Original Article

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Comparison between External Oblique Intercostal Plane (EOI) Block and Incisional Local Infiltration Effect in Open Cholecystectomy: A Randomized Controlled Trial

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Abstract:

Objective: To compare 24-hour postoperative opioid consumption, converted to intravenous morphine equivalents, between patients receiving external oblique intercostal plane (EOI) block and those receiving incisional local infiltration (LA) in open cholecystectomy. Primary outcome: 24-h morphine equivalents. Secondary: pain intensity on a 0–10 numeric rating scale (NRS). The minimal clinically important difference (MCID) was defined as ≥30% opioid reduction and ≥1-point NRS decrease.

Material and Methods: Forty-four patients undergoing open cholecystectomy were randomized to EOI or LA (22 each). The EOI group received 20 mL of 0.25% bupivacaine for EOI block after skin closure, and the LA group received the same dose for local infiltration before skin closure.

Results: For the primary outcome, 24-h morphine equivalent consumption showed no significant difference between the groups (–4.09 mg; p-value=0.058). Ward opioid use (2–24 h) was lower in the EOI group (10.2±5.3 mg) than the LA group (14.1±6.9 mg); mean difference –3.96 mg, 95% CI (–7.69 to –0.22), p-value=0.038. This 28% reduction did not meet the 30% MCID. Median movement NRS in the ward was significantly lower with EOI (6 [IQR 5–6]) than LA (7 [IQR 5.75–8]); median difference –1, 95% CI (–2.00 to 0.00), p-value=0.022, meeting the 1-point MCID.

Conclusion: Although the EOI block did not significantly reduce total 24-hour morphine consumption, it was associated with a clinically meaningful reduction in movement-evoked pain.

Keywords: external oblique intercostal plane block, major abdominal surgery, open cholecystectomy, postoperative analgesia, regional anesthesia

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Introduction

Postoperative pain remains a significant concern after abdominal surgery, substantially influencing recovery time, hospital stay duration, and patient satisfaction. High levels of pain, especially on the first postoperative day, are not only distressing but are also strongly associated with an increased risk of complications within 30 days of surgery.[1] These outcomes are influenced by various factors, including the choice of anesthesia techniques, the patient's underlying health conditions, and strategies to manage pain effectively.

For patients undergoing open gallbladder surgery under general anesthesia, the pain can be particularly intense[2]. This results from a combination of visceral pain caused by gallbladder resection and somatic pain originating from the surgical incision under the right rib cage, corresponding to the T6–T10 dermatomes. Managing this pain effectively is crucial for enhancing recovery and minimizing the need for opioids.

Methods like the transversus abdominis plane (TAP) block[3,4] and the erector spinae plane (ESP) block are commonly employed for managing postoperative pain.[5,6] However, they are not without limitations and complications. The subcostal TAP block, for instance, can be challenging to perform in patients with thick abdominal walls, posing risks of organ injury, such as to the liver and intestines[7,8], abdominal infections[9], and inconsistent anesthetic spread[10]. Conversely, the ESP block requires a lateral decubitus position during administration. It has been associated with rare but serious complications, such as transient paraplegia from the unintended spread of local anesthetic into the epidural space[11],

At Buriram Hospital, multimodal analgesic approaches, including TAP blocks, ESP blocks, and incisional local infiltration (LA), have been adopted to mitigate postoperative pain. However, the search for safer, more effective methods continues.

A promising alternative is the external oblique intercostal plane (EOI) block. This technique involves injecting local anesthetic between the sixth and seventh ribs, from the midclavicular to the anterior axillary line, targeting the external oblique muscle plane to achieve adequate analgesia in the T6–T10 region for 24–48 hours[12–15]. Recent studies have demonstrated its potential advantages, including simple administration in a supine position, even in obese patients[16], and the absence of reported complications[17].

This study aimed to assess the efficacy and safety of the EOI block compared to incisional local infiltration techniques. The findings are intended to inform the development of more effective postoperative pain management strategies, ultimately reducing pain and promoting faster recovery in abdominal surgery.

Material and Methods

This study was carried out at Buriram Hospital in Buriram, Thailand, between March 1 and December 31, 2024. Ethical approval was granted by the Ethics Committee of Buriram Hospital (BR 0033.102.1/9).

The participants included patients aged 18 or older who were scheduled for open cholecystectomy with a right Kocher's incision classified under the American Society of Anesthesiologists (ASA) physical status I–III. Exclusion criteria included: allergies to local anesthetics, receipt of any non-opioid analgesic intraoperatively or within 24 h postoperatively, communication difficulties, coagulation disorders, infection at the block site, anatomical abnormalities of the right chest, situs inversus, pregnancy, and refusal to participate.

A preliminary retrospective study involving 10 patients per group was conducted to estimate the appropriate sample size. The 24-hour postoperative opioid consumption, calculated as intravenous morphine equivalents, was 13.16±7.98 mg in the control group and

6.4±7.55 mg in the EOI group, indicating approximately a 50% reduction in the EOI group. Based on this effect size, a total of 44 participants (22 per group) were calculated to achieve 80% power at a significance level of α=0.05. To account for possible data attrition, the final sample size was increased to 46 patients (23 per group). Randomization was performed using permuted blocks of varying sizes through an online randomization tool. (https://www.sealedenvelope.com/double-blind-randomized-control-trial).

After the patient signed the consent form, a sealed envelope and the perioperative protocol were delivered to the operating room. The patient remained blinded to group allocation. A blinded anesthesiologist and nurse anesthetist were not allowed to open the sealed envelope but were provided with the perioperative management protocol. During surgery, patients were continuously monitored using electrocardiography, pulse oximetry, end-tidal CO_2 monitoring, and non-invasive blood pressure measurement. General anesthesia was induced with propofol (1–2 mg/kg), succinylcholine (1.5 mg/kg), and fentanyl (1–2 μg/kg). Maintenance of anesthesia was achieved with sevoflurane (0.8–1 MAC) and either cisatracurium or atracurium. Bolus intravenous fentanyl (0.5–1 μg/kg every 5–10 minutes) or morphine (0.05–0.1 mg/kg every 30 minutes) was administered as needed if mean arterial pressure was >20% above baseline.

Before skin closure, the same anesthesiologist, assigned solely to perform the intervention, not outcome assessment, opened the sealed opaque envelope. The surgeon, who also did not participate in postoperative care or outcome evaluation, followed the group assignment. In the LA group, 20 mL of 0.25% bupivacaine was infiltrated at the surgical incision site prior to skin closure. For the EOI group, immediately after skin closure, a right-sided EOI block was performed under ultrasound guidance. A single anesthesiologist administered 20 mL of 0.25% bupivacaine into the external oblique intercostal plane at the sixth to seventh rib level, between the anterior axillary and midclavicular lines, using a Pajunk Sonoplex 21G, 100 mm needle, as shown in Figure 1[14].

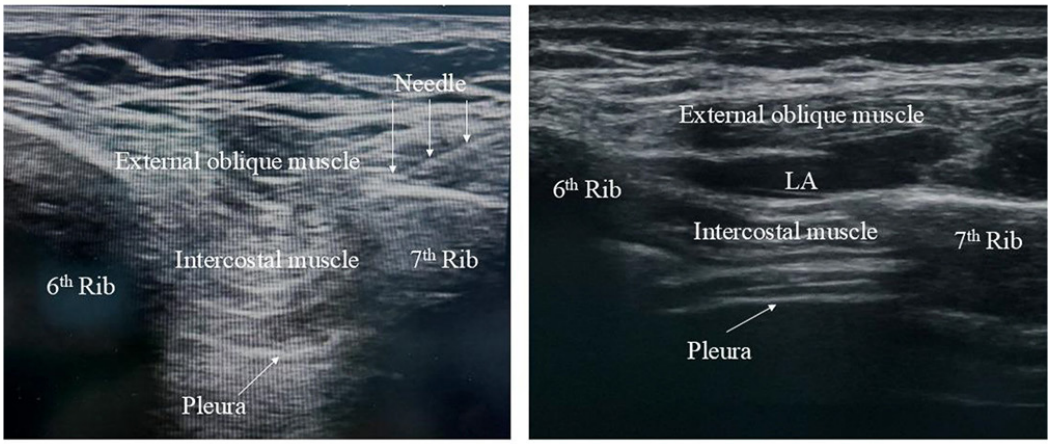

Figure 1 Ultrasound-guided EOI block, (A) In-plane needle advancement (white arrows) from caudad to cephalad between the 6th and 7th ribs, deep to the external oblique muscle overlying the seventh rib, (B) After injection, a hypoechoic layer of local anesthetic (LA) spreads beneath the external oblique muscle and above the intercostal muscle

To prevent bias, the attending anesthesiologist and nurse anesthetist were blinded in the preoperative and intraoperative periods until just before skin closure. No further intravenous opioids were administered after that point. Tracheal extubation was performed after confirming adequate reversal of neuromuscular blockade and fulfillment of standard extubation criteria.

Following surgery, patients were monitored in the post-anesthesia care unit (PACU) and observed for one hour. Blinded nurses assessed the numerical rating scale (NRS) at both admission and discharge, and recorded total opioid use according to the study protocol. Intravenous morphine 1 mg or fentanyl 10 μg was administered for NRS scores of 4–10, if the sedation score was <2 and the respiratory rate >8 breaths/min. An additional dose could be given in 5–15 minutes if the NRS remained at 4–10. After PACU discharge, patients were monitored in the surgical ward from the 2nd to the 24th postoperative hour by a blinded surgical ward nurse. Per protocol, blinded nurses assessed NRS scores every 4 hours and administered intravenous morphine 2 mg for NRS scores of 4–10 under the same conditions (sedation score <2 and respiratory rate >8 breaths/min). Additional doses could be given every 5–15 minutes if pain persisted[18]. At the 24-hour mark, NRS at rest and during movement was assessed, and complications, including LA toxicity, vascular injury, pneumothorax, and hemothorax, were evaluated by a blinded anesthesiologist. All the data within the postoperative 24-hour period, including opioid consumption converted to intravenous morphine equivalents (morphine equivalents), NRS scores, patient demographics, and perioperative variables, were collected by blinded nurses, nurse anesthetists, and anesthesiologists. Equianalgesic dose conversions used in this study were as follows: 1 mg of intravenous morphine=10 μg of intravenous fentanyl=7.5 mg.[19]

Statistical analysis

The primary objective of this study was 24-hour morphine equivalents. Secondary objectives included the NRS score within the first hour at the PACU and the pain scores both at rest and during ambulation, recorded in the surgical ward between the second and twenty-fourth postoperative hours.

All statistical analyses were conducted using SPSS version 26.0. The distribution of continuous variables was tested for normality with the Shapiro–Wilk test. Depending on distribution, group comparisons were conducted using either the independent t-test or the Mann–Whitney U test.

Descriptive statistics, including means ± standard deviation or median with interquartile ranges (IQR), were used as appropriate based on the distribution of the data. Morphine equivalents and NRS scores were analyzed and reported accordingly at each postoperative time point.

The minimal clinically important difference (MCID) for the primary outcome, postoperative period consumption, was predefined as a 30% relative reduction in morphine equivalents, based on previously published literature that established this threshold as indicative of meaningful clinical benefit in acute postoperative pain management[20]. For the secondary outcome, pain intensity was measured using the NRS; a 1-point reduction was set as the MCID, in line with evidence suggesting this level represents the smallest difference perceived as beneficial by patients undergoing abdominal surgery[21]. These predefined MCID values were used to interpret whether statistically significant findings were also clinically relevant.

Results

The study was conducted consistently with the CONSORT flow diagram, with written informed consent secured from all participants, and presents the patient enrollment, allocation, follow-up, and analysis as illustrated in Figure 2. Of the 46 randomized patients, 2 were excluded: 1 for postoperative delirium and 1 for requiring intubation within 24 hours. The final analysis included 22 patients in both the EOI and LA groups.

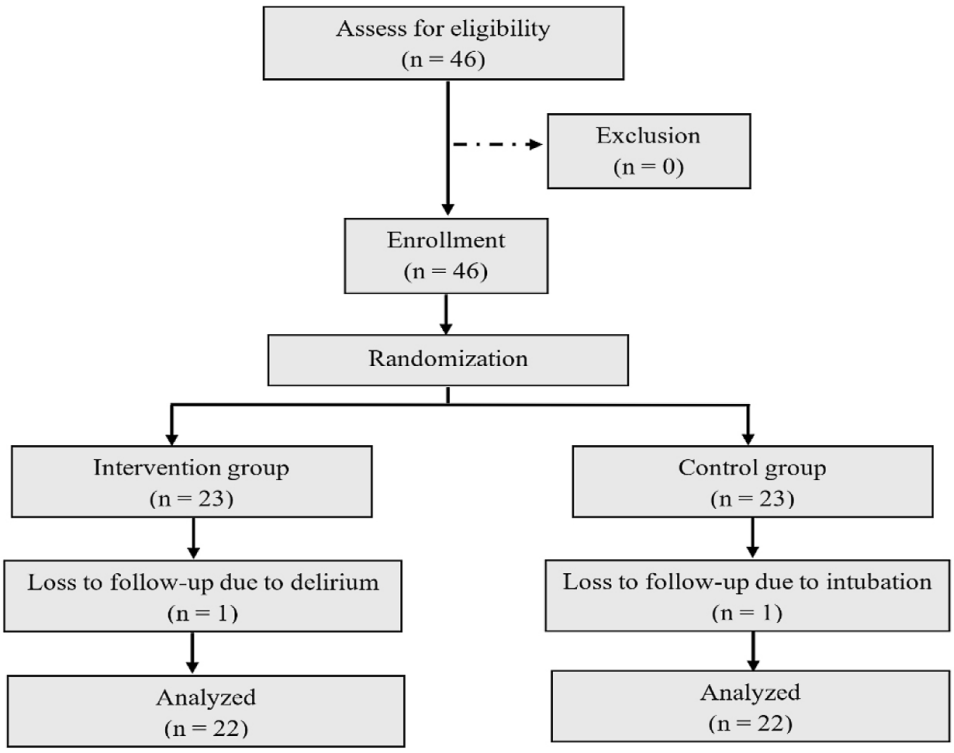

Figure 2 CONSORT flow diagram

Table 1 summarizes baseline characteristics and perioperative data. While most variables were comparable between the groups, anesthesia duration was significantly longer in the EOI group.

The primary outcome, which was the consumption of postoperative opioids within 24 hours, morphine equivalents, is shown in Table 2. Opioid consumption in the surgical ward (from the second to the twenty-fourth postoperative hour) was significantly decreased in the EOI group relative to the LA group. Although the reduction of 3.96 mg reached statistical significance (p-value=0.038), it corresponded to a 28% relative decrease, which is below the predefined MCID of 30% for morphine equivalent consumption[20]. Therefore, the clinical relevance of this finding may be limited. No statistically significant differences were found in opioid consumption during the immediate postoperative period in the PACU (first hour) or for the total 24-hour postoperative period (Table 2).

The secondary outcome, movement NRS in the surgical ward, was lower in the EOI group (median 6 [IQR 5–6]) than the LA group (median 7 [IQR 5.75–8]); median difference=-1, 95% CI (-2.00 to 0.00), p-value=0.022. A 1-point decrease on the NRS was considered the MCID[21,22], indicating a clinically meaningful reduction in the movement pain. No clinically or statistically significant differences were found in pain scores at PACU admission or discharge, or in resting pain scores in the ward (all Δ=0; p-value>0.050) (Table 3).

No complications and adverse effects associated with local anesthetic infiltration at the surgical wound or the EOI block, such as pneumothorax, local anesthetic systemic toxicity (LAST), vascular injury, or hemodynamic instability, were observed in this study.

Table 1 Patient characteristics

Variables	Groups		Mean Difference (95% CI)	Median Difference (95% CI)	p-value
	EOI (n=22)	LA (n=22)			
Gender					
Male[#]	12 (54.55%)	13 (59.09)			0.761[a]
Female[#]	10 (45.45%)	9 (40.91)			
ASA					
I[#]	3 (13.64 %)	1 (4.55%)			
II[#]	12 (54.55%)	11 (50%)			0.455[a]
III[#]	7 (31.82%)	10 (45.45%)			
Age (years)[*]	56.18 ± 13.80	63.55 ± 12.16	−7.36 (−15.05 −0.32)		0.060[b]
BMI (kg/m2)[#]	24.69 (3.94–28.42)	22.88 (20.71–25.63)		1.81 (−1.25 −3.77)	0.296[c]
Anesthesia Time (minutes)[*]	108.86 ± 42.59	77.50 ± 20.80	31.36 (10.97 – 51.76)		0.003[b]
Perioperative opioid consumption, converted to intravenous morphine equivalents (mg)[#]	10.00 (10.00–10.50)	10.00 (10.00–10.00)		0.00 (0.00 −0.00)	0.533[c]

[*]=Mean±standard deviation, [#]=Median interquartile range (IQR); [a]=Chi-square test, [b]=Independent samples t-test; [c]=Mann-Whitney U test, Mean/median differences were calculated as EOI – LA (Hodges–Lehmann estimator for medians). EOI=external oblique intercostal plane, LA=local infiltration, BMI=body mass index, ASA=American Society of Anesthesiologists, 95% CI=95% confidence interval

Table 2 Postoperative opioid consumption (mg, IV morphine equivalent)

Timepoint (hours)	Groups		Mean Difference (95% CI)	Median Difference (95% CI)	p-value
	EOI (n=22)	LA (n=22)			
0–1 (PACU)[#]	0.00 (0.00–3.25)	0.00 (0.00–4.00)		0.00 (0.00–0.00)	0.969[c]
2–24 (ward)[*]	10.18±5.30	14.14±6.87	−3.96 (−7.69 – −0.22)		0.038[b]
0–24 (total)[*]	11.73±6.17	15.82±7.65	−4.09 (−8.32 −1.37)		0.058[b]

[*]:Mean±standard deviation, [#]=Median interquartile range(IQR), [b]=Independent samples t-test, [c]=Mann-Whitney U test; Mean/median differences were calculated as EOI – LA (Hodges–Lehmann estimator for medians), EOI=external oblique intercostal plane, LA=local infiltration, PACU=post-anesthesia care unit, 95% CI=95% confidence interval

Table 3 Postoperative pain score

Postoperative Numerical Rating Scale (NRS)	Groups		Median difference (95% CI)	p-value
	EOI (n=22)	LA (n=22)		
PACU (admission)[#]	1.00 (0.00–7.00)	2.00 (0.00–5.00)	−1.00 (−1.00–2.00)	0.709[c]
PACU (discharge)[#]	2.00 (0.00–3.00)	2.00 (0.00–2.00)	0.00 (0.00–1.00)	0.293[c]
Resting NRS in surgical ward[#]	3.00 (2.00–3.00)	3.00 (2.75–4.00)	0.00 (−1.00–0.00)	0.068[c]
Movement NRS in surgical ward[#]	6.00 (5.00–6.00)	7.00 (5.75–8.00)	−1.00 (−2.00–0.00)	0.022[c]

[#]=Median interquartile range (IQR); [c]=Mann-Whitney U test, Median differences were calculated as EOI – LA using the Hodges–Lehmann estimator, EOI=external oblique intercostal, LA=local infiltration, PACU=post-anesthesia care unit, 95% CI=95% confidence interval

Discussion

Postoperative pain subsequent to major abdominal surgery contributes to a higher risk of both infectious and non-infectious complications within 30 days, likely due to the immunosuppressive effects of surgery. Adequate perioperative and postoperative pain management is essential for preserving immune balance, minimizing postoperative complications, and enhancing recovery[1].

Open cholecystectomy is classified as a major abdominal surgery that results in moderate to severe pain, primarily of somatic origin, followed by visceral pain.[2] Compared to other regional techniques, such as subcostal TAP and ESP blocks, the EOI block offers a simpler technique[12,15]. A recent study suggests it offers a safe and technically straightforward alternative, especially in obese patients. Our findings support these characteristics, as no block-related complications were observed and the technique was feasible in all enrolled patients[16,17].

There was no statistically significant difference in opioid consumption during the immediate postoperative period in the PACU (first hour) or the total 24-hour postoperative period (Table 2). Postoperative morphine equivalents in the surgical ward (second–24th hour) were significantly decreased in the EOI group compared to the LA group, showing a 28% reduction. However, this reduction did not reach the predefined MCID of 30%. This result is consistent with the study by Korkusuz et al. (2023), which also found no clinically meaningful reduction in opioid consumption following bilateral EOI plane block in laparoscopic cholecystectomy. To minimize bias in perioperative opioid administration, patients received the intervention just before extubation and transfer to the PACU, and sensory blockade testing was not performed in awake patients, which could contribute to undetected partial or failed blocks that could not be excluded from the analysis. Based on prior studies by Elsharkawy et al. and White and Ji, the dermatomal sensory blockade of T6–T10 occurs within 15–30 minutes of administration, which might explain the lack of significant opioid sparing effect findings during the first postoperative phase in the PACU.[13,16]

The secondary outcome of this study showed that the movement of the NRS score in the ward was statistically significantly lower in the EOI group than the LA group, and this difference reached a clinically important level. The median score was 6 [IQR 5–6] in the EOI group and 7 [IQR 5.75–8] in the LA group; median difference =-1, 95% CI (-2.00 to 0.00), p-value=0.022[21,22]. This may be explained by the effect of the EOI block on somatic sensory nerves, which can reduce movement-related pain. However, no significant differences were found in NRS scores at the PACU admission/discharge or in resting pain in the ward, possibly due to the persistence of visceral pain not covered by the EOI block. Previous studies suggest that the EOI block primarily targets the lateral cutaneous branches of T6–T10 and does not provide visceral analgesia[12-15].

Although the secondary outcome, movement pain score, was significantly lower in the EOI group, suggesting that the EOI block may be effective for postoperative somatic pain control in upper abdominal surgery, its particular benefit might be in obese patients. The EOI block can be performed in the supine position and requires less needle depth compared to TAP or ESP blocks, which could make it an easier and more convenient option for obese patients[14,16]. However, the primary outcome, morphine equivalent consumption over 24 hours, did not reach statistical significance. Also, the EOI block requires more resources and costs than simple local anesthetic infiltration at the surgical wound.

Future research should explore the optimal volume of anesthetic and the potential role of adjuvant agents to enhance the effectiveness and extend the duration of EOI blockade. The reliability of dermatomal sensory blockade should be studied in a larger population. In addition, postoperative follow-up should be extended to 48–72 hours

to assess longer-term analgesic efficacy, as well as recovery quality. Comparative studies involving EOI, subcostal TAP, and ESP blocks in upper abdomen surgery with a larger sample size are also warranted to better determine their relative efficacy and safety.

This study has several limitations. First, sensory blockade testing was not performed to prevent potential bias; consequently, some patients in the intervention group may have received incomplete or failed blocks. Second, demographic data revealed that anesthesia duration was significantly longer in the EOI group than the LA group, which is a confounding factor. Third, the quality of postoperative recovery was not assessed, which may be important for evaluating the benefit of the EOI block as part of a multimodal analgesia strategy. Finally, the anesthesiologist who performed the EOI block and the surgeon who performed local infiltration were not blinded, which may have introduced performance bias.

Conclusion

This study demonstrated that the EOI block is an effective technique for reducing movement pain during the second–24th postoperative hour in the surgical ward. However, it did not significantly reduce total opioid consumption over 24 hours. Further studies are warranted to optimize the volume and explore the use of adjuvants in the EOI block. A larger sample size is also recommended to confirm its analgesic effects and clinical significance.

Conflict of interest

All authors declare that they have no conflicts of interest.

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