Original Article

Comparison of analgesic efficacy of ultrasound-guided external oblique intercostal plane block and subcostal transversus abdominis plane block in patients undergoing upper abdominal surgery: A randomised clinical study

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ABSTRACT

Background and Aims: Upper abdominal surgeries are associated with severe postoperative pain. External oblique intercostal (EOI) block blocks both anterior and lateral cutaneous branches of intercostal nerves. We compared the postoperative analgesic efficacy of unilateral EOI block with conventional unilateral subcostal transversus abdominis plane (TAP) block. **Methods:** Fifty American Society of Anesthesiologists (ASA) I/II patients scheduled for upper abdominal surgery via subcostal incision were randomly assigned to receive either EOI block (Group E) or subcostal TAP block (Group T) with 25 mL of 0.2% ropivacaine. Postoperatively, these patients received intravenous (IV) fentanyl through a patient-controlled analgesia (PCA) pump with settings of demand-only mode. The primary outcome was the time to activation of PCA postoperatively. Secondary outcomes were 24-hour opioid consumption, pain scores (at 30 minutes and at 1, 2, 4, 6, 12, and 24 hours), patient satisfaction scores (48 hours), and block-related complications. Unpaired *t*-test and Mann-Whitney U test were used for analysis. A *P* value less than 0.05 was considered to be statistically significant. **Results:** Patients in Group E had an increased mean time of activation of PCA [610.28 [standard deviation (SD): 118.95)] minutes vs 409.68 (SD: 101.36) minutes] ($P = 0.001$). The 24-hour postoperative mean fentanyl consumption was 102.40 (SD: 25.70) μg in Group E versus 123.20 (SD: 34.38) μg in Group T ($P = 0.019$). Patients in Group E had better satisfaction scores ($P < 0.001$). Pain scores were better at 30 minutes and 6 hours. **Conclusion:** EOI block provides effective postoperative analgesia in upper abdominal surgeries as it prolongs the duration of PCA activation with a better patient satisfaction score.

Keywords: Abdominal surgery, external oblique intercostal block, fentanyl, patient-controlled analgesia, patient satisfaction, postoperative pain, subcostal transversus abdominis plane block

INTRODUCTION

Upper abdominal incisions cause severe intraoperative and postoperative pain.[1] Neuraxial techniques, though the gold standard for pain management, can be associated with complications.[2] Interfascial plane block techniques have been identified as a part of multi-modal analgesia for upper abdominal surgeries with subcostal incisions. These include the subcostal transversus abdominis plane (TAP) block, quadratus lumborum (QL) block, and erector spinae plane (ESP)

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block. These blocks have limitations such as proximity to the operative field, technical difficulties associated with the depth of the anatomical target site, and infection or coagulation-related contraindications.[3] External oblique intercostal (EOI) plane block is a novel technique that blocks lateral and anterior cutaneous branches of the intercostal nerves (ICNs) from T6/7 to T10/11.[4] It has various advantages, such as distance from the surgical site, technical ease, and possibility of catheter insertion.[3] Though a subcostal TAP block is commonly used, it spares the lateral cutaneous branches.

We aimed to compare the postoperative analgesic efficacy of ultrasound (US)-guided EOI and subcostal TAP in patients undergoing such surgeries. The study's primary outcome was to compare the time to first rescue analgesia postoperatively in patients undergoing upper abdominal surgery via a subcostal incision receiving either EOI or subcostal TAP block. The secondary outcomes included time of block performance; intraoperative and postoperative 24-hour opioid consumption; pain scores at 30 minutes and 1, 2, 4, 6, and 12 hours; and patient satisfaction score (PSS); and any adverse effects such as vomiting, sedation, pneumothorax, hematoma, and respiratory depression. Hence, we hypothesised that the EOI block would be more effective than the subcostal TAP block in providing postoperative analgesia in patients undergoing upper abdominal surgeries with subcostal incisions.

METHODS

Following approval by the institutional ethics committee (vide approval number AIIMS/Pat/IEC/2023/1007 dated 31/01/2023) and registration at the Clinical Trials Registry-India (vide registration number CTRI/2023/02/050011, www.ctri.nic.in), this double-blind, randomised controlled study was conducted in a tertiary care centre between March 2023 and January 2024. The study was carried out using the principles of the Declaration of Helsinki, 2013, and Good Clinical Practice. Fifty American Society of Anesthesiologists (ASA) physical status I/II patients aged between 18 and 65 years undergoing upper abdominal surgery with unilateral subcostal incision were recruited in our study. After explaining the details of the study procedure, written informed consent was obtained for participation and the use of patient data for research and educational purposes. Patients with body mass index (BMI) <20 kg/m^2 or >30 kg/m^2, allergy to local anaesthetics, infection at the site of injection, on chronic analgesic therapy, or inability to understand pain scores or the functioning of patient-controlled analgesia (PCA) pump were excluded from the study.

Block randomisation was performed using online software (Open Epi software version 3.01, Atlanta, GA, USA). The random allocation sequence was concealed in sequentially numbered opaque, sealed envelopes that were opened on the day of surgery. Patients were randomly allocated to one of the two groups: Group E received a US-guided unilateral EOI block using 25 mL of 0.2% ropivacaine, and Group T received a US-guided unilateral subcostal TAP block using 25 mL of 0.2% ropivacaine.

An anaesthesiologist with 25 such blocks experience performed the blocks. He was not involved in perioperative management or data collection. The co-investigator who conducted the case was blinded to the groups allocated and the blocks given. The postoperative data were collected by pain nurses who were unaware of the group allocations.

The patients were reviewed on the day before the surgery and given the patient information sheet. The procedure, pain scores, and use of the PCA pump were explained to them. On the day of surgery, they were shifted to the operating room, where standard ASA monitors were attached. Baseline parameters such as heart rate (HR), non-invasive blood pressure (NIBP), electrocardiogram (ECG), oxygen saturation (SpO_2), and temperature were recorded. General anaesthesia (GA) was given using intravenous (IV) fentanyl 2 μg/kg, propofol 2 mg/kg, and atracurium 0.5 mg/kg, followed by tracheal intubation with an appropriately sized cuffed endotracheal tube. Anaesthesia was maintained with air, oxygen, and sevoflurane to maintain a minimum alveolar concentration (MAC) of 1–1.2. The blocks were performed under strict aseptic conditions with US machines equipped with a high-frequency linear probe with a sterile sheath (Ultrasound machine M-Turbo, Fujifilm Sonosite Edge II, Inc., Bothell, WA, United States) and 22-G, 80-mm echogenic needle (Sonoplex needles, Pajunk, Germany).

In Group E, a high-frequency linear transducer (5–12 MHz) was placed in the parasagittal plane between the midclavicular and anterior axillary line at the level of the $6^{th}/7^{th}$ rib. The external oblique muscle and intercostal muscle (ICM) were identified.

The needle was inserted in the plane from cephalad to caudad direction to pierce the external oblique muscle and deposit 25 mL of 0.2% ropivacaine between the external oblique and ICM [Figure 1].

In Group T, scanning began in an oblique plane immediately below the costal margin. The transversus abdominis muscle was identified lying posterior to the rectus muscle. The needle was inserted in the plane lateral to medial to lie between the transversus abdominis and the rectus muscle. Once the plane was confirmed using hydro dissection, the local anaesthetic was injected. The total duration of block performance was taken from the placing of the probe till the injection of local anaesthetic.

Skin incision was allowed at least 20 minutes after the injection of the drug. Any increase in HR or mean arterial pressure (MAP) more than 20% of the baseline was treated with IV fentanyl 0.5 μg/kg. Total intraoperative IV fentanyl consumption was noted in both groups. All patients received IV dexamethasone 0.1 mg/kg at the start of surgery. Intraoperatively, haemodynamic parameters (HR/MAP) were recorded at 5, 30, 60, and 90 minutes after the skin incision and the end of surgery. The patients received IV paracetamol 15 mg/kg after induction of anaesthesia and 6th hourly till 24 hours after surgery.

At the end of the surgery, IV ondansetron 0.1 mg/kg and reversal agents (IV neostigmine 0.05 mg/kg and IV glycopyrrolate 0.01 mg/kg) were administered. After tracheal extubation, patients were shifted to the post anaesthesia care unit. The patients were connected to a PCA pump (CADD Legacy^{TM} PCA, Smiths Medical International Ltd, USA) programmed for a demand-only mode with no basal rate: bolus of IV fentanyl 20 μg, with a 10-minute lockout interval and a maximum fentanyl dose per hour of 120 μg. The primary outcome was the time to activate the PCA pump postoperatively. The secondary outcomes were 24-hour IV fentanyl consumption, NRS (patient was asked to take deep inspiration) at 30 minutes, 1, 2, 4, 6, 12, and 24 hours, and PSS on a scale of 0–10 (0: least satisfaction, 10: maximum satisfaction) at 48 hours after surgery. Adverse effects such as nausea, vomiting, and respiratory depression ($SpO_2 < 90\%$) were recorded.

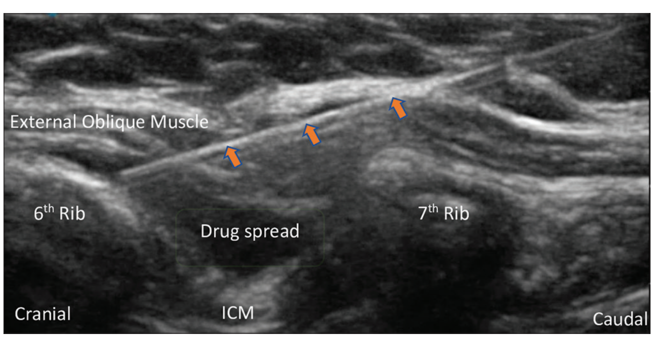

Figure 1: Sonoanatomy of the external oblique intercostal plane block. ICM: intercostal muscle, red arrow: needle path

The sample size was calculated based on a study by Kamhawy *et al*.[5] comparing subcostal TAP block with thoracic paravertebral block in patients undergoing open cholecystectomy (Open Epi software version 3.01, Atlanta, GA, USA). The mean time for the first rescue analgesic administration was 248.7 [standard deviation (SD): 44.0] minutes in the oblique subcostal TAP group. Anticipating an increment of 20% in the duration of the first rescue analgesic administration with a power of 80% and an alpha error of 5%, the sample size was calculated as 23 in each group. To accommodate for dropouts, we took a sample size of 25 in each group.

Statistical Package for the Social Sciences (SPSS) statistics software version 21.0 (Armonk, NY: IBM Corp, USA) statistical software was used for data analysis. The normality of data was tested using the Kruskal–Wallis test. Continuous quantitative normally distributed data (age, weight, duration of surgery, time to PCA activation, and perioperative opioid consumption) were compared using unpaired *t*-tests. Quantitative discrete data (NRS and PSS scores) and non-normally distributed data (intraoperative opioid consumption and block performance time) were compared using the Mann–Whitney U test. P values < 0.05 were considered to be statistically significant.

RESULTS

Fifty patients were enroled and completed the study [Figure 2]. Demographic characteristics, type and duration of surgery, intraoperative fentanyl consumption, and block performance time were comparable among the two groups ($P > 0.05$) [Tables 1 and 2]. Intraoperative haemodynamics showed a lower trend in Group E, which was not statistically significant [Figure 3].

Patients in Group E had an increased time of activation of PCA ($P = 0.001$) and lower 24-hour postoperative IV fentanyl consumption ($P = 0.019$) [Table 3]. Pain

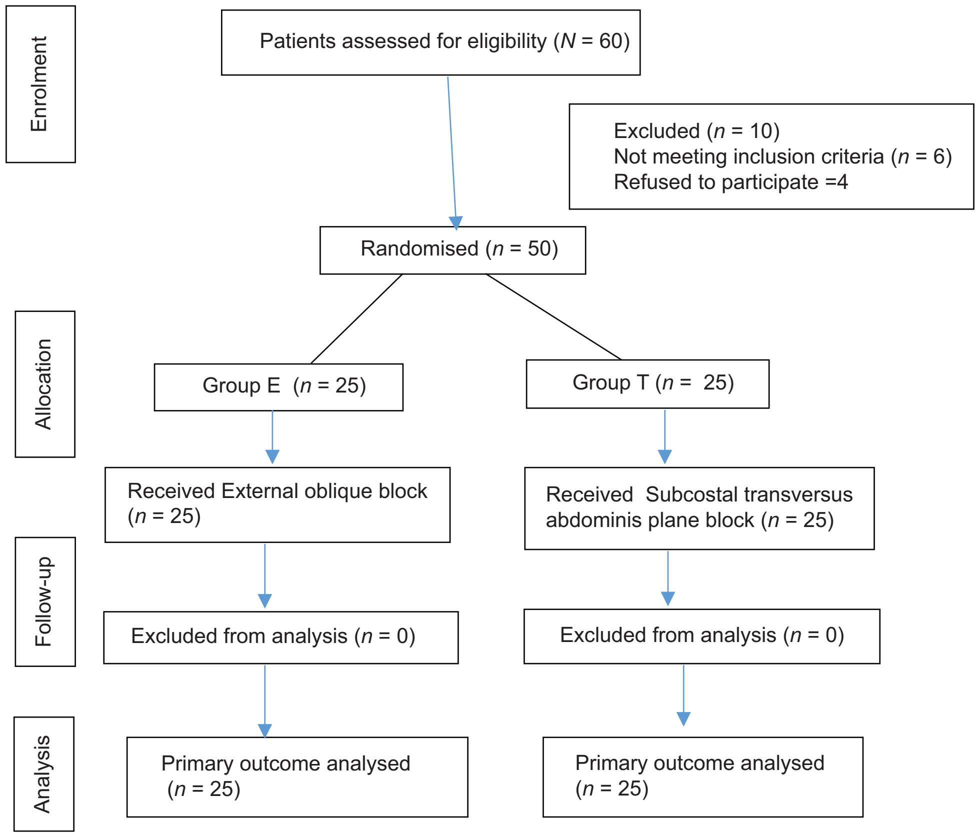

Figure 2: Consolidated standards of reporting trials (CONSORT) flow diagram, n = number of patients

Table 1: Patient demographics and surgical characteristics

	Group E (*n*=25)	Group T (*n*=25)
Age (years)	45.28 (12.60)	40.84 (14.89)
Gender (male/female)	15/10	18/7
Body mass index (kg/m^2)	25.28 (2.98)	23.76 (3.35)
American Society of Anesthesiologists physical status (I/II)	10/15	13/12
Type of surgery (open cholecystectomy/splenectomy/radical cholecystectomy)	10/10/5	14/8/3
Duration of surgery (minutes)	112.8 (43.54)	115.2 (31.9)

Data expressed as mean (standard deviation) or frequency. E=External oblique plane, T=Subcostal transversus abdominis, *n*=number of patients

scores were comparable at all time points except at 30 minutes and 6 hours, which were lower in Group E [Figure 4].

Patients in Group E had better satisfaction scores ($P < 0.001$) [Table 2]. Two patients of Group T and one patient of Group E reported nausea. No incidence of respiratory depression was noted.

DISCUSSION

This study shows that US-guided EOI block significantly prolongs the time to the first analgesic requirement, with little difference in 24-hour opioid consumption and pain scores as compared to subcostal TAP block in patients undergoing upper abdominal surgeries. The prolonged duration of analgesia led to better satisfaction scores in the Group EOI.

Pain in upper abdominal surgeries is more difficult to manage than in lower abdominal surgeries and is associated with significant morbidity.[6] US-guided fascial plane blocks have come a long way from deeper blocks such as QL to more superficial ones such as TAP and EOI. The upper abdominal wall derives sensory innervation from ICNs from T6 to T10. Effective blockade of these nerves ensures adequate analgesia. Subcostal TAP block targets the upper abdominal wall but spares the lateral cutaneous branches of the ICNs.[7] Hence, it might not be effective for upper abdominal surgeries involving subcostal incisions, such as the liver and gallbladder.

Elsharkawy *et al*.[4] conducted a study on two embalmed cadavers. They found that dye injected between EO and ICM at the 6th/7th rib covers the lateral and anterior cutaneous branches of the ICN from T6/7 to T10/11. This is due to the strategic position of the point of the needle tip at the time of drug injection, which, due to

Table 2: Patient satisfaction scores, additional opioid consumption and block performance time between two groups

	Group E (*n*=25)	Group T (*n*=25)	Effect size *r* (95% CI)	*P*
PSS	9 (8–9)	7 (7, 7.5)	0.80 (1.00, 2.00)	<0.001
Additional intraoperative fentanyl consumption (μg)	45.0 (37.5–60)	50 (40–60)	−0.16 (−0.71, 0.39)	0.618
Block performance time (seconds)	192 (183–200)	199 (185–207)	−0.31 (−0.87, 0.25)	0.587

Data expressed as median (IQR). CI=confidence interval, IQR=interquartile range, PSS=Patient satisfaction score, E=External oblique plane, T=Subcostal transversus abdominis, *n*=number of patients

Table 3: Time to rescue analgesia and postoperative fentanyl consumption between two groups

	Group E (*n*=25)	Group T (*n*=25)	Mean Difference (95% CI)	*P*
Time to activation of PCA (minutes)	610.28 (118.95) [561.20, 659.36]	409.68 (101.36) [367.84, 451.52]	200.60 [137.76, 263.43]	<0.001
24-h fentanyl consumption (μg)	102.40 (25.70) [91.79, 113.01]	123.20 (34.48) [108.96, 137.44]	−20.80 [−38.09, −3.50]	0.019

Data expressed as mean (SD) [95% confidence interval]. SD=standard deviation, CI=confidence interval, PCA=patient-controlled analgesia, E=External oblique plane, T=Subcostal transversus abdominis, *n*=number of patients

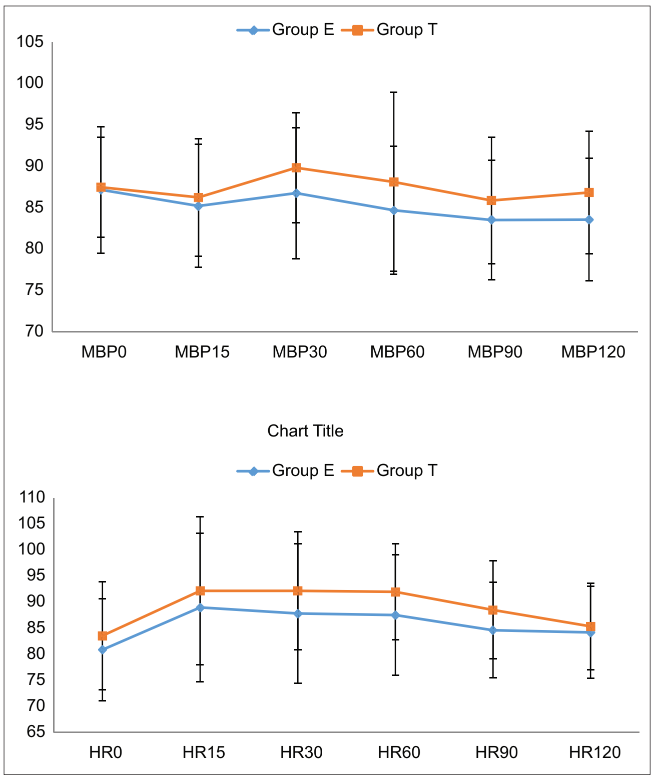

Figure 3: Intraoperative haemodynamics variation between two groups with time

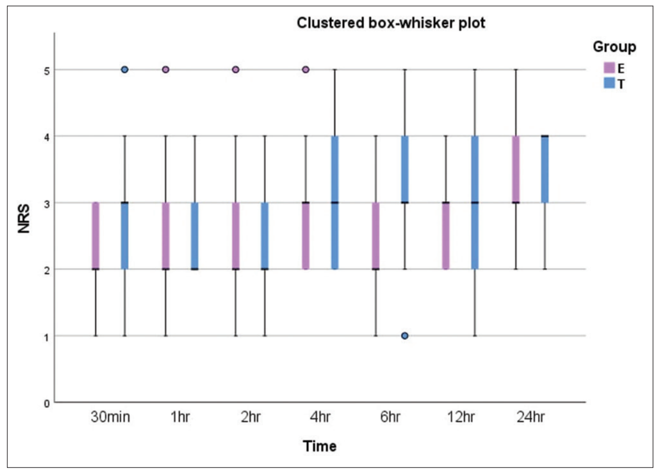

Figure 4: Scattered box whiskers plot showing postoperative pain scores at various times

its high volume, spreads laterally to cover the lateral branch and anteriorly to cover the anterior branch. This ends up providing consistent dermatomal coverage of the upper abdominal wall. Our clinical finding that the time of first PCA activation was significantly prolonged in Group E reaffirms Elsharkawy's findings.

A recent study compared patients undergoing laparoscopic sleeve gastrectomy receiving EOI block with those receiving no block; 24-hour morphine consumption was reduced by a median of 46.4% in the EOI arm as compared to the other arm, thus establishing the opioid-sparing effect of EOI.[8] The authors in another study compared bilateral EOI with port site infiltration in patients undergoing the same surgery. Lower opioid consumption and pain scores with no increase in adverse effects were observed with EOI block as compared to port site infiltration.[3] Clinical experience with EOI blocks in open nephrectomies and liver surgeries (open or laparoscopic) has also been encouraging.[9-11]

Subcostal TAP blocks have been used in multi-modal analgesic regimes for upper abdominal surgeries.[12] Sensory evaluation after this block shows better dermatomal coverage in the upper abdomen than the posterior TAP block. Though the duration of PCA activation was less in the TAP group, the pain scores and the postoperative opioid consumption were similar in both groups.

The incidence of nausea/vomiting was not significant in either group; this might be due to the multimodal prophylactic regimen involving ondansetron and dexamethasone. No block-related complication was noted in both groups due to the superficial nature of the blocks. Nonetheless, while inserting the in-plane needle, an eye was kept on important underlying structures such as the pleura.

External oblique plane block offers advantages such as ease of performance and needle/catheter entry away from the surgical site. It can also be performed in patients with previous surgery having tissue scarring and obliteration of the subcostal plane. One major shortcoming of this block is its inability to provide visceral analgesia. The limitations of this study include that we have not compared EOI with blocks that also provide visceral analgesia. In addition, we have given only unilateral blocks, though studies suggest that there could be sensory overlap in the upper abdominal innervation. Further studies comparing it with erector spinae or paravertebral block can be formulated. We have had surgeries with unilateral incisions. Bilateral blocks or continuous EOI blocks by inserting catheters should also be studied in the future. Further trials with larger sample sizes can validate our findings.

CONCLUSION

In conclusion, the external oblique intercostal plane block is an effective component of the multi-modal analgesic regime for patients undergoing upper abdominal surgeries.

Statement on data sharing

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' Institution policy.

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Conflicts of interest

There are no conflicts of interest.

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