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Original Article

Comparison of analgesic efficacy of combined external oblique intercostal and rectus sheath block with local infiltration analgesia at port site in patients undergoing laparoscopic cholecystectomy: a randomized controlled trial

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Background: Conventional fascial plane block approaches for upper abdominal surgeries spare the lateral cutaneous nerve. An external oblique intercostal block (EOIB) may be suitable for upper abdominal incisions as it blocks the lateral and anterior branches of the intercostal nerves T6–T10. However, there is a paucity of studies evaluating this block in clinical settings. The study aimed to compare the analgesic efficacy of combined EOIB and rectus sheath block with local infiltration analgesia (LIA) in laparoscopic cholecystectomy (LC).

Methods: After obtaining written informed consent, 70 patients were randomly allocated to undergo right-sided EOIB with 20 ml and left-sided RSB with 10 ml of 0.25% bupivacaine at the end of surgery (group ER, n = 35). Patients in the LIA group (n = 35) underwent local infiltration at the port site using 20 ml of the same solution (group LIA, n=35).

Results: The visual analog scale scores with combined EOI and RSB were significantly lower than those with LIA at 1, 2, 4, 8, and 12 h (P < 0.001). Rescue analgesics were required by 65.7% and 14.3% of the patients in the LIA and block groups, respectively (P < 0.001). The time to first rescue analgesic was significantly greater in the ER group than that in the LIA group (2.8 ± 1.10 vs. 1.6 ± 0.50 h; P = 0.012). The number of times rescue analgesia was required was significantly lower in the ER group than that in the LIA group (1.00 ± 0.00 vs. 1.83 ± 0.72; P = 0.015). Nausea and vomiting scores were higher in the LIA group than those in the ER group (P < 0.001). Patient satisfaction scores were higher in the ER group than those in the LIA group.

Conclusions: EOIB combined with RSB provides superior analgesia compared with LIA and should be considered for LC.

Keywords: Analgesia; Anesthesia; Bupivacaine; Cholecystectomy; Intercostal nerve; Laparoscopic; Local; Nerve block; Patient satisfaction; Postoperative pain; Rectus sheath block.

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the preferred treatment over open surgery for gallbladder lesions because of its minimal invasiveness; it is associated with less postoperative pain, minimal surgical complications, and a short length of hospital stay [1]. Pain after LC is multifactorial: somatic pain due to incision and visceral pain due to carboperitoneum. Somatic pain predominates visceral pain and is intense during the immediate postoperative period [2]. Owing to the multiple sources of pain, a multimodal approach is used to alleviate pain. Various pharmacological interventions (opioids, non-steroidal anti-inflammatory drugs, and adjuvant agents such as dexamethasone), port-site local infiltration analgesia (LIA), and intraperitoneal instillation are commonly used modalities. However, the increasing awareness of opioid-related adverse events, including respiratory depression, paralytic ileus, and sedation, has led to a shift toward the use of opioid-sparing techniques for postoperative analgesia [3]. In recent years, ultrasound-guided fascial plane blocks have been rapidly incorporated into multimodal analgesia for laparoscopic abdominal surgeries [4]. The transverse abdominal plane (TAP) block has been conventionally used to provide analgesia during upper and lower abdominal surgeries [3].

The ultrasound-guided oblique subcostal transverse abdominal plane (SCTAP) block, first described by Hebbard et al. [11], has the potential to provide analgesia for upper abdominal dermatomes [3]. A local anesthetic (LA) is injected into the fascial plane between the rectus abdominis and the transverse abdominis muscles. It provides analgesia to the anterior abdominal wall by blocking the anterior cutaneous branches of the nerve roots arising from the T7–T10 spinal nerves but does not cover the lateral cutaneous branches of the segmental nerves [5]. Hence, the SCTAP block may not adequately cover areas lateral to the midclavicular line, where ports and drains may be placed [3]. This limits the utility of this block in upper abdominal surgeries such as cholecystectomy, nephrectomy, and hepatectomy. To overcome this important limitation of the SCTAP block, Elsharkawy et al. [4] described an external oblique intercostal block (EOIB) that largely covers the lateral and anterior cutaneous branches of the intercostal nerves and contributes to the innervation of the upper abdominal wall.

The rectus sheath block (RSB) is routinely added to the subcostal plane block to provide adequate analgesia to the middle wall of the abdomen formed by the rectus muscles [1]. In this technique, LA is administered between the rectus muscle and posterior rectus sheath. This technique provides analgesia by blocking the terminal branch of the ventral ramus along the course of the T7–L1 nerves [6]. In the present study, only the left RSB was added to the right EOIB because the umbilical port has been reported to be the most painful in our experience. The umbilical dermatomes on the ipsilateral side were covered by the right EOIB, whereas the left RSB was planned to cover the contralateral side.

We hypothesized that EOIB combined with RSB is a more effective regional anesthesia technique than LIA. Therefore, we conducted a prospective randomized comparative trial to evaluate the quality of postoperative analgesia provided by a combination of EOIB and RSB versus LIA at port sites in patients who underwent LC.

MATERIALS AND METHODS

This prospective interventional randomized comparative study was conducted over six months (from April 2023 to October 2023) in the Department of Anesthesiology and Intensive Care at a tertiary care center in northern India after obtaining approval from the Institutional Ethical Committee and registration with the Clinical Trial Registry of India (CTRI NUMBER: CTRI/2023/04/052035). Written informed consent was obtained from all enrolled patients in a well-understood language. Institutional ethics committee approval was obtained before the start of the study.

The study was conducted on adult patients aged 18–65 years, with American Society of Anesthesiologists status I and II, and who underwent laparoscopic cholecystectomy under general anesthesia. Patients with any history of allergy or hypersensitivity to local anesthetics, contraindications to the block procedure (history of coagulopathy or use of anticoagulants, local site infections at the site of needle insertion), inability to understand the visual analog scale (VAS), chronic opioid intake, body mass index > 30 kg/m^2 or body weight < 50 kg, pregnancy, or any cardiopulmonary or hepatorenal disease were excluded.

The primary objective of this study was to compare the analgesic efficacy of the two regional anesthesia techniques using the VAS at 1 h postoperatively. The secondary outcomes included VAS scores for 24 h, time to first rescue analgesia, cumulative 24-h analgesia requirement, and patient satisfaction.

Liu et al. [7] observed that the mean VAS score at 1 h in the local anesthesia infiltration group was 5.6 ± 2.0. Taking

these values as a reference and assuming a 25% difference in the level of pain between the two groups, the minimum required sample size with 80% power and a 5% level of significance was 32 patients in each study group. Allowing for 5% attrition, the final required sample size was adjusted to 35 patients per group. Therefore, a total of 70 patients were recruited.

The block randomization technique was employed in a series of blocks of 10 for randomization, and a sealed envelope system was used for allocation concealment. After obtaining written informed consent, patients were randomly allocated to one of the two groups:

- Group ER (n = 35): Patients in this group received right-sided EOIB using 20 ml of 0.25% bupivacaine with 1:200,000 adrenaline and left-sided RSB using 10 ml of 0.25% bupivacaine with 1:200,000 adrenaline at the end of the surgery.
- Group LIA (n = 35): Patients received local infiltration at the port site using 20 ml of 0.25% bupivacaine with 1:200,000 adrenaline.

The patient and postoperative outcome assessor were not aware of the group allocation.

All patients underwent a thorough pre-anesthetic checkup with a detailed history, examination, and relevant laboratory investigations one day before surgery. Patients were provided with a patient information sheet and an informed consent form. Those willing to participate in the study were informed about the block technique and use of the VAS. All patients were provided with standard fasting instructions preoperatively (8 h for solids and 2 h for clear liquids). All patients received oral alprazolam (0.5 mg) and pantoprazole (40 mg) at night and two hours before surgery.

On the day of surgery, patients were transferred to the operating room. Upon arrival in the operating room, standard monitoring, including heart rate, mean arterial pressure, electrocardiography, and arterial oxygen saturation (SpO_2), was established. An end-tidal carbon dioxide ($EtCO_2$) monitor was connected to the anesthesia circuit. The intravenous line was secured with an 18 G intravenous cannula, and infusion of an isotonic fluid was initiated.

General anesthesia was induced using fentanyl (2 μg/kg), a titrated dose of propofol (2–3 mg/kg), and vecuronium (0.1 mg/kg). The airway was secured with an appropriately sized Proseal laryngeal mask airway (ProsealTM Laryngeal mask airway, Teleflex). Ventilation was initiated in a volume-controlled mode at a tidal volume of 6–8 ml/kg body weight and a respiratory rate of 12–14 min using a closed-circle breathing system maintaining an $EtCO_2$ of 30–35 mmHg. Low-flow anesthesia was maintained with isoflurane (1–1.5%) in oxygen and air (50:50) titrated to achieve 1 minimum alveolar concentration, and a maintenance dose of vecuronium was administered as needed. Routine monitoring of hemodynamic and other vital parameters was continued at 15-min intervals until the end of the procedure.

Paracetamol (1 g) was administered intravenously 30 min before the end of surgery, followed by every 8 h. Both groups received the blocks per group allocation after surgery prior to extubation in the supine position.

Block procedure

1. External oblique intercostal block

A linear ultrasound transducer (38 mm, high-frequency [8–13 MHz] sonosite [M-Turbo, Fujifilm Inc.]) was placed in the paramedian sagittal oblique plane between the midclavicular and anterior axillary lines at the level of the sixth rib. The short-axis view of the ribs was identified by placing the transducer at the level of the xiphoid process, which corresponded to the seventh rib, and moved upward (Fig. 1). The skin entry point was at the level of the sixth rib, from the superomedial to the inferolateral side. After piercing the skin and subcutaneous tissue, the fascial plane between the external oblique and intercostal muscles was identified, and the needle tip position was confirmed by hydrodissection. After negative aspiration, 20 ml bupivacaine 0.25% with 1:200,000 adrenaline was injected caudally into the sixth rib using a 5-cm 22G insulated nerve block needle (Stimuplex® A, B. Braun Medical (India) Pvt. Ltd.) [4].

2. Rectus sheath block

The skin was disinfected, and the transducer was placed at the level of the umbilicus immediately lateral to the left side in a transverse position. The needle was inserted in-plane in a medial-to-lateral orientation through the subcutaneous tissue to pierce the anterior rectus sheath. The needle was advanced through the body of the muscle until the tip rested on the posterior rectus sheath (Fig. 2). After negative aspiration, 0.5–1 ml of normal saline was injected to verify the location of the needle tip. Following visualization of the correct separation of the posterior rectus sheath from the rectus muscle, 10 ml of 0.25% bupivacaine with 1:200,000 adrenaline was administered to the left side [8].

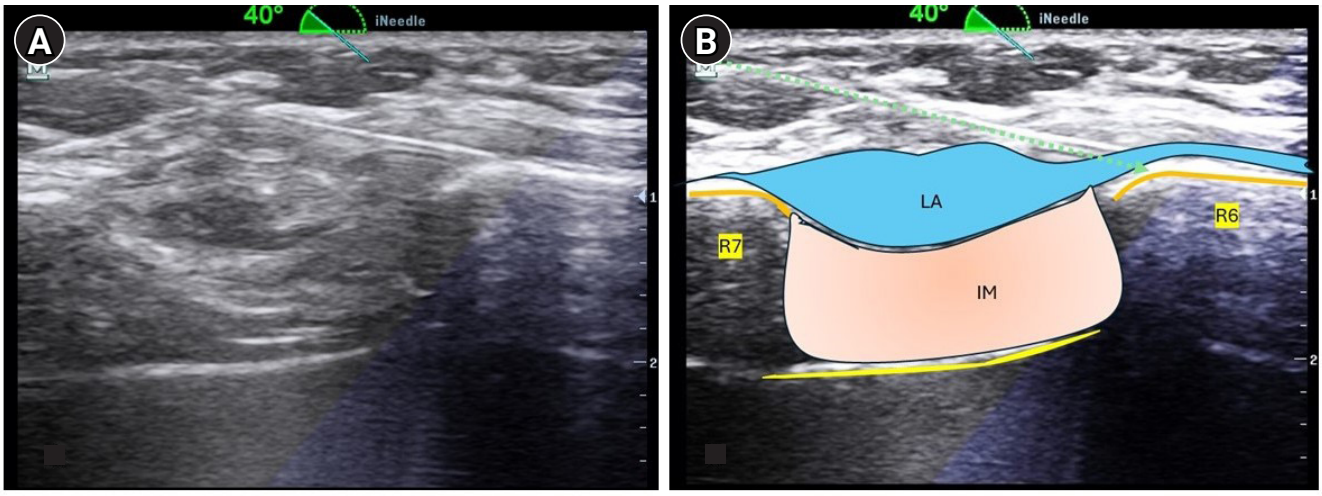

Fig. 1. Ultrasound-guided external oblique intercostal block. (A) Needling technique. (B) Labeled image. R7: seventh rib, LA: local anesthetic, IM: intercostal muscles, R6: sixth rib, yellow line: pleura, dotted green line: needle trajectory.

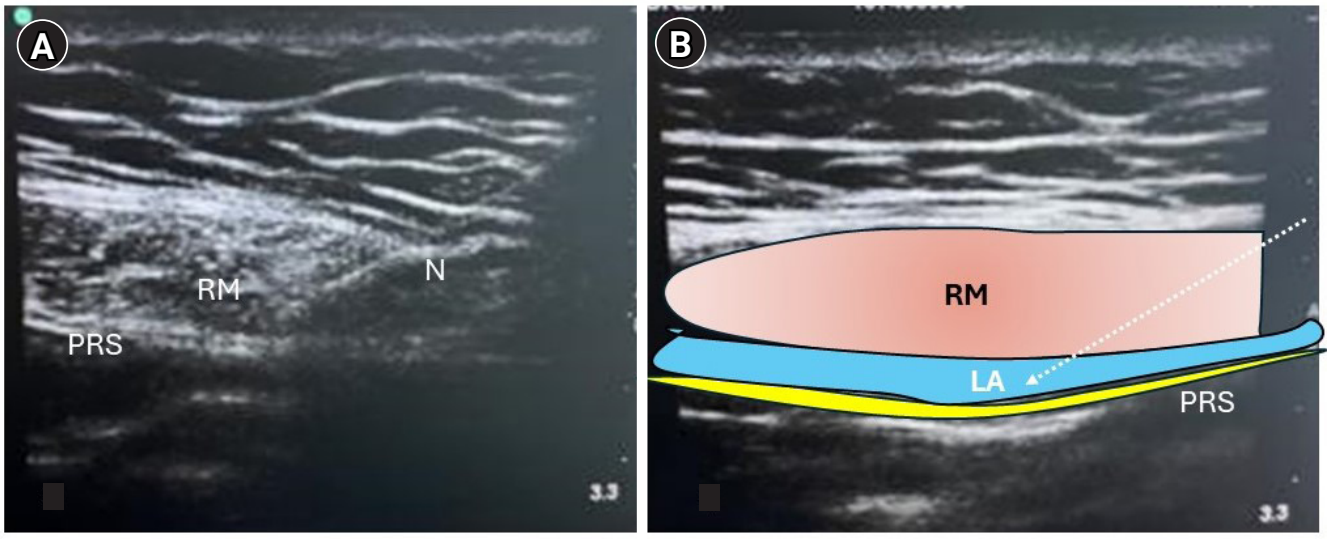

Fig. 2. Rectus sheath block. (A) Needling technique. (B) Labeled image. N: block needle, RM: rectus muscle, PRS: posterior rectus sheath. LA: local anesthetic deposited between RM and PRS.

3. Local infiltration analgesia

The LIA group received 20 ml of 0.25% bupivacaine with 1:200,000 adrenaline at the port sites at the time of wound closure (6 ml for the epigastric port, 6 ml for the umbilical port, and 4 ml for both working ports) in various tissue planes (skin, subdermal, subfascial, and peritoneal) under direct visualization by the surgeon (Fig. 3).

Postoperatively, all patients were transferred to the post-anesthesia care unit (PACU), and hemodynamic monitoring was continued. In the ER group, sensory block was assessed 30 min after administration of the block or once the patient was fully awake in the PACU. Dermatomal sensory block was defined as an area of sensory loss in the T6–T10 dermatomes on the right side of the anterior and lateral hemithorax. The anterior hemithorax was defined as the distance from the sternum to the anterior axillary line, and the lateral hemithorax was defined as the distance from the anterior axillary line to the posterior axillary line. The extent of sensory dermatomal blockade was determined by the loss of cold sensation to ice, and the block was graded as follows: 0, complete failure; 1, partial sensory loss (loss of cold sensation but touch can be perceived); and 2, complete anesthesia. A successful block was defined as partial or complete sensory blockade in the examined territory.

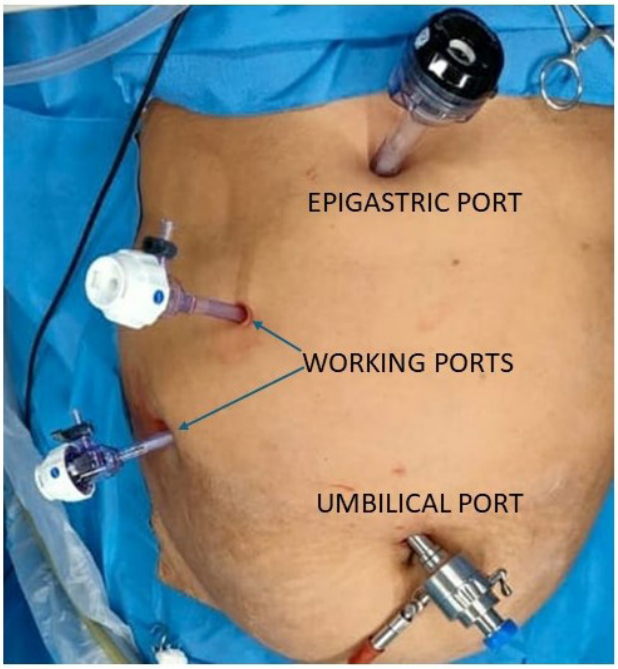

Fig. 3. Port placement.

Postoperative pain (at rest) was evaluated at 1, 2, 4, 8, 12, and 24 h after the completion of surgery using a VAS score ranging from 0 (no pain) to 10 (worst pain). The time for rescue analgesia was defined as the time from block performance to the first dose of rescue analgesia. Rescue analgesia in the form of tramadol 1 mg/kg intravenously was administered on demand or if the VAS score was 4 or higher. The frequency of rescue analgesia required and the total amount of analgesia required over 24 h were recorded. Side effects of the analgesics, including nausea/vomiting, sedation, and respiratory depression, were noted. Patient satisfaction with pain relief was assessed using a Likert scale (1, very unsatisfied; 2, unsatisfied; 3, neutral; 4, satisfied; and 5, very satisfied) after 24 h. The level of sedation was assessed using the Brussels Score [9].

Statistical analysis

Data were entered into an Microsoft Excel 2007 (Microsoft) spreadsheet and analyzed using SPSS software, version 21.0 (IBM Co.). Categorical variables were presented as numbers and percentages (%), and continuous variables were presented as mean ± SD and median (1Q, 3Q). The normality of the data was tested using the Kolmogorov-Smirnov test. If normality was rejected, non-parametric tests were used. A cross-sectional comparison of the numerical data of the two groups at each time point was performed using a *t*-test. If the data were not normally distributed, we used the Wilcoxon-Mann-Whitney *U* test. For the progression of parameters within each group, we used one-way ANOVA or Friedman test, depending on whether the data were normally or non-normally distributed. Finally, the group × time inter action was investigated using linear mixed-effects regression/generalizing estimating equations for normal and non-normal data. Qualitative variables were compared using the chi-squared test or Fisher's exact test. Statistical significance was set at $P < 0.05$.

RESULTS

In total, 82 patients were screened for eligibility. After excluding 12 patients, 70 patients who met the inclusion criteria were randomized equally into the two study groups, as depicted in the flow of participants in the consort diagram (Fig. 4). Demographic characteristics and duration of surgery were comparable between the two groups (Table 1). The VAS score was significantly lower in the ER group than that in the LIA group at 1 h (4.0 ± 1.1 vs. 6.6 ± 1.1), 2 h (3.7 ± 0.9 vs. 5.5 ± 1.0), 4 h (3.0 ± 0.9 vs. 5.00 ± 1.2), 8 h (2.18 ± 0.9 vs. 3.5 ± 1.3), and 12 h (1.80 ± 0.90 vs. 3.3 ± 1.2) (all $P < 0.001$; Figs. 5, 6).

Rescue analgesia was required in 65.7% of the patients in the LIA group compared to only 14.3% in the ER group ($P < 0.001$; Table 2).

The time (from intervention) to the first rescue analgesic administration was significantly longer ($P = 0.012$; Table 2) in the ER group than that in the LIA group. The number of times rescue analgesia was required was also significantly lower in the ER group than that in the LIA group ($P = 0.015$; Table 2). All patients in the ER group developed successful sensory blocks in the anterior and lateral hemithorax along the distribution of the T6–T10 nerves.

During the first 24 h after surgery, the nausea and vomiting scores were lower in the ER group than those in the LIA group ($P < 0.001$; Table 2). No other adverse effects were observed in either group.

DISCUSSION

The present randomized controlled trial revealed that right-sided EOIB with left-sided RSB provided superior analgesic characteristics to LIA for postoperative analgesia after LC. The time to the first rescue analgesia was greater, opioid

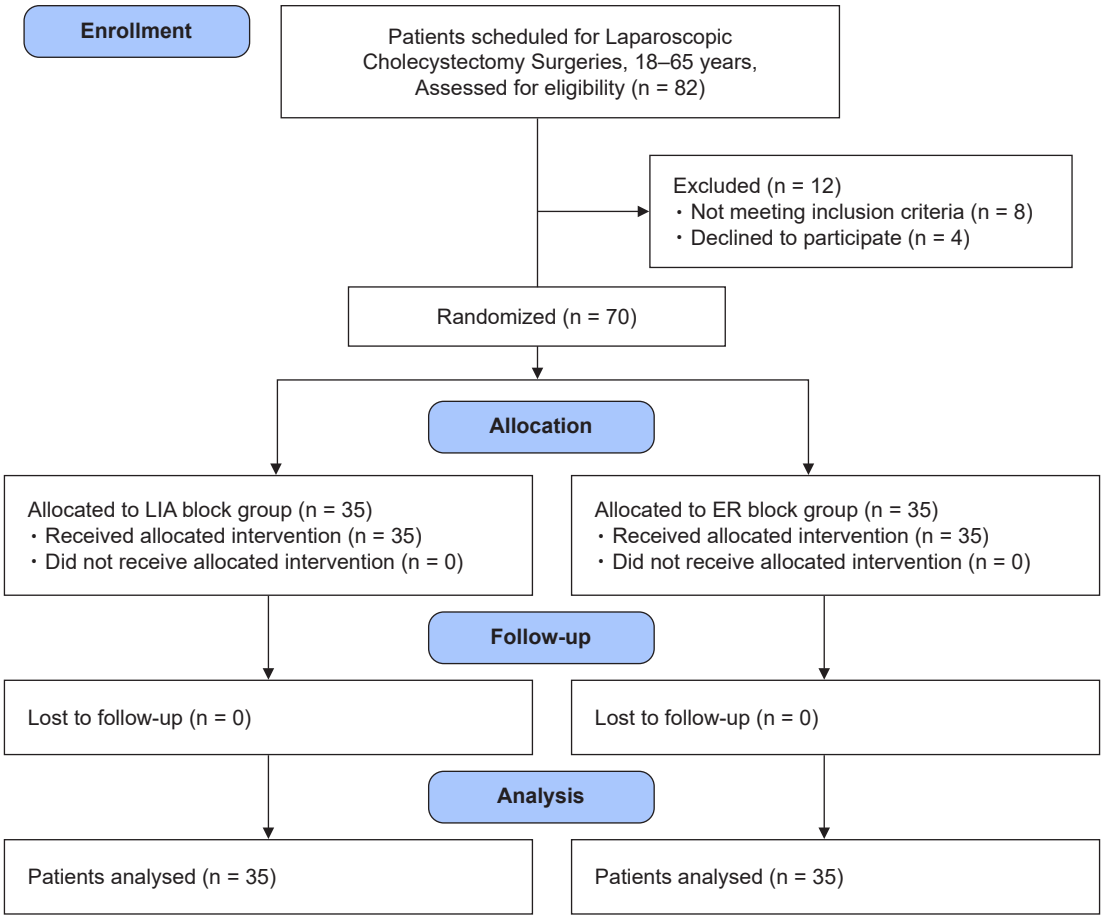

Fig. 4. Consort diagram.

Table 1. Demographic Parameters

Parameters	ER group	LIA group	P value
Age (yr)			
18–30	17 (48.6)	14 (40.0)	0.275
31–40	7 (20.0)	14 (40.0)	
41–50	5 (14.3)	5 (14.3)	
51–60	4 (11.4)	2 (5.7)	
61–65	2 (5.7)	0 (0.0)	
Sex			
M	5 (14.3)	7 (20.0)	0.526
F	30 (85.7)	28 (80.0)	
Weight (kg)	62.14 ± 7.42	60.54 ± 7.42	0.380
Height (cm)	157.71 ± 9.70	156.91 ± 8.60	0.651
BMI (kg/m^2)	25.03 ± 2.64	24.59 ± 2.33	0.466
ASA grade I/II	6 (17.1)/29 (82.9)	9 (25.7)/26 (74.3)	0.382
Duration of surgery (min)	63.83 ± 14.32	63.00 ± 12.02	0.772

Values are presented as number (%) or mean ± SD. LIA: local infiltration analgesia, BMI: body mass index, ASA: American Society of Anesthesiologists. P value <0.05 is significant.

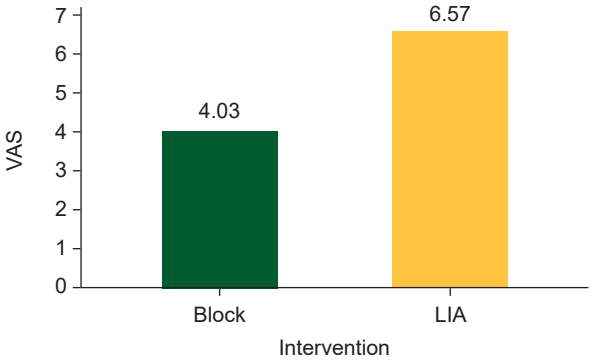

Fig. 5. Graph depicting association between intervention and mean VAS scores at 1 h. VAS: visual analog scale, LIA: local infiltration analgesia.

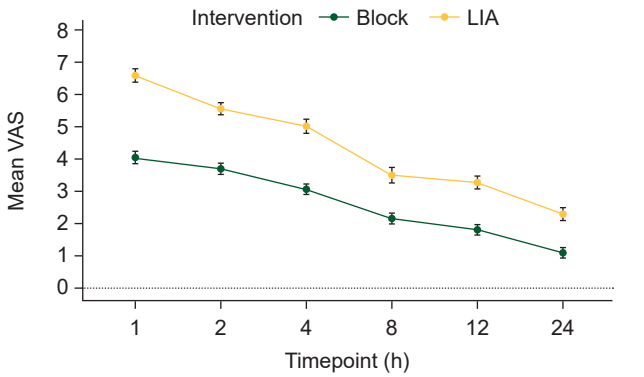

Fig. 6. Graph depicting association between intervention and mean VAS scores at different time intervals. VAS: visual analog scale, LIA: local infiltration analgesia.

Table 2. Analgesic Parameters

Parameters	ER group	LIA group	P value
No of patients requiring rescue analgesia (n)	5 (14.3)	23 (65.7)	< 0.001
Time (from intervention) when rescue analgesia needed (h)	2.80 ± 1.10	1.61 ± 0.50	0.012
Number of times rescue analgesia needed (n)	1.00 ± 0.00	1.83 ± 0.72	0.015
Nausea/vomiting assessment score	0.23 ± 0.55	1.26 ± 0.98	< 0.001
Patient satisfaction score	3.40 ± 1.09	2.17 ± 0.71	< 0.001

Values are presented as number (%) or mean ± SD. LIA: local infiltration analgesia. P value < 0.05 is significant.

consumption was lower, VAS scores were lower, and patient satisfaction was significantly higher in the ER group than those in the LIA group.

Upper abdominal incisions can cause severe pain. Li et al. [10] documented that upper abdominal surgeries are more

painful postoperatively than lower abdominal surgeries and require more opioids. LIA is a simple and commonly used technique that provides analgesia. However, it is incomplete and short-lived [7]. Ultrasound-guided SCTAP was introduced as a variant of the TAP block, which is administered below the costal margin and has the potential to provide postoperative analgesia for supraumbilical abdominal surgery [11]. Although it is an efficient block, it provides inadequate analgesia for incisions involving the lateral sides of the upper abdomen [5,12,13]. Ma et al. [13] administered SCTAP blocks to 20 patients undergoing LC with 0.5 ml/kg of 0.25% levobupivacaine. Upon assessment of the sensory loss, the authors found that the lateral upper abdominal dermatomes were spared, although the anterior abdominal wall was covered well with the block.

To overcome this limitation of the SCTAP block, a novel interfascial plane block, the EOIB has been described in the literature [4]. The lateral cutaneous branches of the T6–T12 intercostal nerves emerge at the junction of the serratus anterior and external oblique muscles and supply the lateral abdominal wall. EOIB targets the nerves at this level, and LA can further block the anterior cutaneous branches by tracking along the external oblique intercostal plane toward the linea semilunaris along the anterior rectus sheath, which is created by joining the external oblique muscle fascia to other abdominal wall muscle aponeuroses. Hamilton et al. [14] studied the spread of a dye injected superficially and deep into the external oblique muscle of a freshly frozen cadaver to evaluate dermatomal coverage. Using this approach, they proposed that effective analgesia for incisions involving the upper lateral abdomen could be achieved by blocking the lateral cutaneous branches T7–T11. The study concluded that deep injection into the external oblique muscle may have technical advantages over the superficial plane, owing to better delineation of the target fascial plane between the external oblique and intercostal muscles on ultrasound imaging. Therefore, in this study, we used a deeper injection technique.

White and Ji studied EOI plane catheter insertion in two patients with morbid obesity with contraindications to thoracic epidural analgesia and paravertebral blockade for up-

per abdominal surgeries [15]. They found that EOIB was a simple, effective, and convenient alternative to more invasive blocks, particularly in the setting of morbid obesity.

In our study, the standard four-trocar technique (umbilicus, epigastrium, right lateral subcostal region, and right subcostal-midclavicular region) was used, and these regions were innervated by T6–T10 dermatomes. The EOIB has been found to block the T6–T10 dermatomes, thereby covering the lateral and anterior abdominal walls, and should potentially provide effective analgesia for these incisions [4,14]. Elsharkawy et al. [4] administered bilateral ultrasound-guided EOIB with 15 ml of bupivacaine 0.25% on each side to patients undergoing abdominal surgery. The authors observed a consistent dermatomal sensory blockade of T6–T10 at the anterior axillary line and T6–T9 at the midline in all patients. Similarly, we observed a loss of sensation in the anterior and lateral hemithorax, corresponding to the same dermatomes in the ER group.

In a previous study on patients undergoing LC, EOIB administered bilaterally provided effective perioperative analgesia [16]. Coşar can and Erçelen [17] had similarly combined EOIB with RSB and found it effective for laparoscopic bariatric surgery. Kamei et al. [8] investigated the efficacy of ultrasound-guided RSB for single-incision laparoscopic cholecystectomy in comparison with a control group. RSB provided effective analgesia, as assessed by significantly lower VAS scores and a reduced need for rescue analgesia.

In the current study, the VAS scores were significantly lower in the ER group than those in the control group at all time points. Our findings are in agreement with previous case series and clinical trials that documented effective pain relief and low pain scores with EOIB [16,17]. In the study by Korkusuz et al. [16], the pain scores were significantly lower in EOIB group at all time points, both during rest and during movement until 24 h, than those in the control group. A previous study by Pourseidi and Khorram-Manesh [18] compared intercostal neural blockade of the T7–T11 nerves in patients undergoing LC; the VAS scores in the LC group remained lower in the block group than those in the control group until 24 h, indicating effective and prolonged analgesia.

The time to first analgesic administration was significantly longer in the EOIB group than that in the LIA group. The frequency of the requirement for rescue analgesics and their consumption over 24 h were significantly higher in the LIA group than that in EOIB group. This result is consistent with the findings of studies by other authors who documented minimal postoperative opioid requirements after EOIB for upper abdominal surgery [4,16,17]. This result is attributed to the consistent dermatomal coverage of the relevant (T7–T11) nerves with this block, as found in our study and previous studies [4,14]. The frequency of side effects such as nausea/vomiting and sedation scores were significantly higher in the control group than that in the block group, presumably because of the substantially higher tramadol consumption in this group.

However, this study has certain limitations. First, constraints arise from the single-center design. The results may vary across the two geographical regions with varied patient populations, surgical techniques, and expertise. Second, the fact that the blocks were performed by a single expert anesthesiologist introduces the potential for variability in the results based on the practitioner's expertise. Third, unlike EOIB and RSB, LIA was performed by multiple surgeons, which may have implications for the study outcomes. Finally, EOIB could not be compared with other established blocks, which could be a direction for future research.

We injected LA beneath the external oblique muscle and could not comment on the analgesic efficacy of EOIB when performed superficially to the external oblique muscle. Furthermore, we did not use bilateral EOIB because we believe that only left-sided RSB is additionally required for the umbilical port, and RSB also requires a lower LA volume. Our hypothesis was supported by the effectiveness of the block procedure in terms of postoperative analgesia.

Conclusion

EOIB provides superior analgesic characteristics with higher patient satisfaction than LIA for postoperative analgesia in adult patients undergoing LC. Its use is safe and leads to fewer postoperative complications.

FUNDING

None.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the

current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

Writing - original draft: Vaishnovi Gangadhar, Anju Gupta,Suman Saini. Writing - review & editing: Anju Gupta, Suman Saini. Conceptualization: Vaishnovi Gangadhar, Anju Gupta, Suman Saini. Data curation: Anju Gupta, Suman Saini. Formal analysis: Anju Gupta, Suman Saini. Methodology: Vaishnovi Gangadhar, Anju Gupta, Suman Saini. Project administration: Suman Saini. Funding acquisition: Suman Saini. Visualization: Anju Gupta, Suman Saini. Investigation: Vaishnovi Gangadhar, Suman Saini. Resources: Suman Saini. Supervision: Suman Saini. Validation: Anju Gupta, Suman Saini.

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