Randomized Clinical Trial

The Effect of Unilateral Subcostal Transversus Abdominis Plane Block Applied as Single or Multiple Injections on Pain in Laparoscopic Cholecystectomy

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Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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Background: Effective postoperative pain management in cases of laparoscopic cholecystectomy is essential for recovery and patient satisfaction. The subcostal transversus abdominis plane (TAP) block is a regional analgesic technique used for upper-abdominal pain. While the single-injection TAP has shown benefits in reducing perioperative opioid consumption, the comparative efficacy of the multi-injection version of this block remains insufficiently studied.

Objectives: This study aimed to compare the analgesic efficacy of unilateral single-injection versus multi-injection subcostal TAP blocks in patients undergoing laparoscopic cholecystectomy.

Study Design: A prospective, randomized, single-center, parallel-group clinical trial.

Setting: A tertiary referral center where patients underwent elective laparoscopic cholecystectomy.

Methods: Ninety adult patients (ASA I–III) scheduled for laparoscopic cholecystectomy were randomized into 3 groups: Group S received a single-injection unilateral subcostal TAP block, Group T received a multi-injection unilateral subcostal TAP block, and Group C received no block. Blocks were performed under ultrasound guidance with standardized anesthetic management. The primary endpoint was 24-hour tramadol consumption. Secondary endpoints included postoperative pain scores on the Visual Analog Scale (VAS), intraoperative remifentanil use, postoperative nausea and vomiting (PONV), rescue analgesic requirement, and patient satisfaction. Pain and adverse effects were assessed at 30 minutes and at one, 3, 6, and 24 hours after the procedure. Statistical comparisons were made using analysis of variance (ANOVA), Bonferroni correction, and logistic regression.

Results: Eighty-nine patients completed the trial. Both TAP groups demonstrated significantly reduced intraoperative remifentanil consumption compared with controls. At 24 hours, tramadol use was lowest in the multi-injection group, which also showed significantly lower VAS scores at one, 6, and 24 hours than did the single-injection and control groups ($P < 0.05$). Rescue analgesic requirements were markedly reduced in the multi-injection group, in which PONV incidence was also lowest (92% without PONV vs. 64% in the single-injection group and 52% in the control group; $P = 0.007$). Patient satisfaction was significantly higher in the multi-injection group, with a greater proportion reporting "very satisfied" ($P < 0.001$). No major complications were reported.

Limitations: The study's single-center design limited external generalizability. Dermatomal mapping of block spread was not performed, and long-term outcomes beyond 24 hours were not evaluated.

Conclusions: Both single- and multi-injection subcostal TAP blocks provided effective perioperative analgesia in laparoscopic cholecystectomy. The multi-injection technique demonstrated superior efficacy in pain control, opioid consumption reduction, and patient satisfaction. This type of TAP block may therefore be considered a valuable component of multimodal analgesia protocols for upper-abdominal surgery.

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The management of pain in laparoscopic cholecystectomy continues to evolve, and inadequate strategies adversely affect recovery and patient satisfaction (1). Contemporary practice favors multimodal analgesia to limit opioid exposure, reduce adverse effects, and target pain at its source (2).

The transversus abdominis plane (TAP) block is a regional analgesic technique in which a local anesthetic is deposited within the plane superficial to the transversus abdominis muscle to modulate abdominal and pelvic nociception. Among its approaches, the subcostal TAP block is particularly effective for upper-abdominal pain (3). Cadaveric studies indicate that, for an equivalent total volume, drug distribution differs between a single injection and multiple injections (4). Prior studies have shown that a bilateral single-injection subcostal TAP reduces perioperative opioid requirements in laparoscopic cholecystectomy (5-7). By contrast, a multiple-injection technique may produce a broader anesthetic spread and thereby enhance coverage in the target area. In addition, unilateral subcostal TAP blocks have provided effective analgesia with the advantage of lower injectate volumes (8,9).

Despite these considerations, clinical studies that directly compare single- and multiple-injection subcostal TAP techniques in laparoscopic cholecystectomy remain limited. The hypothesis of the present study was that dividing the subcostal injection into multiple points would improve local anesthetic distribution and result in superior postoperative analgesia to that provided by a single injection. Accordingly, this single-center randomized study evaluated perioperative pain, opioid consumption, postoperative nausea and vomiting (PONV), and patient satisfaction in individuals undergoing laparoscopic cholecystectomy who received unilateral subcostal TAP blocks via a single injection technique or a multi-injection technique. A no-block control group was included to allow comparison of the effects of both interventions.

Methods

This single-center, prospective, randomized, parallel group study was performed with the principles of the Declaration of Helsinki. Approval was accepted by the Ethics Committee of IMUGEAH (Date: 17.05.2018, No: 2018/0119) with the ClinicalTrials.gov database (No: NCT05826652). A total of 90 patients were enrolled in this study. To be included, each patients had to be 18 to 65 years of age, have a physical status that ranged from I to III in the American Society of Anesthesiologists' (ASA's) classification system, and be scheduled for laparoscopic cholecystectomy. Exclusion criteria encompassed a history of allergy to local anesthetics, chronic analgesic use, psychiatric disorders, renal or hepatic dysfunction, coagulopathy, a body mass index (BMI) > 40 kg/m², and pregnancy. Written informed consent was obtained from all patients prior to enrollment, and basic randomization into 3 groups was performed using the sealed-envelope method, meaning that group sequence number and group were selected by operation room technicians. Patients in Group S received a subcostal TAP block through a single injection, patients in Group T received a subcostal TAP block through multiple injections, and patients in Group C did not receive any form of block. All peripheral blocks were performed by a single experienced anesthesiologist. Perioperative follow-up was performed by a team independent of the study to eliminate bias. The patients, perioperative follow-up team, postoperative pain team, care provider, nurses, surgical team, and outcome assessors were blinded. The primary outcome was 24-hour tramadol consumption. Secondary outcomes were the postoperative pain score, perioperative remifentanil consumption, PONV, and patient satisfaction. The primary stopping criteria were hypotension, bradycardia, and drug reactions.

A priori power analysis was conducted using G*Power (version 3.1.9.4, University of Düsseldorf) to determine the required sample size for comparing 24-hour tramadol consumption among the 3 groups. A pilot study, including 10 patients per group, yielded mean tramadol consumptions of 115.1 mg (SD: 51.2) in Group S, 51.2 mg (SD: 36.6) in Group T, and 117.4 mg (SD: 27.0) in Group C. The largest standard deviation (51.2 mg) was used to estimate the effect size (Cohen's f = 0.5992) for a one-way ANOVA design. Based on this

effect size, with a significance level (α) of 0.05 and a desired power of 0.95, the analysis determined that a total of 48 patients (16 per group) would be required for statistically significant differences to be detectable. The achieved power with this sample size was 0.9578, ensuring sufficient sensitivity to detect meaningful differences in tramadol consumption across the study groups. To account for potential dropouts and further enhance statistical power, the final sample size was set to 25 patients per group, exceeding the minimum requirement of 16 per group calculated in the power analysis.

Standard monitoring protocols were implemented upon arrival in the operating theater, and heart rate (HR), mean arterial pressure (MAP), and peripheral oxygen saturation (SpO_2) were recorded during the operation. Anesthesia was induced using propofol (2 mg/kg) and fentanyl (1 μg/kg), and muscle relaxation was achieved with rocuronium (0.5 mg/kg). Once adequate muscle relaxation was confirmed, endotracheal intubation was performed, and mechanical ventilation was initiated with a respiratory rate of 10–14 breaths/min and a tidal volume of 6–8 mL/kg. Anesthesia was maintained using sevoflurane in a 50:50 air/oxygen mixture at a flow rate of 1 L/min. Intraoperative analgesia was provided through a remifentanil infusion at a rate of 0–0.2 μg/kg/min.

Prior to the initiation of surgery, the subcostal TAP block was administered to the patients in Groups S and T under sterile conditions, using ultrasound guidance (Samsung Ultrasound H60, Samsung). The linear probe facilitated visualization of the abdominal musculature.

Both the single- and multiple-injection techniques were performed with the in-plane technique, using a 50 mm 22G peripheral block needle (Stimuplex® A; B. Braun). A single injection of 20 mL of 0.25% bupivacaine was administered above the transversus abdominis muscle adjacent to the linea semilunaris to each patient in Group S. The patients in Group T were given 3 distinct injections: 10 mL of 0.25% bupivacaine above the transversus abdominis muscle adjacent to the linea semilunaris, 5 mL of 0.25% bupivacaine between the transversus abdominis and internal oblique muscles in the subcostal region above the midclavicular line, and 5 mL of 0.25% bupivacaine between the transversus abdominis and internal oblique muscles in the subcostal region above the anterior axillary line (Fig. 1).

Laparoscopic cholecystectomy was performed using 4 trocar placements on the right side of the abdomen. After their gallbladders were removed, all patients received intravenous tramadol (2 mg/kg) and metoclopramide (1 mg/kg). Postoperative analgesia was provided with a patient-controlled analgesia (PCA) device containing tramadol (2 mg/mL, 2 mL demand dose, 10 min lock time). Rescue analgesia consisted of intravenous acetaminophen (1 g) and tenoxicam (20 mg), respectively.

Assessments were conducted at 30 minutes and at one, 3, 6, and 24 hours after the procedure, with the parameters including pain, nausea, and total PCA consumption. Pain intensity was measured using the Visual Analog Scale (VAS; 0 cm = no pain, 10 cm = worst imaginable pain). Postoperative nausea and vomiting (PONV) were evaluated using a verbal descriptive scale (VDS) (0 = no PONV, 1 = mild PONV, 2 = moderate PONV, 3 = severe PONV) (10). Patient satisfaction was evaluated at discharge using a 5-point Likert scale (1 = strongly unsatisfied, 5 = strongly satisfied).

Complications, including infection, bleeding, and subcutaneous emphysema, were documented.

Statistical Analysis

Statistical analyses were conducted using the R programming language software version 4.3.1 (The R Foundation for Statistical Computing, 2024), with visualizations generated via the ggplot2 library. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. The chi-square test was employed for the analysis of categorical data. Binary relationships were evaluated using logistic regression. The normality of continuous data was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests. For normally distributed data, repeated-measures analysis of variance (ANOVA) and one-way ANOVA were employed, with post hoc comparisons performed using the Bonferroni test. Statistically significant results were defined as those with *P*-values less than 0.05.

Results

A total of 90 patients were recruited for the study; however, one patient declined to participate before the operation, resulting in a final sample size of 89. After that individual's decision to decline, the remaining 89 patients were randomized. One patient each in Group S and Group T was lost to follow-up due to open surgery, 2 patients in Group S due to haemorrhage at the injection site, and 2 patients in Group S and Group C due to unexpected, complicated surgery. In each of the 3 groups, follow-up was discontinued for one patient

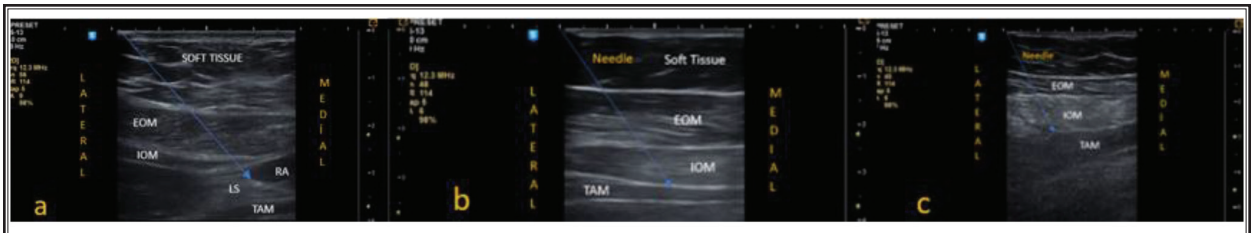


Fig. 1. *a. Local anesthetic was applied between the fascial planes of the transversus abdominis muscle with the rectus abdominis muscle just medial to the linea seminularis. In Group Single (S), the entire volume of the local anesthetic (0.25% 20 mL bupivacaine) was administered in this region. In Group Triple (T), half of the volume of local anesthetic (0.25% 10 ml bupivacaine) was administered in this region. b. One-quarter of the volume of local anesthetic (0.25% 5 ml bupivacaine) was administered between the fascial planes of the transversus abdominis muscle with the internal oblique muscle at the junction of the midclavicular line and the subcostal line for Group T. c. One-quarter of the volume of the local anesthetic (0.25% 5 mL bupivacaine) was administered between the fascial planes of the transversus abdominis muscle with the internal oblique muscle at the junction of the anterior axillary line and the subcostal line for Group T.*
Abbreviations: EOM, external oblique muscle; IOM, internal oblique muscle; TAM, transversus abdominis muscle; RAM, rectus abdominis muscle; LS, linea seminularis.

due to technical problems with the patient-controlled analgesia pump.

No statistically significant differences were observed in age, gender, weight, BMI ($P < 0.05$); however, ASA physical status II was found to be statistically significantly more prevalent in all groups ($P = 0.035$) (Table 1). The MAP and HR were found to be statistically similar among the groups during the operation (df =11.306; MS = 60.213; F = 0.418; $P = 0.949$, df = 8.456; MS = 73.791; F = 0.673; $P = 0.723$, respectively).

While perioperative remifentanil consumption was statistically significantly lower in Group S (0.20 ± 0.11 mg) and Group T (0.14 ± 0.09 mg) than in Group C (0.34 ± 0.30 mg) ($P = 0.037$, $P = 0.001$). The amounts of perioperative remifentanil consumption in Group S and Group T were statistically similar ($P = 0.754$) (Table 2).

When measured using Bonferroni-corrected pairwise comparisons, VAS scores at 30 minutes were significantly lower in Groups S and T than in C (S vs. C, $P < 0.001$; T vs. C, $P < 0.001$), with no difference between S and T ($P = 0.094$). At one hour, between-group differences were statistically significant, with T < S < C (all $P < 0.05$). At 3 hours, VAS scores in T were significantly lower than in C ($P = 0.011$), whereas the differences in S vs. C and S vs. T were not significant ($P = 0.081$ and $P = 1.000$). At 6 hours, the VAS score in T was significantly lower than in both S and C (S vs. T, $P = 0.024$; T vs. C, $P < 0.001$), with the difference between S and C not significant ($P = 0.086$). At 24 hours, scores in T remained significantly lower than in C ($P = 0.027$); other comparisons were not significant (Table 2; Fig. 2).

Bonferroni-corrected pairwise comparisons were also used to measure tramadol consumption. At 30 minutes, consumption of tramadol was highest in Group C, intermediate in Group S, and lowest in Group T (C > S > T), with significant differences between C and S ($P < 0.001$), C and T ($P < 0.001$), and S and T ($P < 0.002$). At one, 3, 6, and 24 hours postoperatively, Group T showed significantly lower tramadol consumption than did both Group S and Group C (both $P < 0.001$ at each time point) (Table 2; Fig. 3).

For the primary outcome, 24-hour tramadol consumption, a post hoc power analysis was performed, considering statistically significant differences among the 3 groups. The power was 0.878.

Statistically significant higher levels of rescue analgesia were observed in Group C than in the other groups ($P < 0.001$, $P = 0.001$; Table 3).

Rescue analgesic use was significantly lower in Group T (30 minutes: 16%; any rescue during follow-up: 36%; second rescue: 4%) than in Group S (30 minutes: 36%; any rescue: 72%; second rescue: 8%) and Group C (30 minutes: 96%; any rescue: 96%; second rescue: 40%) (Table 3). Using Bonferroni-corrected pairwise comparisons, the use of rescue analgesia at 30 minutes was significantly higher in C than in S and T (S vs. C, $P < 0.001$; T vs. C, $P < 0.001$), with the difference between S and T not significant ($P = 0.589$) (S 36%, T 16%, C 96%). For any use of rescue analgesia that took place over 24 hours after the procedure, the instances thereof in T were significantly lower than in C ($P < 0.001$), while the differences between S and T and between S and C were not significant ($P = 0.067$ and $P = 0.146$, respectively) (S 72%, T 36%, C 96%). In the number of patients who needed a second rescue dose, T was significantly lower than C ($P = 0.014$), whereas the differences in S vs. C

and S vs. T were not significant ($P = 0.054$ and $P = 1.000$) (S 8%, T 4%, C 40%).

The proportion of patients who did not experience PONV (grade 0) was highest in Group T (92%), followed by Group S (64%) and Group C (52%; $P = 0.007$). The proportion of patients with mild PONV (grade 1) was lowest in Group T (4%), trailed by Group S (32%) and Group C (40%; $P = 0.009$) (Table 3).

In all groups, high VAS values were found to be associated with high PONV scores in the relationship between PONV status and pain at 30 minutes after the procedure ($P < 0.001$). Logistic regression analysis indicates that this variable has a significant effect on the probability of PONV (Wald = 11.496, df = 1, $P < .001$). The coefficient of the thirtieth-minute VAS variable was found to be -0.620. Each one-unit increase in the thirtieth-minute VAS score has been shown to reduce the probability of PONV (0 nausea-vomiting) by up to 0.538 times (Exp(B) = 0.538, 95% confidence interval [0.376, 0.770]) (Fig. 4).

The patient satisfaction levels at 24 hours were predominantly in the range of "somewhat satisfied" in both Group S and Group C. In contrast, Group T exhibited a significantly higher proportion of patients who were "very satisfied" at 24 hours ($P < 0.001$) (Table 3).

Discussion

The present study evaluated the analgesic efficacy of the unilateral subcostal TAP block delivered as a single injection or as multiple injections in patients undergoing laparoscopic cholecystectomy. Both techniques reduced intraoperative remifentanil requirements from those associated with the control group and provided effective intraoperative analgesia. In addition, the multi-injection approach was associated with lower postoperative pain scores, reduced opioid use, and a lower incidence of PONV; patient satisfaction was also higher in the multi-injection group.

Previous reports indicate that per-

Table 1. *Baseline demographic data.*

		GS	GT	GC	*P*-value (a, b)
Age	M ± SD	50.00 ± 15.64	47.44 ± 17.27	53.56 ± 14.16	0.390
Weight	M ± SD	83.36 ± 13.96	80.24 ± 15.90	83.44 ± 13.17	0.670
BMI	M ± SD	31.45 ± 5.67	29.33 ± 4.83	29.37 ± 4.58	0.243
Gender					0.109
Female	N (%)	17 (68.0)	20 (80.0)	13 (52.0)	
Male	N (%)	8 (32.0)	5 (20.0)	12 (48.0)	
ASA					0.035*
ASA I	N (%)	4 (16.0)	8 (32.0)	1 (4.0)	
ASA II	N (%)	16 (64.0)	15 (60.0)	15 (60.0)	
ASA III	N (%)	5 (20.0)	2 (8.0)	9 (36.0)	

M, mean; SD, standard deviation; ASA, American Society of Anaesthesiologists; BMI: body mass index

a. *P*-values compare general anaesthesia alone to the combination of general anaesthesia and regional anaesthesia (single or triple injections).

b. Chi-square test *: $P < 0.05$.

Table 2. *Pain scores and opioid consumption.*

Dependent Variable			*P*-value (a, b)	
Perioperative Remifentanil Consumption	GS	GT	0.754	Control Group (GC) has a statistically significant difference.
		GC	0.037*	
	GT	GS	0.754	
		GC	0.001*	
	GC	GS	0.037*	
		GT	0.001*	
VAS at 30 mins	GS	GT	0.094	GC has a statistically significant difference.
		GC	< 0.001*	
	GT	GS	0.094	
		GC	< 0.001*	
	GC	GS	< 0.001*	
		GT	< 0.001*	
VAS at one hour	GS	GT	0.001*	All groups are statistically different from one another.
		GC	0.024*	
	GT	GS	0.001*	
		GC	< 0.001*	
	GC	GS	0.024*	
		GT	< 0.001*	
VAS at 3 hours	GS	GT	1.000	A statistically significant difference appears only between Group Triple (GT) and GC.
		GC	0.081	
	GT	GS	1.000	
		GC	0.011*	
	GC	GS	0.081	
		GT	0.011*	

Table 2 cont. *Pain scores and opioid consumption*.

Dependent Variable			*P*-value (a, b)	
VAS at 6 hours	GS	GT	0.024*	GT has a statistically significant difference.
		GC	0.086	
	GT	GS	0.024*	
		GC	< 0.001*	
	GC	GS	0.086	
		GT	< 0.001*	
VAS at 24 hours	GS	GT	1.000	A statistically significant difference appears between only GT and GC.
		GC	0.144	
	GT	GS	1.000	
		GC	0.027*	
	GC	GS	0.144	
		GT	0.027*	
Tramadol at 30 min	GS	GT	0.002*	All groups are statistically different from one another.
		GC	< 0.001*	
	GT	GS	0.002*	
		GC	< 0.001*	
	GC	GS	< 0.001*	
		GT	< 0.001*	
Tramadol at one hour	GS	GT	< 0.001*	GT has a statistically significant difference.
		GC	0.073	
	GT	GS	< 0.001*	
		GC	< 0.001*	
	GC	GS	0.073	
		GT	< 0.001*	
Tramadol at 3 hours	GS	GT	< 0.001*	GT has a statistically significant difference.
		GC	1.000	
	GT	GS	< 0.001*	
		GC	< 0.001*	
	GC	GS	1.000	
		GT	< 0.001*	
Tramadol at 6 hours	GS	GT	< 0.001*	GT has a statistically significant difference.
		GC	1.000	
	GT	GS	< 0.001*	
		GC	< 0.001*	
	GC	GS	1.000	
		GT	< 0.001*	
Tramadol at 24 hours	GS	GT	< 0.001*	GT has a statistically significant difference.
		GC	1.000	
	GT	GS	< 0.001*	
		GC	< 0.001*	
	GC	GS	1.000	
		GT	< 0.001*	

a. Bonferroni corrected in post-hoc t-test results. *: $P < 0.05$, **:$P < 0.001$
b. One-way ANOVA test.

forming a subcostal TAP block before incision reduces intraoperative analgesic requirements (10). In the present study, both the single-injection technique and the multi-injection technique decreased intraoperative remifentanil consumption.

Studies by Ozciftci (8) and Arik et al (9) likewise show that unilateral subcostal TAP provides effective postoperative analgesia during laparoscopic cholecystectomy. In the present study, in which trocar sites were exclusively right-sided, unilateral blocks were effective both intraoperatively and postoperatively.

The comparison aimed to improve simultaneous coverage of anterior and lateral intercostal branches relevant to the incision pattern. In the multi-injection technique, sequential deposits along the subcostal line target the anterior branches medially and allow lateral spread toward the lateral cutaneous branches; this phenomenon may be advantageous when lateral ports contribute substantially to pain. Compared with the single-injection technique, the multi-injection approach was associated with lower postoperative VAS values and reduced opioid consumption.

In laparoscopic cholecystectomy, procedure-specific postoperative pain management (PROSPECT) recommendations propose port-site wound infiltration with a long-acting local anesthetic or intraperitoneal instillation of diluted, high-volume local anesthetic as the first line of treatment, in addition to basic multimodal analgesia (acetaminophen plus an NSAID/COX-2 inhibitor) and intraoperative dexamethasone. Ultrasound-guided fascial plane, TAP, oblique subcostal transversus abdominis plane (OSTAP), or erector spinae plane (ESP) blocks are considered second-line for patients at higher risk of pain or when first-line measures are inadequate, recognizing technique variability, the need for expertise, and the potential for local-anesthetic systemic toxicity with larger volumes. Rectus sheath, quadratus lumborum, and paravertebral blocks (which have inconsistent benefits or

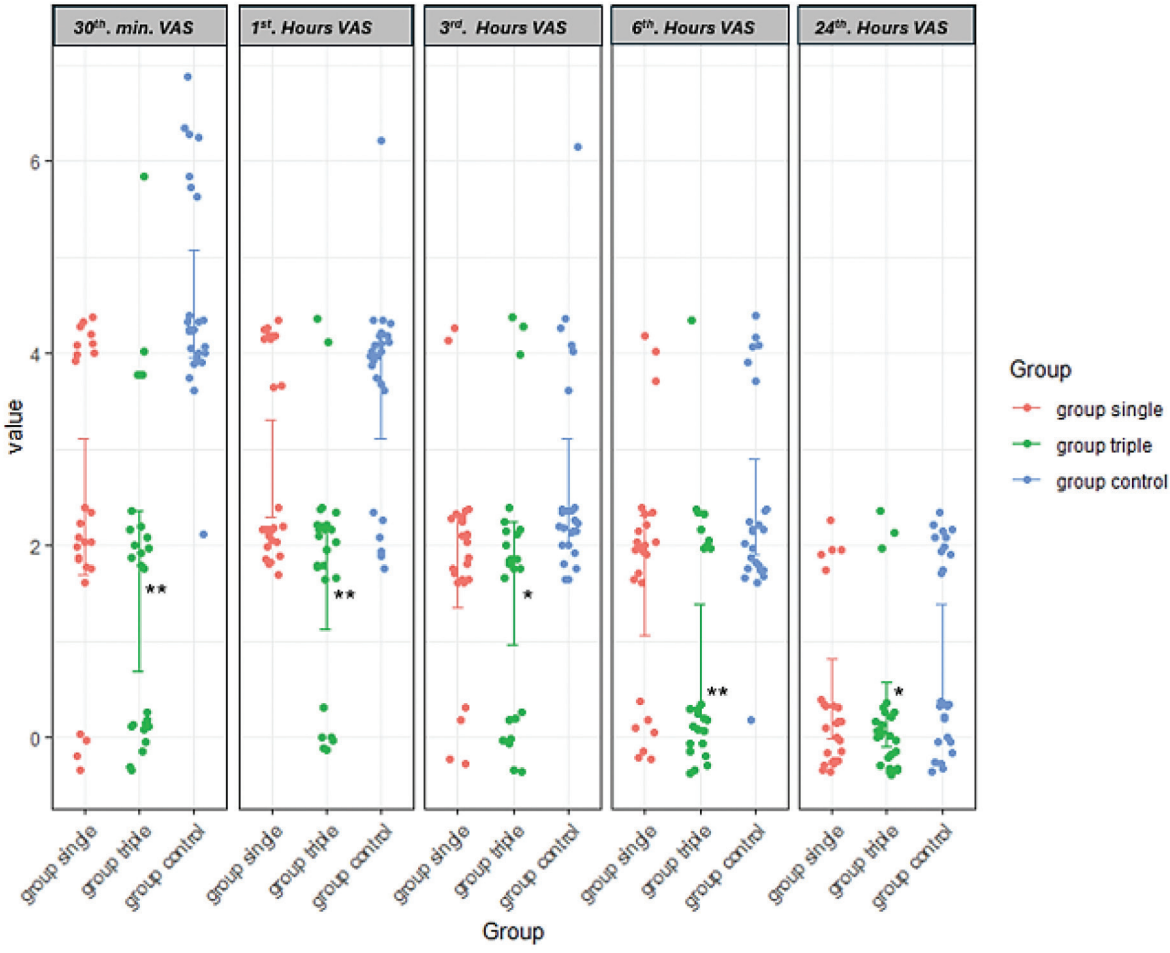


Fig 2. *a. Throughout all time points, VAS values for pain were found to be statistically significantly lower in Group T than in the other 2 groups in the assessment of pain. b. One-way analysis of variance (ANOVA) test.*
*: $P < 0,05$; **: $P < 0.001$. VAS, Visual Analog Scale.

less favorable risk profiles), like neuraxial techniques (which impose burdensome side effects), are not recommended for routine use. Combining port-site infiltration with intraperitoneal local anesthetic is discouraged due to the risk of overdosing. Opioids should be restricted to rescue procedures. This sequence supports effectiveness, simplicity, safety, and suitability for day-case surgery (2).

In fascial plane blocks, analgesia depends on local anesthetic spreading along the permeable planes formed by the hyaluronic acid (HA)-rich fascial interstitium and the collagen fiber network via pressure-driven bulk flow (hydrodissection) and extracellular matrix-mediated diffusion/interlayer sliding, thereby reaching nociceptors and small nerve branches within the plane; body-wide interstitial fluid/solute transport is a key determinant of this process. The aponeurotic fascia, with its thicker, tensile architecture, tends to retain injectate within the compartment, whereas the epimysial fascia is thinner/more fragile and influences spread and seepage differently. Fascia is rich in free nerve endings, and cellular elements such as fasciocytes (regulating interlayer gliding through HA synthesis) and telocytes (three-dimensional cellular communication/repair) contribute to tissue viscoelasticity and pain modulation. Individual variability arises from anatomical factors (fascial thickness/sub-layer architecture, lines of fusion, scarring), biochemical states (HA content/densification), patient factors (obesity, positioning, physical status), and technical variables (volume, rate,

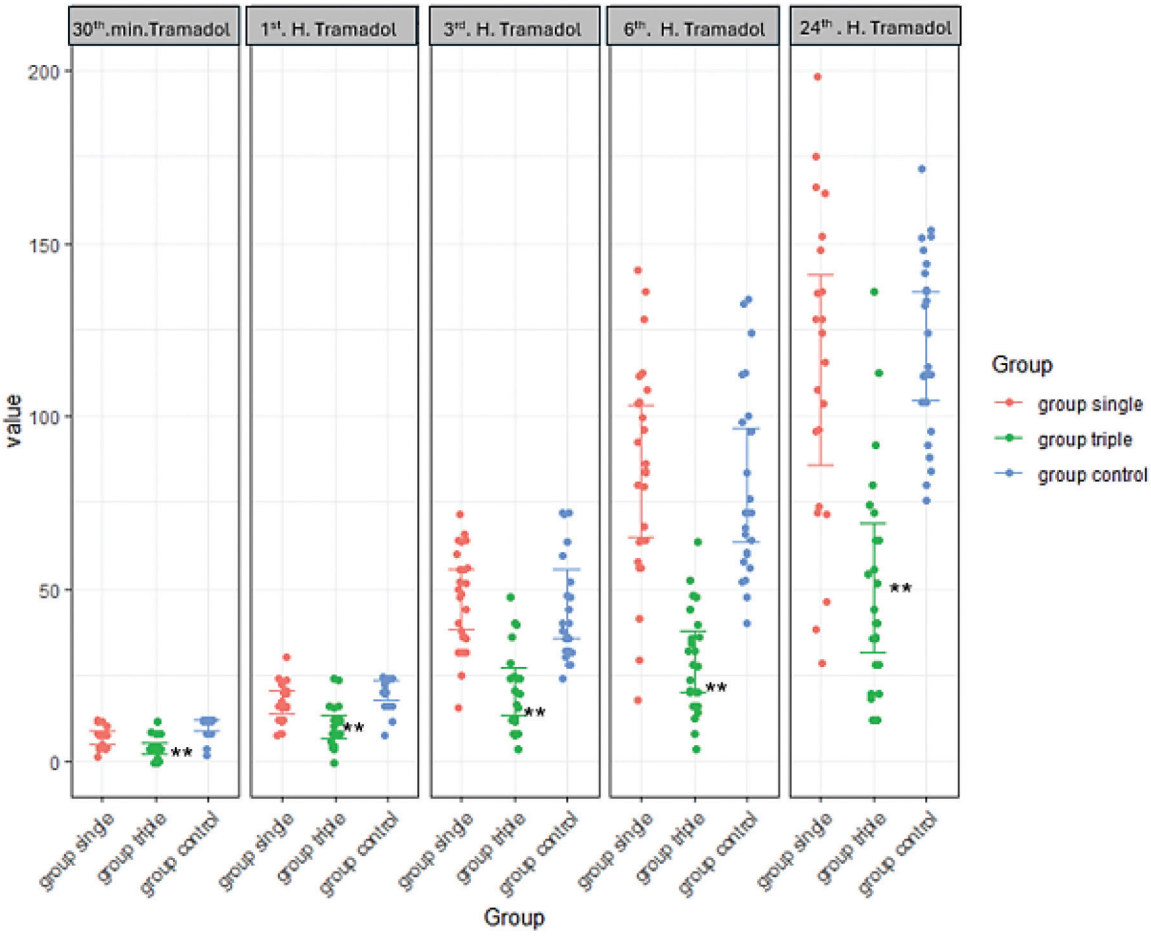


Fig. 3. *a. Throughout all time points, tramadol consumption was found to be statistically significantly lower in Group T than in the other 2 groups in the assessment of pain. b. One-way ANOVA test;*
*: P <0.05; **: P <0.001. Graphics of error bar.

direction, single–multiple injections), all of which alter an analgesic's dermatomal spread and duration of effect (11-13).

Among available options, the external oblique intercostal (EOI) plane block most reliably covers lateral and anterior upper-abdominal territories (≈T6–T10) and is advantageous when lateral ports predominate; the OSTAP block best covers anterior/paramedian segments (≈T6–T10) but often spares lateral branches; the modified thoracoabdominal nerve block through perichondrial approach (M-TAPA) primarily targets anterior branches (≈T6/7–T11/12). Block selection should align with port locations, the desired dermatomal field, and the need to include lateral cutaneous innervation (14,15). The ESP block can also provide combined anterior–lateral coverage through paravertebral spread; however, this block generally requires patient repositioning, which may limit routine use in day-case workflows (16,17). Targeting the thoracoabdominal nerves (T7–T11) appears optimal for laparoscopic cholecystectomy (18). In volunteers, bilateral subcostal TAP blocks that used 20 mL of 0.375% ropivacaine produced blockades of T7–T12 in the mid-abdomen, with variable T6 and L1 involvement, and effectiveness up to 22 hours (19). Other techniques in this region show a similar pattern: M-TAPA and exterior semilunaris transversus abdominis plane (SE-TAP) blocks have been associated with lower postoperative pain scores, less frequent uses of rescue analgesics, and a lower incidence of PONV (20-22). In a case series of SE-TAP blocks, sensory spread

Table 3. *Postoperative rescue analgesia, nausea-vomiting and patient satisfaction variables.*

			Group S	Group T	Group C	*P*-value (a, b)
Rescue analgesia (30 mins post-op)	N/A	N(%)	16 (64.0)	21 (84.0)	1 (4.0)	< 0.001**
	A	N(%)	9 (36.0)	4 (16.0)	24 (96.0)	
First rescue analgesia	N/A	N(%)	7 (28.0)	16 (64.0)	1 (4.0)	< 0.001**
	A	N(%)	18 (72.0)	9 (36.0)	24 (96.0)	
Second rescue analgesia	N/A	N(%)	23 (92.0)	24 (96.0)	15 (60.0)	0.001**
	A	N(%)	2 (8.0)	1 (4.0)	10 (40.0)	
PONV 0 (no PONV)	N/A	N(%)	9 (36.0)	2(8.0)	12 (48.0)	0.007*
	A	N(%)	16 (64.0)	23 (92.0)	13 (52.0)	
PONV 1 mMild PONV)	N/A	N(%)	17 (68.0)	24 (96.0)	15 (60.0)	0.009*
	A	N(%)	8 (32.0)	1 (4.0)	10 (40.0)	
Patient satisfaction at 24 hours	Undecided	N(%)	3 (12.0)	1 (4.0)	6 (24.0)	< 0.001**
	Somewhat satisfied	N(%)	15(60.0)	6 (24.0)	17 (68.0)	
	Very much satisfied	N(%)	7 (28.0)	18 (72.0)	2 (8.0)	

a. *P*-value compares general anaesthesia alone to the combination of general anaesthesia and regional anaesthesia (single or triple injections). *: $P < 0.05$, **: $P < 0.001$.
b. Chi-square test.
N/A: not available; A: available; PONV: postoperative nausea and vomiting

from approximately T6–T7 to T11–T2 anteriorly and to the posterior axillary line for 24 hours was described (22). Three-dimensional computerized tomography of volunteers showed that a 25-mL SE-TAP injectate reached the anterior and lateral abdominal walls and the costal margin and spread along the semilunaris (23). However, a study has reported a limited effect of the subcostal TAP block on postoperative pain after laparoscopic cholecystectomy (24).

In the present study, single- and triple-injection subcostal TAP blocks provided similar analgesia for up to 3 hours, whereas the effect of the triple-injection technique persisted to 24 hours. Although tramadol use at 30 minutes was similar between the single-injection technique and the control group, both TAP groups required less rescue analgesia than the control group during follow-up. Notably, the M-TAPA application site corresponds to the second injection site, and the SE-TAP site corresponds to the first injection site in our multi-injection protocol; in our study, these were applied unilaterally and with lower volumes of local anesthetic.

Chronic pain literature also notes that, after viscerosomatic mechanisms develop, the pain component may shift towards the abdominal wall as myofascial pain, and clinicians can use subcostal TAP blocks as diagnostic adjuncts in selected cases (25,26). In pain practice, clinicians also use TAP injections with steroids as an option for treating chronic abdominal pain that remains resistant to standard management (26,27). Also, some studies recommend adding adjuvants (e.g., steroids in chronic pain series and morphine in subcostal TAP trials) to extend the duration of analgesia (27,28).

In the present study, the multi-injection OSTAP technique provided longer-lasting analgesia than the classic single-injection approach. Therefore, this strategy, with or without adjuvants, may provide prolonged and effective analgesia in refractory chronic pain. This possibility may be particularly relevant when the pain has a suspected myofascial abdominal wall component.

After laparoscopy, PONV is common due to both the surgery itself and perioperative opioid use (29). The present study showed lower PONV incidence in the multi-injection group, which may reflect both the direct analgesic effect of the block and opioid sparing; additionally, our logistic regression demonstrated an inverse association between pain intensity and PONV, suggesting that effective pain control may favor recovery. These results align with prior reports of lower PONV rates seen in association with regional techniques (30,31). Patient satisfaction was higher in the multi-injection group, likely reflecting better pain control, fewer opioid-related adverse effects, and less PONV.

Limitations

Post-block dermatomal mapping (pinprick/cold testing) was not performed, so sensory spread could

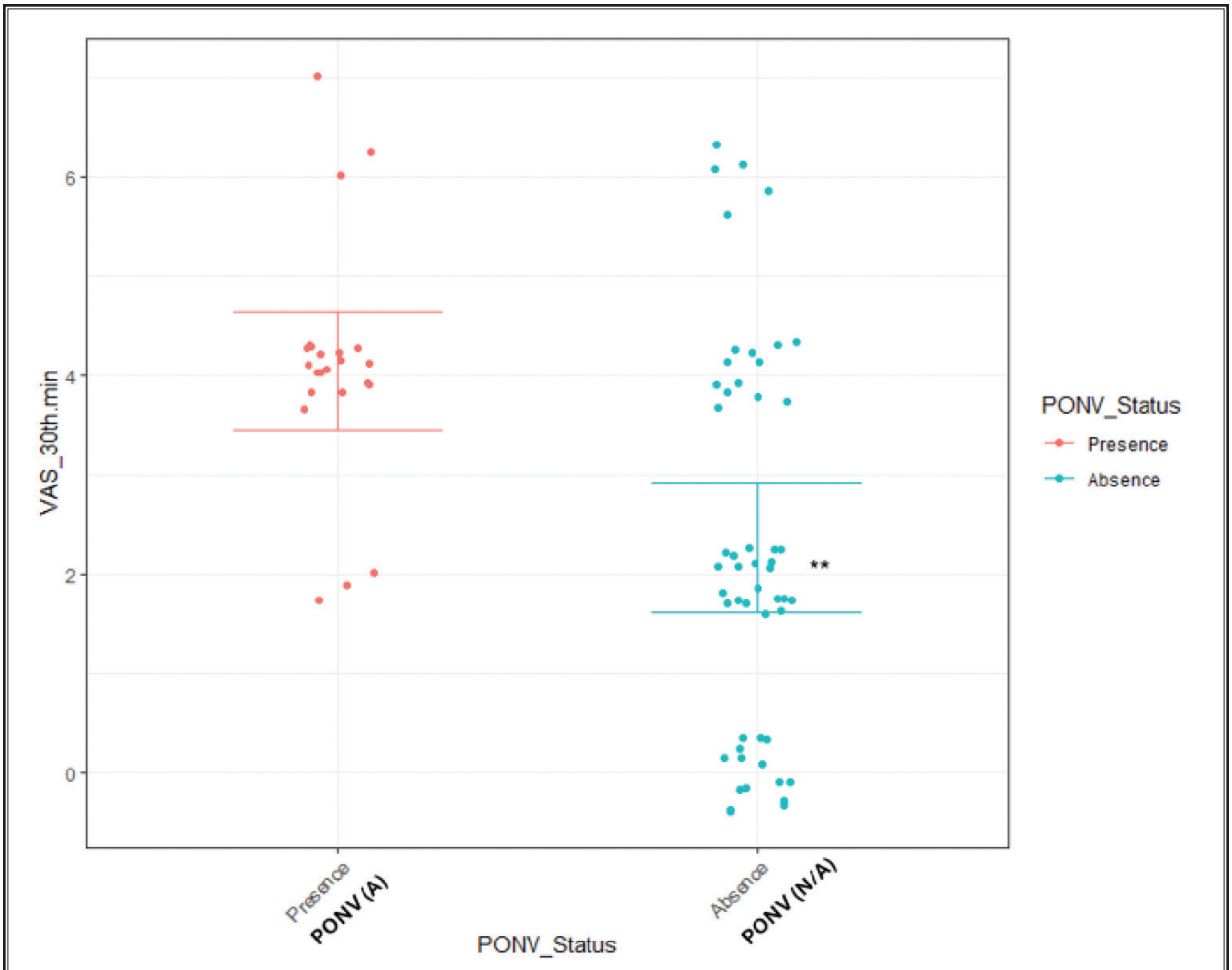


Fig. 4. *a. It has been determined that individuals experiencing PONV have higher VAS scores. b. Independent samples t-test.* *: $P < 0,05$ **; $P < 0.001$. A: available; N/A: not available; VAS 30th. Min, postoperative 30th minute Visual Analog Scale score. PONV: postoperative nausea and vomiting.

not be objectively verified. Visceral pain was not specifically measured; thus, visceral and somatic contributions to postoperative pain could not be distinguished. Pain outcomes were based on the VAS, a subjective metric; objective technologies such as analgesia–nociception indices, pupillometry, skin conductance, and HR variability were not used. The single-center design limits generalizability; confirmation in multicenter cohorts is warranted. Outcomes focused on the early postoperative period and did not assess longer-term pain control or functional recovery. Finally, although the multi-injection subcostal TAP block offered improved analgesia, the technique required more time and operator expertise than its single-injection counterpart.

Conclusion

In laparoscopic cholecystectomy, unilateral subcostal TAP blocks administered as multiple injections provided better analgesia, lower opioid consumption, and higher patient satisfaction than did the single-injection technique and the absence of a block. Within the framework of PROSPECT recommendations and considering the dermatomal characteristics of current fascial plane techniques, the multi-injection subcostal TAP block appears to be a practical, incision-site–focused option that can be performed on a supine patient and is compatible with enhanced recovery after surgery principles. These findings support the use of the multi-injection subcostal TAP block as an effective

perioperative analgesic strategy for upper-abdominal surgery.

Author Contributions

Conceptualization by Mesure Gul Nihan Ozden and Ebru Girgin Dinc; methodology by Mesure Gul Nihan Ozden and Ebru Girgin Dinc; formal analysis and investigation by Mesure Gul Nihan Ozden and Ebru Girgin Dinc; original draft preparation by Mesure Gul Nihan Ozden; reviewing and editing by Mesure Gul Nihan Ozden and Ebru Girgin Dinc.

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