identifying an effective and accessible regional block is clinically important, particularly in settings where open cholecystectomy is still prevalent.

Rationale: Although both subcostal TAP block and ESP block are used to manage postoperative pain following upper abdominal surgery, direct comparative evidence-especially using landmark-guided techniques-remains limited. Subcostal TAP block primarily provides somatic analgesia of the anterior abdominal wall,[19] whereas ESP block may provide broader analgesia due to its paravertebral spread.[13] In resource-limited centres where ultrasound is unavailable, landmark-guided techniques are frequently the only feasible option. Therefore, the present study was designed to compare the duration and quality of postoperative analgesia, rescue analgesic requirements, and hemodynamic responses between landmark-guided subcostal TAP block and landmark-guided ESP block in patients undergoing open cholecystectomy.

Aims and Objectives: The present study aims to evaluate and compare the analgesic efficacy of landmark-guided subcostal TAP block and Erector Spinae Plane (ESP) block, using 0.25% ropivacaine, in patients undergoing open cholecystectomy. Specifically, the study seeks to compare the duration until the first request for rescue analgesia, postoperative pain intensity as measured by the VAS, and total rescue analgesic consumption between the two groups. Additionally, it aims to assess intraoperative and perioperative hemodynamic changes associated with each technique and to compare overall patient and surgeon satisfaction using a 5-point Likert scale.

Materials and Methods

Study Design: This was a hospital-based, prospective, randomized, single-blinded, comparative study with a parallel group design and an allocation ratio of 1:1. The study compared two regional analgesic techniques: landmark-guided subcostal TAP block (Group A) vs. ESP (Erector Spinae Block) (Group B).

Inclusion and Exclusion Criteria: The study included patients aged 18–60 years with an ASA physical status of I or II, a BMI between 18.5 and 24, and those scheduled for elective open cholecystectomy under general anesthesia. Patients were excluded if they had severe cardiorespiratory, hepatic, renal, neurologic, or endocrine disorders; psychiatric problems; a known allergy to ropivacaine; or if the surgical procedure was expected to last more than one hour. All study procedures were carried out in the Surgery Operation Room Complex of Midnapore Medical College and Hospital.

Sample Size Calculation: For a randomised controlled trial for detecting difference of means, required sample size formula is:

$$n = \frac{(\sigma_1^2 + \sigma_2^2)\,(z_{\alpha/2} + z_{\beta})^2}{\delta^2}$$

Where, n = number of participants in each group, σ 1= standard deviation for group 1, σ 2 = standard deviation for group 2, z = conventional Z values and δ = minimal clinically important differences of mean (MCID).

Based on pilot study, using power of 0.90 and significance level of 0.05, sample size calculated was 90. Taking the dropout rate as 10%, the total sample size was calculated to be 100.

Data Collection Procedure: Data were collected prospectively for all enrolled patients after administering the assigned regional block (subcostal TAP block for Group A and ESP block for Group B), each performed on the right side using 20 ml of 0.25% Ropivacaine prepared by diluting 6.6 ml of 0.75% commercial solution with normal saline to a total volume of 20 ml. Following standardized block techniques specific to each group, general anesthesia was induced and maintained using an identical protocol for all participants to ensure comparability. Demographic variables, block details, intraoperative anesthetic requirements, and postoperative analgesic outcomes were recorded systematically. Observation points included the time of block administration, induction, intraoperative events, and postoperative assessments, allowing consistent and uniform data collection across both groups.

Outcomes: The primary outcome measured was the time to the first request for rescue analgesia, recorded from patient extubation until the need for the first analgesic dose when the VAS score exceeded 4. Secondary outcomes included the mean pain score assessed using a 10-point Visual Analogue Scale at multiple intervals from extubation up to 24 hours, total rescue analgesic consumption (Injection Paracetamol 1 g IV) over 24 hours, and hemodynamic parameters-SBP, DBP, MAP, and HR-monitored at baseline, intraoperatively at specified intervals after skin incision, and postoperatively. Respiratory parameters including respiratory rate and SpO_2 were recorded preoperatively, intraoperatively, and postoperatively. Patient and surgeon satisfaction were evaluated using a 5-point Likert scale at the time of discharge, and any adverse effects such as postoperative nausea and vomiting or headache were documented during the 24-hour follow-up period.

Statistical Analysis: Statistical analysis was performed using GraphPad Prism version 9.5.0. Continuous variables such as the duration of first rescue analgesia, total analgesic consumption, mean VAS scores, and hemodynamic parameters were compared between the two groups using the unpaired Student's t-test, and results were presented as mean ± standard deviation (SD). Categorical variables, including sex, ASA grade, adverse effects, and Likert scale satisfaction scores, were analyzed using the Chi-square test or Fisher's exact test where appropriate. A p-value of <0.05 was considered statistically significant.

Results

Table 1: Participant Flow

Stage	Group A (OSTAP)	Group B (ESP)	Notes
Assessed for eligibility	100	-	
Excluded prior to randomisation	0		
Randomised	50	50	Computer-generated sealed envelopes.
Received intended intervention	50	50	Landmark guided OSTAP / ESP performed.
Lost to follow-up after randomisation	0	0	
Discontinued intervention	0	0	
Analysed for primary outcome	50	50	Analyses performed on original assigned groups.

In table 1 the trial recruited and completed follow-up for all randomized patients (no post-randomisation exclusions), analysed per assigned groups (n=50 each). Recruitment period: August 2022 – February 2024**.** Trial ended on completion of planned recruitment/follow-up (study completed as planned).

Table 2 illustrates baseline comparability of groups (age, sex, ASA, weight, height, BMI, duration of surgery). Baseline demographic and clinical variables were comparable across groups (no statistically significant differences).

Table 2: Baseline Demographic & Clinical Characteristics

Characteristic	Group A (n=50)	Group B (n=50)	p-value	Interpretation
Age (years), mean ± SD	38.64 ± 3.86	37.08 ± 4.82	0.08	NS.
Sex (male), n (%)	15 (30%)	16 (32%)	0.829	NS.
ASA I / II, n (%)	45 (90%) / 5(10%)	46 (92%) / 4(8%)	0.727	NS.
Weight (kg), mean ± SD	66.50 ± 4.82	67.20 ± 5.66	0.512	NS.
Height (cm), mean ± SD	164.08 ± 4.44	164.52 ± 4.42	0.623	NS.
BMI (kg/m^2), mean ± SD	24.67 ± 0.79	24.78 ± 1.16	0.586	NS.
Duration of surgery (min), mean ± SD	57.58 ± 7.07	56.64 ± 7.31	0.519	NS.

Table 3 illustrates denominators used for each outcome and whether analyses used original assigned groups. All outcomes were analysed using the full randomized sample (n=50 per group). The thesis reports no missing outcome data for the primary 24-hour follow up period; analyses were by original assigned groups.

Table 3: Numbers Included in Each Analysis & Analysis Population

Outcome / Analysis	Denominator in Group A	Denominator in Group B	Analysis Population
Primary outcome - time to first rescue analgesic	50	50	Analysis by original assigned groups (intention to treat as randomised; no losses).
Total rescue analgesic consumption (paracetamol, g)	50	50	Per protocol = all randomized (no exclusions).
VAS at multiple timepoints (0–24 h)	50	50	All timepoints recorded for n=50 each.
Haemodynamics (HR, SBP, DBP, MAP) peri-op & post-op	50	50	All analysed in original groups.
Adverse events (PONV, headache)	50	50	All analysed.

Table 4 illustrates group means, SDs, between-group difference, 95% CI, and p-value.CI was computed: difference = 360.46 − 295.42 = 65.04 min. SE = sqrt (14.56²/50 + 11.62²/50) ≈ 2.635; 95% CI ≈ 65.04 ± 1.96×2.635 = (≈59.9, 70.2). ESP block (Group B) gave a clinically and statistically significant longer time to first rescue analgesic - about 65 minutes longer (95% CI ≈ 59.9–70.2).

Table 4: Primary Outcome: Time to First Rescue Analgesic (mins)

Outcome	Group A (OSTAP) mean ± SD	Group B (ESP) mean ± SD	Mean difference (B − A)	95% CI (B − A)	p-value
Time to first rescue analgesic (mins)	295.42 ± 14.56	360.46 ± 11.62	+65.04 mins	59.9 to 70.2 mins	< 0.0001

Table 5 illustrates selected VAS (1 hour) and total paracetamol consumption with effect sizes and precision. Negative difference means Group B had lower scores / consumption (favouring ESP). CIs computed from thesis means/SDs and n=50 per group. ESP block reduced pain intensity (example at 1 h: mean VAS lower by ≈0.92 units) and reduced paracetamol consumption (mean reduction ≈0.54 g over 24 h), both statistically significant and clinically consistent.

Table 5: Key Secondary Efficacy Results (VAS, Total Rescue Analgesic)

Outcome	Group A mean ± SD	Group B mean ± SD	Mean difference (B − A)	95% CI (B − A)	p-value
VAS at 1 hour (units)	1.96 ± 0.82	1.04 ± 0.87	**−0.92**	**−1.25 to −0.59**	<0.0001
Total paracetamol (g, 24 h)	2.04 ± 0.82	1.50 ± 0.57	**−0.54 g**	**−0.82 to −0.26 g**	0.0003

Table 6 illustrates SBP and MAP at timepoints that were reported as statistically significant in the thesis, with mean differences and CIs. ESP group had modest but statistically significant lower SBP and MAP at several intra- and early post-operative timepoints - consistent with reduced nociceptive response. For the two intra-op timepoints above I computed CIs from reported means/SDs (n=50). Other haemodynamic timepoints showed no statistical difference.

Table 6: Haemodynamic Outcomes Where Differences were Significant (selected time points)

Parameter (time)	Group A mean ± SD	Group B mean ± SD	Mean difference (B − A)	95% CI (B − A)	p-value
SBP - intraop 30 min (mm Hg)	123.08 ± 5.74	119.52 ± 6.41	−3.56 mm Hg	−5.95 to −1.17	0.0047
MAP - intraop 30 min (mm Hg)	92.26 ± 3.92	90.52 ± 3.69	−1.74 mm Hg	−3.23 to −0.25	0.0259
SBP - post-op 0 min (mm Hg)	121.80 ± 7.97	118.22 ± 8.04	-----	—	0.0292
MAP - post-op 0 min (mm Hg)	91.46 ± 4.81	89.32 ± 4.45	----	—	0.0245

Table 7 illustrates binary outcomes (PONV, headache) - absolute and relative effect sizes. Absolute effect sizes are small (2 percentage points). Relative risks are unstable with small counts. No

pre-specified subgroup analyses or adjusted multivariable analyses are reported in the thesis (no adjusted estimates). No important differences in reported minor adverse events (PONV, headache). No serious harm reported.

Outcome	Group A n (%)	Group B n (%)	Absolute difference (B − A)	Relative effect (RR)	p-value
PONV	3 / 50 (6%)	4 / 50 (8%)	+2% (more in B)	RR = 1.33	0.695 (NS)
Headache	2 / 50 (4%)	3 / 50 (6%)	+2% (more in B)	RR = 1.50	0.646 (NS)

Table 7: Other Analyses, Binary Outcomes, and Effect Sizes

Table 8 illustrates harms recorded and their distribution; indicates absence of major adverse events. It reports only minor, infrequent adverse effects (PONV, headache) balanced across groups. No major harms (e.g., LAST, neurological deficit, re-operation) were recorded within the 24-hour follow-up window.

Table 8: Harms /Unintended Effects

Harms/Adverse Effects	Group A (n=50)	Group B (n=50)	Comment
Post-op nausea & vomiting (PONV)	3 (6%)	4 (8%)	NS; no serious sequelae reported.
Headache	2 (4%)	3 (6%)	NS; mild and self-limited per thesis.
Local anaesthetic systemic toxicity (LAST)	0	0	None reported.
Other serious AEs (readmission, re-operation)	0	0	None reported in 24-hour follow up.

Discussion

Effective perioperative pain management is essential to reducing morbidity, enhancing recovery, and improving patient satisfaction following open abdominal surgery. [2,20] Open cholecystectomy produces both somatic and visceral pain,[10] making regional anesthesia techniques an important component of multimodal analgesia. This randomized comparative study evaluated the analgesic efficacy of landmark-guided ESP block versus subcostal TAP block using 0.25% ropivacaine for postoperative pain following open cholecystectomy.

The principal finding of this trial is that ESP block provided significantly longer duration of analgesia**,** lower postoperative VAS pain scores**,** and reduced rescue analgesic consumption compared with the subcostal TAP block. Patients receiving ESP block requested their first rescue analgesic at a mean of 360.46 ± 11.62 minutes, substantially longer than the 295.42 ± 14.56 minutes observed with the subcostal TAP block ($p < 0.0001$). Pain scores were consistently lower in the ESP group during the first 12 postoperative hours, and total paracetamol consumption was significantly reduced (1.5 ± 0.57 g vs 2.04 ± 0.82 g, $p = 0.0003$). These findings demonstrate superior postoperative analgesia with ESP block, even when both techniques are performed using landmark-guided methods.

The analgesic superiority of ESP block in this study aligns well with existing literature. Prior studies comparing ultrasound-guided ESP block with subcostal TAP block in laparoscopic cholecystectomy reported prolonged analgesia, reduced rescue opioid consumption, and improved pain scores with ESP block.[21,22,23] These results are supported by anatomical evidence that ESP block facilitates spread into the paravertebral and epidural spaces via the costotransverse foramina, thereby blocking both dorsal and ventral rami and offering visceral as well as somatic analgesia.[13,24,25] In contrast, subcostal TAP block primarily targets somatic nerves (T6–L1) within the anterior abdominal wall , and therefore may provide less complete analgesia for surgical procedures involving significant visceral manipulation.

Additional observations in this study include modest but statistically significant reductions in systolic blood pressure and mean arterial pressure at several intraoperative and early postoperative time points in the ESP group, suggesting more effective attenuation of nociceptive sympathetic activation. Patient satisfaction scores were also higher with ESP block, whereas surgeon satisfaction did not differ significantly between groups. Importantly, both blocks demonstrated similar safety profiles, with low and comparable incidences of postoperative nausea–vomiting and headache, consistent with findings from previous investigations.[22]

Generalizability: Despite these limitations, the findings remain clinically relevant, particularly for resource-limited settings where ultrasound machines may not be routinely available. The demonstration that landmark-guided ESP block provides superior analgesia compared with landmark-guided subcostal TAP block enhances its practical value for peripheral centers in India and

similar health systems. [17,18] However, results should be extrapolated cautiously to laparoscopic surgeries, high-BMI patients, or institutions with established ultrasound-guided regional anaesthesia practices.

Interpretation and Overall Implications: Taken together, this study supports ESP block as a more effective regional analgesic technique than subcostal TAP block for open cholecystectomy when using 0.25% ropivacaine. ESP block's broader neural coverage, visceral analgesic benefit, and favorable hemodynamic and satisfaction outcomes underscore its usefulness in perioperative pain management. These findings are consistent with the growing body of evidence favoring ESP block for abdominal surgeries. [21,22] Given its ease of performance, safety profile, and suitability in settings without ultrasound, ESP block represents a valuable alternative in optimizing postoperative analgesia in open upper-abdominal procedures.

Limitations: The present study has several limitations that should be acknowledged. First, all regional blocks were performed using landmark-guided techniques because ultrasound equipment was not available in the institution, which may have reduced placement accuracy and introduced operator-dependent variability. Second, only surgeries completed within one hour were included, potentially limiting applicability to longer or more complex procedures. Third, as a single-center study, the findings may not be fully generalisable, and multicenter trials would strengthen external validity. Additionally, a fixed volume of local anesthetic was administered to all patients, and no adjuvants were used, preventing assessment of dose-response relationships or potential benefits of additive agents. Because a low concentration of ropivacaine (0.25%) primarily produces sensory blockade, motor block was not evaluated. Finally, the study included only ASA I–II patients with BMI ≤24, excluding higher-risk individuals and limiting applicability to broader surgical populations.

Conclusion

Based on the findings of this randomized comparative study, landmark-guided erector spinae plane block provides superior postoperative analgesia compared with landmark-guided subcostal transversus abdominis plane block in patients undergoing open cholecystectomy. When performed with 20 ml of 0.25% ropivacaine, the erector spinae block resulted in significantly prolonged duration of pain relief, lower postoperative pain scores, and reduced requirement for rescue analgesic medication. Additionally, it offered better hemodynamic stability during the early postoperative period and demonstrated a similar safety profile with minimal adverse effects. These results suggest that, particularly in resource-limited settings where ultrasound is not readily available, landmark-guided erector spinae block is an effective and reliable regional analgesic technique for managing postoperative pain after open cholecystectomy.

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