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Comparison of oblique subcostal, posterior, or dual transversus abdominis plane block in laparoscopic cholecystectomy: a prospective, randomized-controlled, double-blind study

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Title: Comparison of oblique subcostal, posterior, or dual transversus abdominis plane block in laparoscopic cholecystectomy: a prospective, randomized-controlled, double-blind study

Brief title: Dual, Posterior, and OSTAP Blocks in LC

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ABSTRACT

Background: The transversus abdominis plane (TAP) block is widely used for postoperative analgesia in patients undergoing laparoscopic cholecystectomy (LC). This study aimed to compare postoperative analgesic efficacy and opioid consumption among oblique subcostal (OSTAP), posterior, and dual TAP blocks.

Methods: In this prospective, randomized-controlled, double-blind study, 85 patients aged 18–65 years with ASA physical status I–II undergoing LC were enrolled. Patients were randomized into three groups: Group O received active OSTAP with placebo posterior TAP, Group P active posterior TAP with placebo OSTAP, and Group D active dual (OSTAP + posterior) TAP block. Blocks were performed using 0.5% bupivacaine, 1% prilocaine, and saline (10 mL each). The primary outcome was postoperative pain intensity assessed by the numerical rating scale (NRS) within the first 24 hours. Secondary outcomes included analgesic consumption, postoperative nausea and vomiting, sedation scores, and dermatomal sensory coverage. $P < 0.05$ was considered statistically significant using SPSS 22.0.

Results: Seventy-one patients were analyzed. At 30 minutes postoperatively, severe pain (NRS ≥ 7) at rest was not observed in Group D, whereas it occurred in 8.3% of Group P and 23.8% of Group O patients ($P = 0.008$). No patients in Group D required tramadol, compared with 33.3% in Group O and 8.3% in Group P ($P = 0.001$). Dermatomal spread was significantly broader in Groups D and P than in Group O ($P = 0.001$).

Conclusions: Dual TAP block provides superior early postoperative analgesia compared with OSTAP, while posterior TAP demonstrates comparable efficacy. Both techniques may be considered effective options for postoperative pain management in LC.

Trial Registration: The study was registered at ClinicalTrials.gov (ID: NCT04693156; registered on December 25, 2020).

Key words: Postoperative pain, Analgesia, Laparoscopic cholecystectomy, Transversus abdominis plane block

1. Introduction

Laparoscopic cholecystectomy (LC) is the gold-standard treatment for symptomatic cholelithiasis due to its minimally invasive nature [1,2]. Despite its advantages, LC is still

associated with moderate to severe postoperative pain arising from trocar incisions, pneumoperitoneum, and visceral irritation, with up to 32% of patients requiring opioid analgesia [3]. Effective postoperative pain management is essential for improving recovery, minimizing complications, and reducing hospital stay. Multimodal analgesia, combining systemic and regional techniques, helps achieve this while limiting opioid-related side effects such as nausea, vomiting, and respiratory depression. Among regional techniques, the transversus abdominis plane (TAP) block is widely used for abdominal surgeries [4-7]. First described by Rafi in 2001, it targets thoracolumbar nerves (T6–L1) between the internal oblique and transversus abdominis muscles [8]. The ultrasound-guided approach, introduced by Hebbard in 2007, enhanced the block's accuracy and safety [4]. Several TAP block variations have since been developed—lateral, posterior, subcostal, and oblique subcostal (OSTAP) approaches [9]. The posterior TAP block has been associated with reduced pain scores and analgesic consumption after LC [10,11]. Cadaveric and imaging studies suggest it may allow paravertebral spread and partial sympathetic blockade, enhancing both somatic and visceral analgesia [12, 13]. Nevertheless, supraumbilical coverage may remain limited with posterior approaches alone. To address this limitation, Hebbard described the OSTAP approach, in which local anesthetic is distributed along the oblique subcostal line to provide supraumbilical abdominal wall analgesia [5]. Subsequent reports suggested that spread may extend from T6 to L1 when a catheter-based technique is used [6]. However, such spread depends on adequate hydrodissection and can be technically challenging [6]. Therefore, dual TAP strategies have been proposed to target both upper and lower abdominal wall innervation. Although the original dual TAP concept described by Børglum et al. involved separate injections into the upper intercostal and lateral/classic TAP compartments, later clinical studies adapted this principle by combining subcostal or oblique subcostal TAP with posterior TAP block to broaden analgesic coverage

and reduce pain and opioid consumption [14-16]. **Given the inconsistent results of comparative TAP block studies in LC** [**9, 14, 17**]**,** we compared the postoperative analgesic efficacy of OSTAP, posterior TAP, and dual TAP blocks in patients undergoing LC, hypothesizing that dual TAP block would provide enhanced analgesia with reduced opioid requirements.

2. Methods

2.1. Study design and ethics

This prospective, randomized, controlled, double-blind, parallel-group clinical trial was approved by the Ethics Committee of Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine (Decision No. 132002, dated October 7, 2020). The study was conducted in accordance with the CONSORT guidelines and the principles of the 2013 Declaration of Helsinki and was registered at ClinicalTrials.gov (ID: NCT04693156; registered on December 25, 2020).

A total of 85 patients aged 18–65 years, classified as American Society of Anesthesiologists (ASA) physical status I–II and scheduled for elective LC under general anesthesia due to cholelithiasis, were enrolled between February 2021 and September 2022. Exclusion criteria included emergency surgery for acute cholecystitis, intraoperative gallbladder perforation, history of biliary surgery, renal insufficiency, coagulopathy, pregnancy, morbid obesity, psychiatric disorders, epilepsy, substance or alcohol abuse, and allergies to study medications. Written informed consent was obtained from all participants.

2.2. Randomization and blinding

Patients were randomized in a 1:1:1 ratio into three groups via computer-based randomization (https://www.randomizer.org).

- **Group O:** OSTAP block with 0.5% bupivacaine, 1% prilocaine, and saline (10 mL each); posterior TAP with 30 mL saline
- **Group P:** Posterior TAP block with 30 mL of the same local anesthetic solution; OSTAP with 30 mL saline.
- **Group D:** Both OSTAP and posterior TAP blocks with 30 mL of the same local anesthetic solution each.

Allocation was concealed in sequentially numbered opaque envelopes. All patients and the experienced anesthesiologist performing the blocks were blinded to group allocation. Study solutions were prepared by an independent anesthetist not involved in patient care. Another blind investigator conducted postoperative assessments.

2.3. Anesthesia and surgical procedure

Patients received intravenous (IV) midazolam (0.03 mg/kg) for premedication. Standard monitoring, including electrocardiography (ECG), noninvasive blood pressure, peripheral oxygen saturation (SpO_2), and end-tidal carbon dioxide ($EtCO_2$), was applied and recorded. Anesthesia was induced with fentanyl (2 μg/kg, IV) and propofol (2 mg/kg, IV), followed by rocuronium (0.6 mg/kg, IV) for muscle relaxation and orotracheal intubation. General anesthesia was maintained with sevoflurane 2% in 40% oxygen and 60% air using pressure-controlled ventilation. All patients received IV paracetamol 1 g and tramadol 100 mg during skin closure and ondansetron 8 mg. All laparoscopic cholecystectomies were performed using a standard four-port technique. Patients were extubated following reversal of the neuromuscular blockade with IV neostigmine (0.02 mg/kg) and atropine (0.01 mg/kg). Then they were transferred to the recovery unit.

2.4. Block interventions

Blocks were administered at the end of the surgery, before extubation, under ultrasound-guidance (Esaote MyLab™Alpha, Italy) using a high-frequency (5-12 MHz) linear probe with 100-mm 22G Quincke needles (Stimupleks A100, Braun, Germany). The skin was prepared using 10% povidone-iodine, and a sterile cover was applied to the probe. To match the predominant pain distribution of LC while limiting total local anesthetic exposure, each patient received a right-sided OSTAP block followed by a posterior TAP block.

OSTAP blocks were performed in the supine position. The probe was placed obliquely along the subcostal margin, near the xiphoid, toward the iliac crest. Using an in-plane approach, the needle was inserted in a medio-lateral direction to access the fascial plane between the rectus abdominis (RA) and transversus abdominis (TA) muscles (Figure 1a). After negative aspiration, correct needle placement was confirmed with 1–2 mL saline, followed by injection of the prepared solution along the subcostal line according to group allocation. Posterior TAP blocks were performed with the patient in a 15° left lateral tilt. The probe was placed posterolaterally between the costal margin and iliac crest, posterior to the midaxillary line. The external oblique (EO), internal oblique (IO), TA, and quadratus lumborum (QL) muscles were identified (Figure 1b). The needle was inserted in-plane toward the fascial plane between IO and TA near the QL aponeurosis. Following negative aspiration and confirmation with saline, the prepared solution was injected (Figure 1c). Proper deposition was confirmed by hypoechoic hydrodissection. Total local anesthetic doses were kept below recommended maximum limits in all patients.

2.5. Postoperative pain evaluation and analgesia

Postoperative pain was assessed using the Numeric Rating Scale (NRS; 0 = no pain, 10 = worst pain imaginable), and patients were educated preoperatively. NRS scores were initially recorded in the recovery unit at the 30th minute and subsequently at 2, 4, 6, 8, 12, and 24 hours postoperatively, both at rest and during movement (in the seated position). Pain severity

was categorized as mild (NRS 0–3), moderate (4–6), and severe (≥7). All patients received 1 g IV paracetamol every 8 hours as standardized preventive analgesia. For NRS ≥ 4, 50 mg dexketoprofen; for NRS ≥ 7, 100 mg tramadol was administered IV as a rescue analgesic.

2.6. Outcome measures and data collection

The primary outcome was postoperative pain intensity (NRS). The secondary measures were analgesic requirements within 24 hour after surgery, incidence of postoperative nausea and vomiting (PONV) assessed using a 4-point scale (0: no nausea or vomiting, 1: nausea without vomiting, 2: one episode of vomiting, and 3: two or more episodes of vomiting), sedation levels using the Ramsay Sedation Scale (RSS), and sensory dermatomal coverage assessed using a pinprick test with a blunt needle applied on the right side, parasagitally covering the T6 to L2 dermatomes. All variables were recorded at the predefined time points. Age, sex, body weight, height, body mass index (BMI), history of previous surgeries, and ASA scores were recorded preoperatively. The duration of anesthesia, pneumoperitoneum, surgery, block performance time, and surgical drain placement, as well as postoperative hemodynamic parameters and side effects, were recorded. Time to first ambulation and the length of hospital stay were documented.

2.7. Sample size calculation

Sample size for the primary outcome was calculated based on a 2-point NRS difference (SD = 2) as clinically significant, using data from Shin et al. [20]. G*Power 3.1 determined that a total of 63 patients (21 per group) were required ($\alpha = 0.05$, power = 0.9). To account for potential dropouts, 85 patients were enrolled (28 in Group O, 28 in Group P, 29 in Group D).

2.8. Statistical analysis

Statistical analysis was performed on a per-protocol basis using SPSS 22.0. Descriptive statistics were presented as mean ± SD or median (25^{th} –75^{th} percentile) for continuous

variables and as frequency (%) for categorical variables. Normality was assessed using the Kolmogorov–Smirnov test. For normally distributed data, Student's t-test and repeated-measures ANOVA with Bonferroni correction were used. Non-normally distributed data were analyzed using the Kruskal–Wallis and Mann–Whitney U tests. Within-group comparisons over time were assessed with the Friedman test and Dunn–Bonferroni correction. Categorical variables were compared using Pearson's chi-square or Fisher's exact test when appropriate. A $P < 0.05$ was considered statistically significant.

3. Results

Eighty-five patients were enrolled. After exclusions due to incomplete data or additional analgesic use, data from 21, 24, and 26 patients in Group O, Group P, and Group D, respectively, were included in the final analysis, as illustrated in the CONSORT flow diagram (Figure 2).

All three groups were comparable in demographics, ASA status, surgical history, and perioperative parameters, including anesthesia and surgical duration, pneumoperitoneum and block times, drain use, time to first mobilization, and length of hospital stay ($P > 0.05$) (Table 1). No block-related complications (hematoma, infection, and local anesthetic systemic toxicity) were observed in any groups during the entire follow-up period.

3.1. Postoperative pain

In the initial assessment performed 30 minutes postoperatively at rest, severe pain was not observed in any of the patients in Group D (Dual TAP). In contrast, it occurred in 8.3% of Group P (posterior TAP) and 23.8% of Group O (OSTAP) patients. The difference between Group D and Group O was statistically significant ($P = 0.008$). Also, patients who experienced mild pain at rest were significantly higher in Group D (88.5%) compared to Group O (42.9%) ($P = 0.008$) (Table 2). A similar trend was observed for movement-evoked

pain at the same point: no patients in Group D had NRS scores in the severe range, whereas 8% of patients in Group P, and 24% of patients in Group O experienced severe pain with movement. However, this difference did not reach statistical significance (P = 0.09) (Supplementary Table 1). At the 2nd, 4th, 6th, 8th, 12th, and 24th postoperative time points, pain severity—both at rest and with movement—was similar across all groups. Additionally, mean NRS scores and corresponding area under the curve (AUC) values for both at rest and with movement were comparable among the three groups throughout the 24-hour postoperative period (P > 0.05) (Supplementary Tables 2 and 3).

3.2. Postoperative analgesic consumption

Throughout the 24-hour postoperative period, no patient in Group D required tramadol, whereas tramadol was administered to seven patients (33.3%) in Group O, a statistically significant difference (P = 0.001) (Figure 3a). Of these seven patients in Group O, five (23.8%) required tramadol within the first 60 minutes postoperatively, resulting in a significant difference compared with Group D (P = 0.02). In Group P, tramadol was required in two patients (8.3%), with no significant difference compared to either Group O or Group D. No patients in any group required tramadol after the 6th postoperative hour. Dexketoprofen requirements were similar across all groups (P = 0.11) (Figure 3b).

3.3. Sensory distribution and postoperative nausea and vomiting

The wider dermatomal coverage was seen at the 2nd postoperative assessment in all groups and tended to decrease starting at the 4th hour postoperatively (Table 3).

Dermatomal spread was significantly broader in Groups P and D than in Group O from the 30th minute to the 8th postoperative hour (P < 0.05 for all) (Table 3), with the most frequent involvement at T11, T12, and L1 (P < 0.001). The most frequently involved dermatome was T12 at the 2nd hour in both Groups P (66.7%) and D (80.8%), significantly more than in

Group O ($P < 0.001$). Although T10 was most frequently involved in Group O (19%), this did not differ significantly from Groups P and D ($P > 0.05$). Group P and Group D showed comparable dermatomal involvement throughout the follow-up period ($P > 0.05$) (Table 3).

The PONV scores did not differ significantly between groups at any assessed time point ($P = 0.19$). There were no significant differences in RSS and hemodynamic parameters between the groups at any time point ($P > 0.05$).

4. Discussion

In this randomized, double-blind, prospective study, we evaluated and compared the postoperative analgesic efficacy of OSTAP, posterior TAP, and dual TAP blocks in patients undergoing LC. Our results showed that the dual TAP block provided superior analgesia in the early postoperative period compared to the OSTAP block. Most patients in the dual TAP group reported mild pain at rest, and notably, none required opioid rescue analgesia. Posterior TAP block demonstrated the closest performance to dual TAP in terms of pain control and reduced analgesic requirement. These findings support the idea that combining OSTAP with posterior TAP may enhance analgesic efficacy through a synergistic mechanism.

The number of studies investigating the efficacy and optimal application of regional analgesic techniques continues to grow steadily, highlighting their increasing clinical relevance. Although the recent PROSPECT guidelines recommend TAP blocks in LC as a second-line option due to the need for advanced expertise and concerns about systemic toxicity, they also acknowledge their usefulness and analgesic effectiveness in certain clinical scenarios, particularly in patients for whom opioid use is undesirable or when high levels of postoperative pain are expected [18]. In our study, the dual TAP block reduced opioid consumption and may therefore be recommended in these selected patient groups. The absence of local anesthetic toxicity or block-related complications further supports the safety

of combining ultrasound-guided TAP blocks when used within recommended dose limits. Given the growing use of ultrasound in anesthesia practice and the increasing evidence supporting their efficacy, greater emphasis should be placed on the role of combined TAP block techniques in anesthesiology training.

The concept of combining different TAP block techniques was first introduced by Børglum et al. in 2011, who described a dual TAP block involving separate injections targeting the upper intercostal and lower classic TAP plexuses [15]. This approach was reported to be effective as a rescue analgesic method. In a subsequent magnetic resonance imaging study, they emphasized that the upper and lower TAP plexuses are anatomically distinct and stated that when effective analgesia of the entire abdominal wall is desired, separate injections targeting both plexuses are necessary [19]. In this context, different dual TAP block approaches, including combinations of subcostal TAP with posterior TAP or OSTAP with posterior TAP, have been used as postoperative analgesic techniques in various abdominal surgeries and were found to be effective when compared to placebo [14, 16]. In our study, we utilized the dual TAP approach by combining OSTAP and posterior TAP blocks. Differing from previous studies, our objective was to directly compare the dual TAP block with OSTAP and posterior TAP blocks individually. Dual TAP blocks have been shown in the literature to reduce pain scores and opioid consumption, findings that are consistent with our results [14, 15].

In addition, the posterior TAP block also demonstrated favorable results when used alone in our study. Although the difference in pain scores and opioid use between posterior TAP and OSTAP was not always statistically significant, patients in the posterior TAP group showed diminished NRS scores with lower opioid requirements. These outcomes may be attributed to the analgesic properties of the posterior TAP block. Studies have demonstrated that the injection site for posterior TAP lies near the junction of the internal oblique and transversus abdominis muscles with the quadratus lumborum aponeurosis, allowing local anesthetic to

spread into the paravertebral space [12, 13]. This paravertebral extension may result in sympathetic blockade and enhance the overall quality of analgesia. The presence of both somatic and visceral analgesic effects in the posterior TAP block may help explain the superior performance of the dual TAP block over the OSTAP block in our study. Our findings also suggest that the posterior TAP block alone achieves analgesic outcomes comparable to those of the dual TAP block in many respects, making it a reliable alternative when a single-injection technique is preferred.

Dermatomal evaluation in our study showed that both posterior and dual TAP blocks provided broader sensory coverage than OSTAP. This difference was especially notable in the lower dermatomes. While posterior and dual blocks predominantly covered the T10–L1 dermatomes, OSTAP was mostly limited to T8–T10. This is consistent with previous studies using single-shot OSTAP techniques, which have shown limited spread to the supraumbilical region, particularly at T9–T10 [20]. In line with our results, Aoyama et al. reported that posterior TAP block commonly involved three dermatomes, especially T11 and T12 [21]. These findings support the use of the posterior TAP block over OSTAP for infraumbilical surgeries. Furthermore, although the posterior TAP block primarily provides coverage of lower dermatomes, its observed effectiveness in LC, where incisions are predominantly supraumbilical, may be attributed to its potential visceral analgesic effect. Further studies are warranted to confirm this hypothesis.

The strengths of our study include its prospective, randomized, and double-blind design, as well as the direct comparison of three distinct TAP block techniques in a standardized surgical setting. However, the study has some limitations. First, we did not include a placebo or no-block control group due to the institutional postoperative multimodal analgesic protocol, limiting comparisons with conventional analgesic regimens. Second, sensory spread in the OSTAP group may have been underestimated because dermatomal mapping was performed

within a limited assessment area. Given the incomplete and variable dermatomal coverage of TAP blocks [12] and the more prominent midabdominal distribution of OSTAP [22], more detailed sensory mapping should be considered in future studies. Finally, the total local anesthetic dose was higher in the dual TAP group than in the single-block groups. Thus, the greater analgesic effect observed with dual TAP may partly reflect the increased local anesthetic dose in addition to broader dermatomal coverage.

5. Conclusions

In conclusion, to our knowledge, this is the first randomized controlled trial comparing OSTAP, posterior TAP, and dual TAP blocks in LC patients. The findings suggest that dual TAP block offers the most effective early postoperative analgesia and eliminates the need for opioid rescue in the postoperative period. Nonetheless, the posterior TAP block also demonstrated favorable outcomes and may be considered a reliable alternative when a dual TAP block is not feasible due to the requirement for two separate injections. Given their proven safety and analgesic efficacy, ultrasound-guided TAP blocks could be more widely adopted in clinical practice through further research aimed at optimizing postoperative pain management strategies.

List of Abbreviations: LC: Laparoscopic cholecystectomy; TAP: Transversus abdominis plane; OSTAP: Oblique subcostal transversus abdominis plane; ASA: American Society of Anesthesiologists; IV: Intravenous; ECG: Electrocardiography; SpO_2: Peripheral oxygen saturation; $EtCO_2$: End-tidal carbon dioxide; RA: Rectus abdominis; TA: Transversus abdominis; EO: External oblique; IO: Internal oblique; QL: Quadratus lumborum; NRS: Numeric Rating Scale; PONV: Postoperative nausea and vomiting; RSS: Ramsay Sedation Scale; BMI: Body mass index

Declarations

Ethics approval and consent to participate: This clinical trial was approved by the Ethics Committee of Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine (Decision No. 132002, dated October 7, 2020). Written informed consent was obtained from all participants.

Consent for publication: Not applicable

Availability of data and materials: The data supporting this study are available from the corresponding author upon reasonable request.

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CRediT authorship contribution statement: CS: Conceptualization, Methodology, Investigation, Data curation, Resources, Formal analysis, Visualisation, Validation, Writing - original draft, Writing - review & editing. EE: Methodology, Supervision. AN: Investigation, Data curation. CAB: Investigation, Data curation. EO: Investigation, Data curation. FA: Conceptualization, Investigation, Methodology, Writing - review & editing. All authors read and approved the final version of the manuscript for publication.

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TABLES

Table 1: Comparison of demographic and perioperative characteristics between the groups

	All Groups (N=71)	Group O (N=21)	Group P (N=24)	Group D (N=26)	p
Age	48 ± 13 50 [21-65]	48 ± 13 49 [22-65]	49 ± 13 51 [27-65]	47 ± 14 50 [21-65]	0.90
Sex					
Woman	43 (% 60.6)	13 (%61.9)	13 (%54.2)	17 (%39.5)	0.71

Man	28 (% 39.4)	8 (%38.1)	11 (%45.8)	9 (%34.6)	
Height (m)	1.66 ± 0.10 1.65 [1.48-1.85]	1.63 ± 0.10 1.60 [1.48-1.85]	1.67 ± 0.05 1.66 [1.60-1.75]	1.65 ± 0.09 1.65 [1.50-1.83]	0.31
Weight (kg)	77 ± 13 78 [50-110]	79 ± 13 76 [59-110]	75 ± 11 79 [51-94]	76 ± 15 78 [50-105]	0.61
BMI (kg/m^2)	28.1 ± 4.3 28.0 [17.6-38.8]	29.6 ± 4.5 28.7 [21.5-38.8]	27.0 ± 4.2 27.8 [17.6-32.8]	28.0 ± 4.0 27.3 [22.2-37.6]	0.11
ASA					
ASA I	32 (%45.1)	9 (%42.9)	10 (%41.7)	13 (%50)	0.82
ASA II	39 (%54.9)	12 (%57.1)	14 (58.3)	13 (%50)	
Prior abdominal surgery					
No	56 (%78.9)	17 (%81.0)	18 (%75.0)	21 (%80.8)	0.85
Yes	15 (%21.1)	4 (%19.0)	6 (%25.0)	5 (%19.2)	
Anesthesia duration (min)	97.9 ± 2.6 90 [60-165]	97.6 ± 27.3 90 [60-165]	94.1 ± 20.8 90 [60-135]	102.0 ± 18.2 105 [60-135]	0.50
Pneumoperitoneum duration (min)	56.0 ± 2.2 50 [25-120]	57.4 ± 22.4 60 [30-120]	53.8 ± 20.0 50 [25-95]	57.0 ± 14.4 53 [35-85]	0.77
Surgery duration (min)	70.5 ± 2.3 70 [35-135]	70.7 ± 23.4 70 [40-135]	68.8 ± 18.7 68 [35-105]	72.0 ± 16.4 70 [45-105]	0.85
Block duration (min)	6.8 ± 0.3 5 [4-15]	7.1 ± 3.4 5 [5-15]	6.9 ± 2.9 5 [5-15]	6.5 ± 2.4 5 [4-10]	0.77
Presence of surgical drain					
No	24 (%33.8)	7 (%33.3)	9 (%37.5)	8 (%30.8)	0.88
Yes	47 (%66.2)	14 (%66.7)	15 (%62.5)	18 (%69.2)	
Mobilization time (h)	6.7 ± 0.2 7 [4-12]	6.6 ± 1.5 7 [4-10]	6.6 ± 1.1 7 [4-8]	6.7 ± 1.4 7 [5-12]	0.95
Length of hospital stay (days)	1.8 ± 0.1 2 [1-4]	1.7 ± 0.8 1 [1-3]	1.8 ± 0.9 2 [1-4]	1.9 ± 1.0 2 [1-4]	0.70

Continuous variables are presented as mean ± standard deviation and median [min–max]; categorical variables are presented as number and percentage. Group O: OSTAP block + posterior TAP with saline; Group P: Posterior TAP block + OSTAP with saline; Group D: Dual TAP block. One-way ANOVA was used to compare continuous variables, and Pearson's chi-square test was used to compare categorical variables. BMI: Body Mass Index, ASA: American Society of Anesthesiologists

Table 2: Comparison of pain severity at rest between groups

NRS	Group O (N=21)	Group P (N=24)	Group D (N=26)	p
30th min				

<4	9 (%42.9)[a]	18 (%75)[a, b]	23 (%88.5)[b]	
4-6	7 (%33.3)[a]	4 (%16.7)[a]	3 (%11.5)[a]	**0.008**
≥7	5 (%23.8)[a]	2 (%8.3)[a, b]	0[b]	
2nd hour				
<4	19 (%90.5)	23 (%95.8)	25 (%96.2)	
4-6	2 (%9.5)	1 (%4.2)	1 (%3.8)	0.68
≥7	0	0	0	
4th hour				
<4	20 (%95.2)	22 (%91.7)	25 (%96.2)	
4-6	0	2 (%8.3)	1 (%3.8)	0.46
≥7	1 (%4.8)	0	0	
6th hour				
<4	19 (%90.4)	24 (%100)	25 (%96.2)	
4-6	1 (%4.8)	0	1 (%3.8)	0.45
≥7	1 (%4.8)	0	0	
8th hour				
<4	20 (%95.2)	24 (%100)	25 (%96.2)	
4-6	1 (%4.8)	0	1 (%3.8)	0.75
≥7	0	0	0	
12th hour				
<4	20 (%95.2)	24 (%100)	26 (%100)	
4-6	1 (%4.8)	0	0	0.30
≥7	0	0	0	
24th hour				
<4	21 (%100)	24 (%100)	26 (%100)	
4-6	0	0	0	-
≥7	0	0	0	

Data are presented as numbers and percentages. Group O: OSTAP block + posterior TAP with saline; Group P: posterior TAP block + OSTAP with saline; Group D: Dual TAP block. Pearson's chi-square test with a Bonferroni correction was used to compare the three groups. When the expected value exceeded 25%, Fisher's exact chi-square test was applied. a–b: Groups sharing the same letter are not significantly different. NRS: Numeric Rating Scale.

Table 3: Dermatomal involvement

Hours	Group O (N=21)	Group P (N=24)	Group D (N=26)	p†	p O-P	p O-D	p P-D
30th min	0.67 ± 1.50 0 [0-5]	2.00 ± 1.82 2.0 [0-5]	2.96 ± 2.05 3.0 [0-7]	**0.001**	**0.007**	**<0.001**	0.11
2nd	0.81 ± 1.75 0 [0-5]	2.38 ± 1.84 3.0 [0-6]	3.12 ± 1.88 3.0 [0-7]	**0.001**	**0.004**	**<0.001**	0.23
4th	0.71 ± 1.68 0 [0-5]	2.08 ± 1.79 2.5 [0-6]	3.12 ± 1.88 3.0 [0-7]	**<0.001**	**0.006**	**<0.001**	0.06
6th	0.62 ± 1.60 0 [0-5]	2.04 ± 1.73 2.5 [0-6][b]	2.73 ± 1.93 3.0 [0-6]	**0.001**	**0.003**	**<0.001**	0.22
8th	0.62 ± 1.60 0 [0-5]	1.67 ± 1.74 1.5 [0-5][b,c,d]	2.35 ± 1.88 2.0 [0-6][b,c,d]	**0.003**	**0.018**	**0.001**	0.24
12th	0.33 ± 0.86 0 [0-3][a,b,c,d,e]	0.42 ± 1.18 0 [0-5][a,b,c,d,e]	1.08 ± 1.77 0 [0-6][a,b,c,d,e]	0.14	0.843	0.094	0.13
24th	0.10 ± 0.44 0 [0-2][a,b,c,d,e]	0.04 ± 0.20 0 [0-1][a,b,c,d,e]	0.04 ± 0.20 0 [0-1][a,b,c,d,e,f]	0.98	0.899	0.854	0.95
p*	**0.012**	**<0.001**	**<0.001**				

Data are presented as mean ± standard deviation or median [min–max].† Comparisons among the three groups were performed using the Kruskal–Wallis test. Pairwise group comparisons were conducted using the Mann–Whitney U test.
*****Within-group comparisons of the number of dermatomes involved were performed using Friedman analysis. a: Significant difference compared with 0 hour (recovery) ($p < 0.05$), b: Significant difference compared with 2 hours ($p < 0.05$), c: Significant difference compared with 4 hours ($p < 0.05$), d: Significant difference compared with 6 hours ($p < 0.05$), e: Significant difference compared with 8 hours ($p < 0.05$), f: Significant difference compared with 12 hours ($p < 0.05$).

FIGURE LEGENDS

Figure 1: a) OSTAP block; the spread of local anesthetic solution is seen on the transversus abdominis plane between the RA and TA muscles. b) Sonoanatomy for the Posterior TAP block. c) The local anesthetic solution spreads to the TAP. Arrows show the needle, RA: Rectus abdominis muscle, EO: External oblique muscle, IO: Internal oblique muscle, TA: Transversus abdominis muscle, TAP: Transversus abdominis plane

Figure 2: CONSORT flow diagram

Figure 3: Comparison of a) percentage of tramadol requirement and b) percentage of dexketoprofen requirement between the groups *p=0.001 between Group O vs Group D

FIGURES

Figure 1:

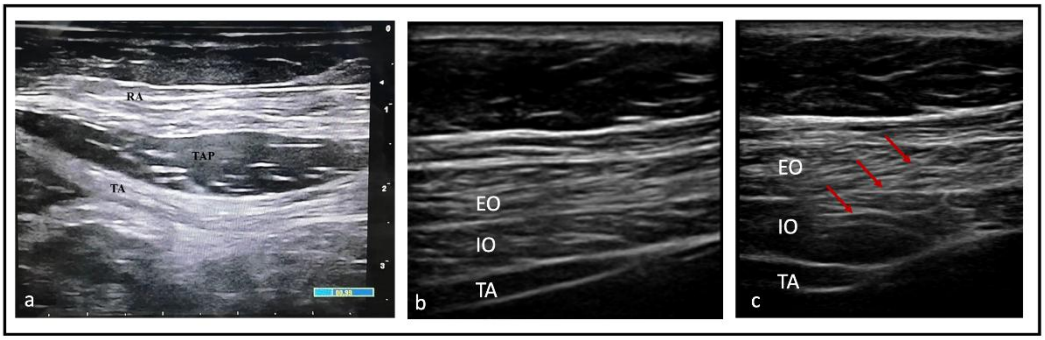


Figure 2:

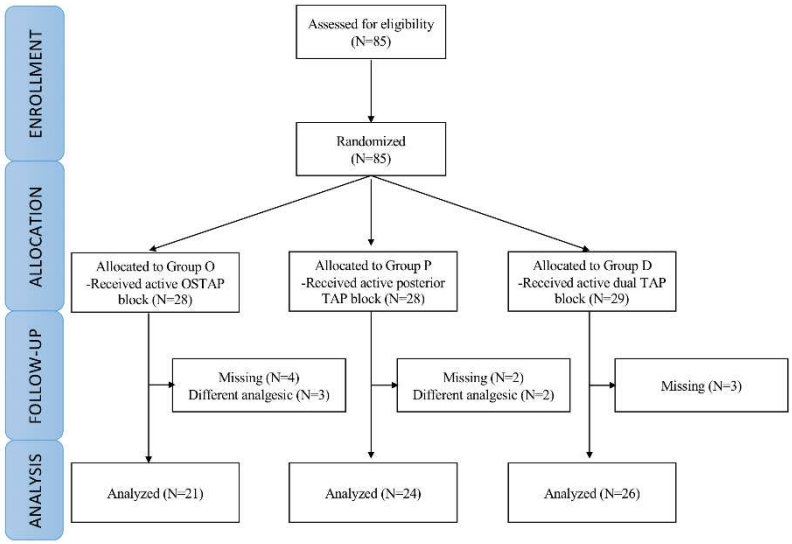
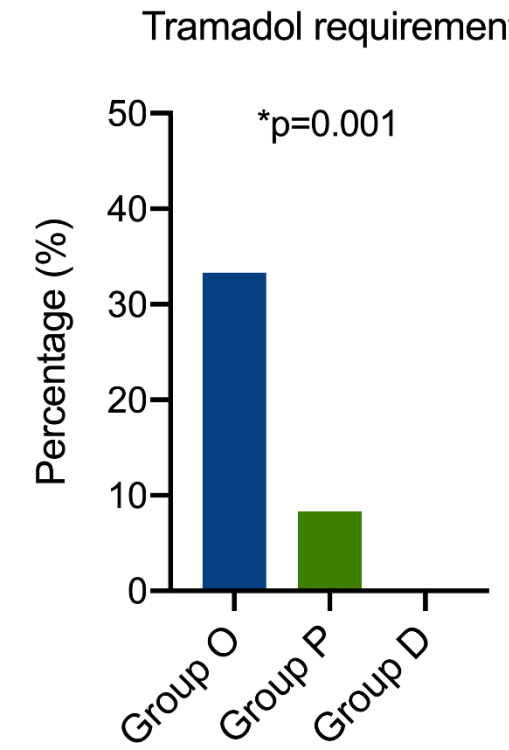
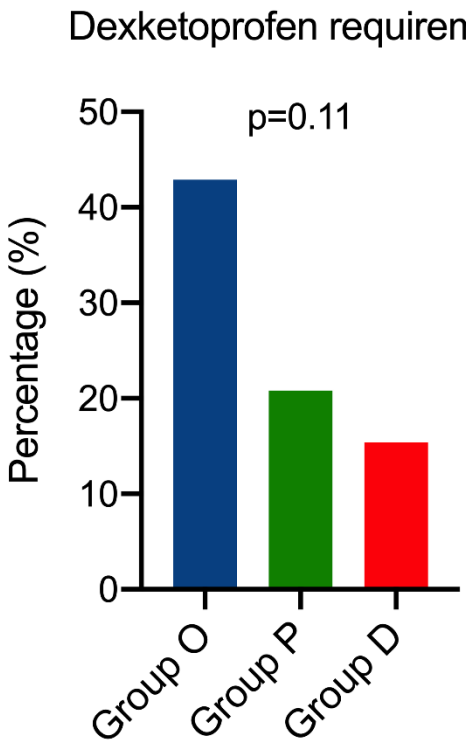

ENROLLMENT
ALLOCATION
FOLLOW-UP
ANALYSIS
Assessed for eligibility (N=85)
Randomized (N=85)
Allocated to Group O -Received active OSTAP block (N=28)
Allocated to Group P -Received active posterior TAP block (N=28)
Allocated to Group D -Received active dual TAP block (N=29)
Missing (N=4) Different analgesic (N=3)
Missing (N=2) Different analgesic (N=2)
Missing (N=3)
Analyzed (N=21)
Analyzed (N=24)
Analyzed (N=26)

Figure 3:


Tramadol requirement
*p=0.001
Percentage (%)
50
40
30
20
10
0
Group O
Group P
Group D

a


Dexketoprofen requirement
p=0.11
Percentage (%)
50
40
30
20
10
0
Group O
Group P
Group D

b

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supp.TableI.docx
- Supp.TableII.docx
- Supp.TableIII.docx