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Modified Thoracoabdominal Nerves Block Through the Perichondrial Approach vs Subcostal Transversus Abdominis Plane Block for Postoperative Recovery After Laparoscopic Cholecystectomy: A Prospective, Randomized Clinical Trial

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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: This study compared the effects of ultrasound-guided modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA) and subcostal transversus abdominis plane (TAP) block on postoperative recovery after laparoscopic cholecystectomy.

Material/Methods: Sixty patients aged 18-65 years with American Society of Anesthesiologists physical status I-II undergoing elective laparoscopic cholecystectomy under general anesthesia were included. At the end of surgery, patients were randomly assigned to receive either ultrasound-guided subcostal TAP block (group T, n=30) or M-TAPA block (group M, n=30), with 20 mL of 0.25% bupivacaine administered on each side. Primary outcome was postoperative recovery at 24 hours (Quality of Recovery-15 [QoR-15] questionnaire). Secondary outcomes included postoperative pain scores (numerical rating scale [NRS]) at 0, 2, 4, 8, 16, and 24 hours, rescue analgesic requirements, and postoperative adverse effects.

Results: The groups were comparable in age, height, weight, duration of surgery, and anesthesia-related variables (all $P>0.05$). Twenty-four-hour QoR-15 scores were similar between groups ($P>0.05$). Likewise, NRS pain scores did not differ significantly between groups ($P>0.05$). Significantly fewer patients required rescue analgesia in group M than in group T (30.0% vs 60.0%, $P=0.020$). Total rescue analgesic dose did not differ between groups ($P=0.943$). Postoperative adverse effects were comparable ($P>0.05$).

Conclusions: In patients undergoing laparoscopic cholecystectomy, ultrasound-guided M-TAPA block did not provide superior postoperative recovery, as assessed by QoR-15, compared with subcostal TAP block. Nevertheless, significantly fewer patients in the M-TAPA group required rescue analgesia (30.0% vs 60.0%, $P=0.020$), although total rescue analgesic consumption was similar between the groups.

Keywords: Analgesia • Cholecystectomy, Laparoscopic • Anesthesia • Anesthesia and Analgesia • Anesthesia, Local

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Introduction

Although laparoscopic cholecystectomy causes less tissue injury and allows faster recovery than open surgery, postoperative pain remains a clinically meaningful problem, arising from somatic (trocar sites), visceral (pneumoperitoneum), and referred shoulder components [1]. Adequate analgesia after laparoscopic procedures therefore requires a multimodal management plan.

For postoperative analgesia in laparoscopic procedures, the Procedure-Specific Postoperative Pain Management (PROSPECT) recommendations endorse regional anesthesia methods together with non-opioid agents [2]. Beyond delivering adequate pain control, such combined strategies can lower opioid requirements and, in turn, help avoid opioid-associated complications, including emesis, queasiness, and excessive somnolence. In particular, postoperative nausea and vomiting (PONV) is among the most common and distressing complications after laparoscopic cholecystectomy and is closely associated with opioid consumption; reducing opioid requirements through effective regional analgesia may therefore lower its incidence. Accordingly, PONV was prospectively recorded as part of the secondary safety outcomes in the present trial.

Among the regional methods available, the subcostal transversus abdominis plane (TAP) block has gained extensive use for analgesia of the anterior abdominal wall during upper-abdominal procedures. Its sensory distribution, however, is not always reliable; coverage of the lateral abdominal wall in particular tends to differ between individuals, which may attenuate the analgesic benefit experienced by certain patients [3].

An alternative fascial plane technique, the modified thoracoabdominal nerves block via the perichondrial approach (M-TAPA), has been proposed with the intent of producing a more extensive thoracoabdominal distribution of local anesthetic. From an anatomical standpoint, M-TAPA has been hypothesized to extend coverage to both the anterior and lateral cutaneous branches of the thoracoabdominal nerves more effectively than the subcostal TAP block. Whether this theoretical wider coverage actually yields tangible gains in patient-reported recovery, however, is yet to be conclusively demonstrated. Although prior investigations have addressed the impact of these blocks on pain intensity and opioid requirement, evidence regarding patient-reported recovery outcomes remains scarce, and head-to-head comparisons between M-TAPA and subcostal TAP block have produced conflicting findings [4].

Postoperative recovery has traditionally been evaluated using objective clinical outcomes, such as complication rates and length of hospital stay. However, these parameters may not fully reflect the patient's subjective recovery experience or perceived well-being. Therefore, patient-centered and validated assessment tools have gained increasing importance. The Quality of Recovery-15 (QoR-15) questionnaire is a brief, reliable, and practical instrument that evaluates recovery from the patient's perspective. Its strong psychometric properties, ease of completion, and high response rates support its use in both clinical practice and research. Moreover, its validity is supported by its association with postoperative complications, operative duration, hospital stay, and patient-reported global recovery scores [5].

Although prior trials have directly compared the M-TAPA and subcostal TAP blocks in laparoscopic cholecystectomy, these studies have predominantly focused on analgesic outcomes, such as pain intensity and opioid consumption, while patient-reported recovery assessed with a validated instrument has received comparatively limited attention. Heterogeneity across surgical settings, perioperative analgesic protocols, and selected primary endpoints further constrains the generalizability of previous findings. The present randomized clinical trial was therefore designed as a confirmatory and incremental head-to-head comparison of the 2 techniques, intended to clarify whether, as part of multimodal analgesia following laparoscopic cholecystectomy, the anatomically proposed wider thoracoabdominal coverage of the M-TAPA block translates into superior patient-reported postoperative recovery, using the QoR-15 questionnaire as the primary endpoint. We postulated that, by virtue of its more extensive thoracoabdominal sensory coverage, the M-TAPA block would yield superior recovery quality compared with the subcostal TAP block. Prespecified secondary endpoints included pain intensity quantified on a numerical rating scale (NRS), total rescue analgesic dose, and the frequency of opioid-associated adverse events, such as emesis, nausea, sedation, hypersensitivity reactions, and any block-related complications.

Material and Methods

Study Design and Ethics

The present prospective, single-institution randomized clinical trial was conducted in compliance with the ethical principles set forth in the Declaration of Helsinki. Each enrolled participant was provided with detailed information about the study, and written informed consent was obtained before participation. Ethical clearance was granted by the Bursa City Hospital Ethics Committee, University of Health Sciences (decision No. 2023-14/10), and authorization was issued by the Turkish Pharmaceuticals and Medical Devices Agency (E-66175679-514.13.02-1236827). The trial is registered on https://clinicaltrials.gov/ with the identifier NCT06198335. Patients were enrolled between January 20, 2024, and August 10, 2025 at

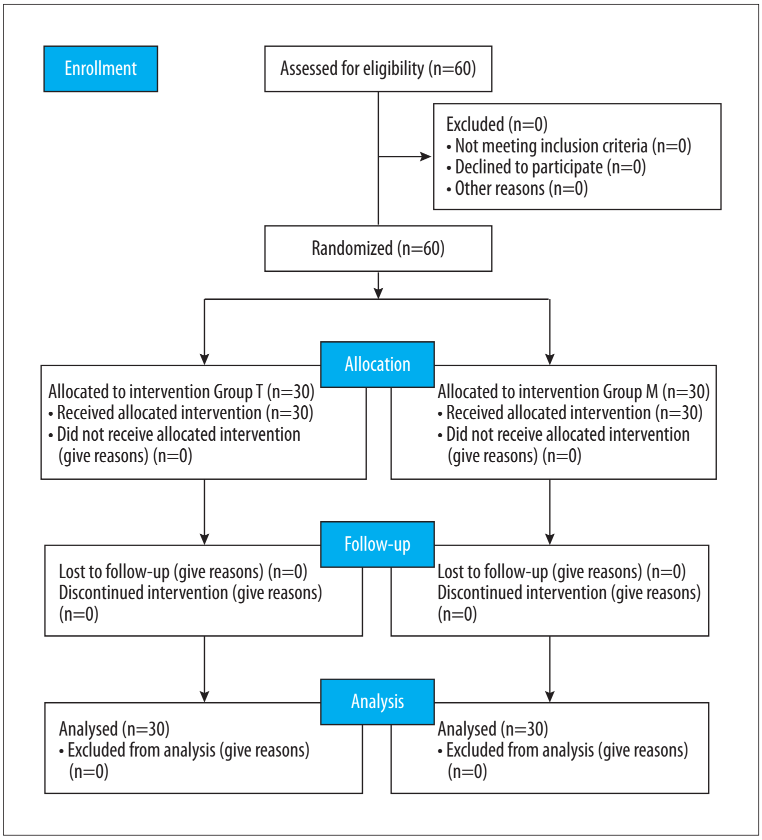

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram of the study.

Bursa City Hospital. Enrollment, allocation, and follow-up of participants are summarized in the Consolidated Standards of Reporting Trials (CONSORT) flow diagram (**Figure 1**).

Eligibility Criteria

Eligible participants were adults aged 18 to 65 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, who were scheduled for elective laparoscopic cholecystectomy under general anesthesia. Patients were excluded if they declined participation, had any contraindication to regional anesthesia, presented with cognitive impairment that would interfere with NRS assessment, had a documented history of allergy or hypersensitivity to local anesthetic agents, were under treatment for a psychiatric disorder or taking psychotropic medications, had a hematological or oncological diagnosis, had severe failure of a major organ system, had alcohol or drug dependence, or had taken any analgesic within the 12 hours preceding surgery.

Randomization, Allocation, and Blinding

Sixty participants were assigned in equal numbers to 1 of 2 groups: the subcostal TAP block group (group T, n = 30) or the M-TAPA group (group M, n = 30). Allocation followed a computer-generated randomization sequence, concealed in sealed opaque envelopes, prepared by a clinician who took no further part in patient management. The allocation envelope was handed to the regional-anesthesia practitioner by independent staff who were uninvolved in the trial. Both the patients and the investigator collecting perioperative data were kept unaware of the assigned intervention. Postoperative assessments were conducted by a separate pain-management nurse who was likewise blinded to group allocation.

Anesthesia and Surgical Management

During the preoperative visit, each patient received a standardized verbal explanation by an anesthesiologist of the planned regional technique (subcostal TAP or M-TAPA) and of how to use the NRS and the QoR-15 questionnaire; no written materials, such as leaflets, were provided. On the patient's arrival in the operating room, routine intraoperative monitoring was instituted, including electrocardiography, pulse rate, noninvasive arterial pressure measurement, and pulse oximetry (SpO2). Premedication consisted of intravenous (IV) midazolam 0.03 mg/kg. Following 3 minutes of preoxygenation through tidal-volume breathing, an experienced anesthesiologist induced anesthesia using IV lidocaine 1 mg/kg, propofol 2 to 2.5 mg/kg titrated until loss of the eyelash reflex, rocuronium 0.6 mg/kg, and fentanyl 2 μg/kg. Tracheal intubation followed induction. Mechanical ventilation was delivered

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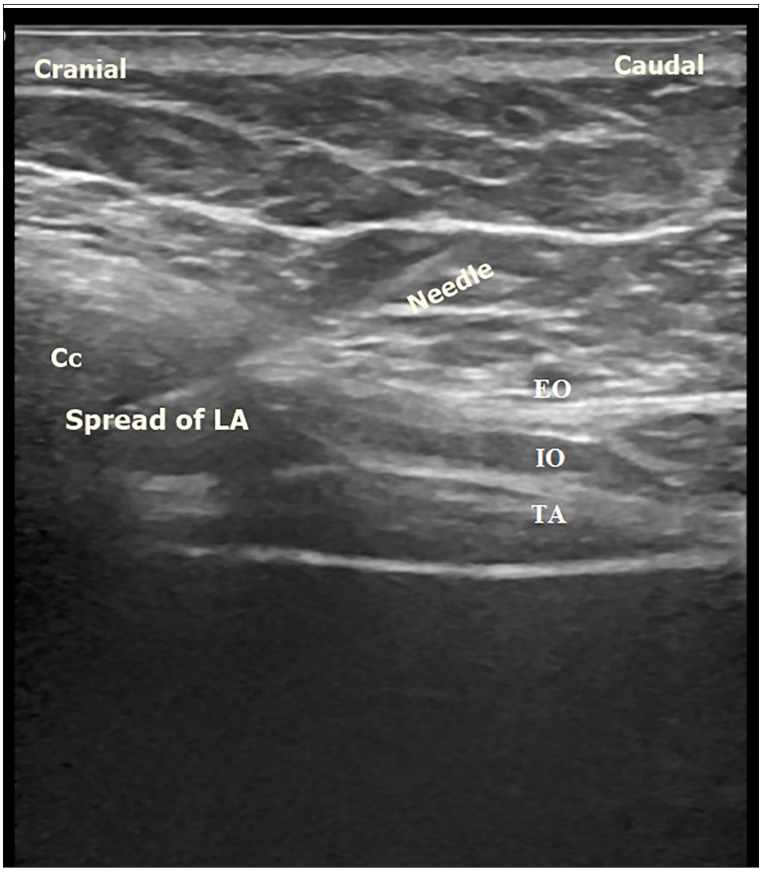

Figure 2. Sonographic anatomy of the modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA) block. The arrows indicate the needle direction. Abbreviations: Cc, costal cartilage; EO, external oblique; IO, internal oblique; TA, transversus abdominis; LA, local anesthetic.

in volume-controlled mode at a tidal volume of 8 mL/kg, with end-tidal CO_2 kept between 35 and 40 mm Hg. Anesthesia was sustained with sevoflurane (1.0-2.0 MAC) in a 50: 50 mixture of oxygen and air. All operations were performed laparoscopically. Intra-abdominal pressure during pneumoperitoneum was capped at 12 mm Hg with insufflated CO_2. The same surgical team conducted every procedure following a standardized operative technique. At the conclusion of surgery, with the patient still in the supine position, the allocated regional block, either subcostal TAP or M-TAPA, was performed. An anesthesiologist proficient in ultrasound-guided regional techniques delivered 20 mL of 0.25% bupivacaine on each side. Following the block, patients emerged from anesthesia and transferred to the postanesthesia care unit, where they remained until reaching an Aldrete score of at least 9, after which they were sent to the surgical ward.

Postoperative Analgesia and Rescue Medication

Standard postoperative analgesia consisted of paracetamol 1 g IV for every patient, with concomitant ondansetron 4 mg IV administered prophylactically against PONV. Scheduled multimodal analgesia comprised IV paracetamol 1 g (Perfalgan) every 8 hours and IV tenoxicam 20 mg every 12 hours in both groups. When an NRS rating of 4 or higher was reported at any postoperative time point, IV meperidine 0.5 mg/kg was administered as rescue analgesia. In this study, rescue analgesia requirement was defined as the proportion of patients who received at least 1 rescue dose during the first 24 postoperative hours, whereas the total rescue analgesic dose was defined as the cumulative amount of meperidine administered during the same period.

M-TAPA Technique

After standard skin antisepsis, a sterile cover was placed over a high-frequency linear ultrasound probe (11-12 MHz, Vivid Q). The block was conducted with an 80-mm needle (Braun, 360°). The transducer was positioned in the sagittal plane at the intersection of the costal cartilage with the midclavicular line. Under in-plane ultrasound guidance, 5 mL of sterile saline was first injected to confirm the correct interfascial location between the inferior border of the costal cartilage and the transversus abdominis muscle (**Figure 2**). After confirmation of needle position, 20 mL of 0.25% bupivacaine was deposited bilaterally to complete the block.

Subcostal TAP Block Technique

Following sterile preparation, a high-frequency linear ultrasound probe (11-12 MHz, Vivid Q) was covered in a sterile sleeve, and

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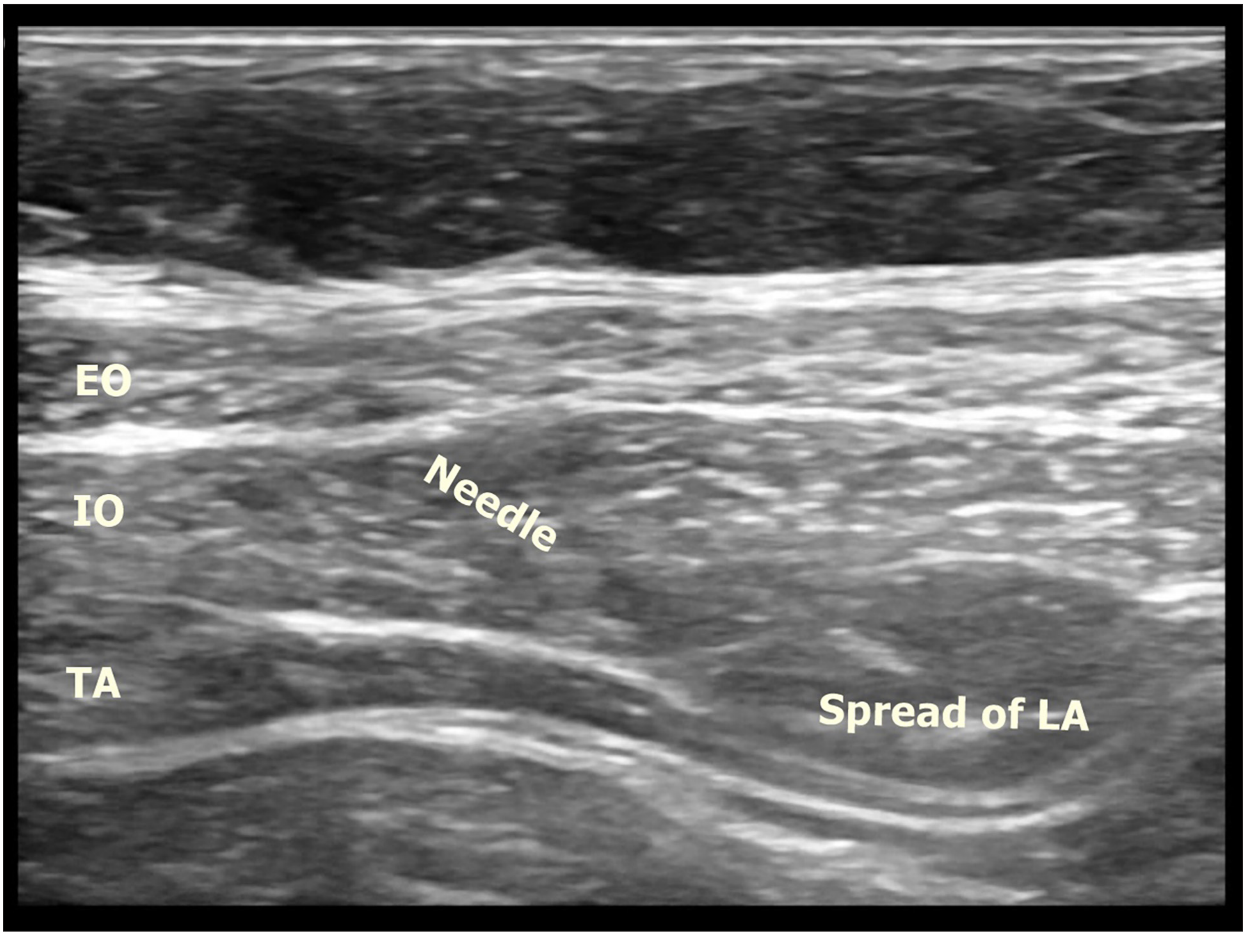

Figure 3. Sonographic anatomy of the subcostal transversus abdominis plane (TAP) block. The arrows indicate the needle direction. Abbreviations: Cc, costal cartilage; EO, external oblique; IO, internal oblique; TA, transversus abdominis; LA, local anesthetic.

the block was conducted with an 80-mm needle (Braun, 360°). With the probe oriented transversely along the subcostal fascial plane, the cutaneous and subcutaneous layers, the 3 abdominal muscle planes, and the underlying peritoneum were sonographically identified. The needle was then advanced in-plane toward the fascial interface separating the internal oblique from the transversus abdominis. Correct positioning was verified with 5 mL of saline, after which 20 mL of 0.25% bupivacaine was administered bilaterally to complete the procedure (**Figure 3**).

Postoperative Assessment

Pain intensity at rest and during activity was self-reported by patients at 0, 2, 4, 8, 16, and 24 hours postoperatively, using a 0-10 NRS on which 0 denoted no pain and 10 denoted the worst conceivable pain. Other parameters recorded during follow-up included the rescue analgesia requirement, the total rescue analgesic dose administered, the occurrence of nausea, vomiting, or pruritus, and any block-related complications. Patient-perceived recovery quality was assessed by administering the QoR-15 questionnaire at 24 hours after surgery.

Statistical Analysis

Sample-size estimation was based on QoR-15 data from a pilot cohort (group M [n = 7]: 127.72 ± 8.67; group T [n = 7]: 109.13 ± 15.33), which corresponded to a between-group mean difference of 18.59 QoR-15 points, a pooled standard deviation of 12.45, and a Cohen's d of approximately 1.49. With a 2-sided α of 0.05 and a planned power of 99% ($\beta = 0.01$), the power calculation indicated that a minimum of 18 patients per group would be required (G*Power version 3.1.9.7). As the pilot cohort was small (n = 7 per group), the resulting effect-size estimate was acknowledged to be subject to imprecision; therefore, allowing for potential dropouts and to provide additional robustness against deviation from the pilot-derived effect size, recruitment was set at 30 patients per group.

The distribution of continuous data was examined by means of the Shapiro-Wilk and Kolmogorov-Smirnov tests. Variables conforming to a Gaussian distribution were summarized as mean ± standard deviation (SD), while those that did not were reported as median (minimum-maximum). Given the ordinal

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Table 1. Demographic and perioperative characteristics of the study groups: Group M: modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA); and Group T: subcostal transversus abdominis plane (TAP) block.

	Group M (n = 30)	Group T (n = 30)	*P* value
Sex, female/male	22/8	21/9	0.774
Age	54 (23-65)	58 (31-65)	0.197
Height	163.9 ± 8.1	167.9 ± 8.9	0.077
Weight	74.7 ± 15.9	79.0 ± 14.9	0.283
ASA (I/II)	2/28	7/23	0.145
Duration of surgery (min)	45 (30-120)	40 (25-125)	0.229
Duration of anesthesia (min)	57.5 (35-135)	50 (35-140)	0.121

Data are presented as mean ± standard deviation, median (minimum-maximum), or number (%), as appropriate. Between-group comparisons were performed using the Pearson chi-square test, Fisher exact test, independent samples *t* test, and Mann-Whitney U test, as appropriate.

nature of NRS ratings, these were chiefly described using median values. Categorical data were tabulated as frequencies and percentages (n [%]). For comparisons of independent continuous variables between groups, the independent samples *t* test was applied when assumptions of normality and equal variance were met; variance equality was checked with the Levene test. Otherwise, the Mann-Whitney U test was used.

The pre-specified primary endpoint was the QoR-15 score 24 hours after surgery. Between-group QoR-15 comparisons employed either the independent samples *t* test or the Mann-Whitney U test, in accordance with the underlying distribution. Secondary endpoints were postoperative NRS scores at rest and on movement, the rescue analgesia requirement, the total rescue analgesic dose administered, and adverse events after surgery. NRS values at each time point were contrasted between groups by means of the Mann-Whitney U test, with effect size expressed as the Hodges-Lehmann median difference (M-TAPA - TAP) accompanied by 95% confidence intervals. Within-subject NRS change scores (ΔNRS [24-2], ΔNRS [24-0], and ΔNRS [24-4]) were also assessed using the same approach. The Holm correction was applied only to the pre-specified family of within-subject NRS change-score comparisons (ΔNRS [24-2], ΔNRS [24-0], and ΔNRS [24-4]), performed separately for the rest and movement domains. The primary endpoint (QoR-15) involved a single comparison and was therefore not subjected to multiplicity adjustment, and the remaining secondary outcomes are reported with uncorrected *P* values. Categorical variables were tested with the Pearson chi-square or Fisher exact test, depending on cell counts. SPSS version 26.0 (IBM Corp, Armonk, NY, USA; released 2019) was used for all analyses, with a 2-sided type I error rate of 5% adopted as the threshold for statistical significance.

Results

Sixty patients were enrolled in total and divided equally between the 2 study groups: 30 in group M and 30 in group T. Baseline demographic and intraoperative characteristics were well-balanced between the groups. Sex distribution, age, height, weight, ASA physical status, surgical duration, and anesthesia duration showed no between-group differences of statistical significance ($P > 0.05$) (**Table 1**).

With respect to the primary endpoint, recovery quality at 24 hours as captured by the QoR-15 questionnaire did not differ between the 2 groups. Median QoR-15 scores were 118.5 (range 58-138) in group M vs 119.5 (range 80-138) in group T ($P = 0.847$). On the other hand, the rescue analgesia requirement was significantly smaller in group M than in the comparator group: 9 patients (30.0%) needed rescue medication in group M against 18 (60.0%) in group T ($P = 0.020$). However, the total rescue analgesic dose administered did not differ significantly between groups ($P = 0.943$) (**Table 2**).

Concerning postoperative pain, the only statistically significant between-group difference in passive NRS was observed at hour 0, when group M reported a lower median value than group T: 1 (0-3) vs 3 (1-4) ($P = 0.021$). At all subsequent time points (2, 4, 8, 16, and 24 hours), passive NRS values were comparable between groups ($P > 0.05$). Active NRS scores likewise showed no statistically significant between-group differences at any postoperative interval ($P > 0.05$) (**Table 3**).

Comparison of within-patient NRS change scores between groups did not reveal any statistically significant differences after Holm correction. For passive NRS, an unadjusted analysis

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Table 2. Comparison of Quality of Recovery-15 (QoR-15) scores, total rescue analgesic dose and rescue analgesia requirement between the 2 groups: Group M: modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA); and Group T: subcostal transversus abdominis plane (TAP) block.

	Group M (n=30)	Group T (n=30)	Effect estimate (95% CI)	*P* value
QoR-15	118.5 (58-138)	119.5 (80-138)	0 (-9 to 8)[a]	0.847
Total rescue analgesic dose (mg)	0 (0-100)	30 (0-100)	—[b]	0.943
Rescue analgesia requirement (yes/no)	9/21	18/12	RR 0.50 (0.28-0.94)[c]	0.020

Data are presented as median (minimum-maximum) or number, as appropriate. Continuous variables were compared using the Mann-Whitney U test and categorical variables using the Pearson chi-square test. [a] Hodges-Lehmann median difference modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA - TAP) with 95% CI. [b] Effect estimate not reported because the outcome is strongly zero-inflated (most patients received no rescue analgesia). [c] Relative risk (RR) of requiring rescue analgesia, M-TAPA vs TAP.

Table 3. Comparison of numerical rating scale (NRS) scores between the 2 groups: Group M: modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA); and Group T: subcostal transversus abdominis plane (TAP) block.

	Group M (n=30)	Group T (n=30)	P value
NRS PASSIVE hour 0	1 (0-3)	3 (1-4)	0.021
NRS PASSIVE hour 2	2 (1-3)	2.5 (2-4)	0.361
NRS PASSIVE hour 4	2 (1-3)	2 (2-3)	0.625
NRS PASSIVE hour 8	2 (1-3)	2 (1-3)	0.794
NRS PASSIVE hour 16	2 (1-2)	2 (1-3)	0.667
NRS PASSIVE hour 24	2 (1-2)	2 (1-2)	0.956
NRS ACTIVE hour 0	0 (0-4)	2 (0-4)	0.808
NRS ACTIVE hour 2	3.5 (3-5)	3 (1-4)	0.242
NRS ACTIVE hour 4	3 (2-5)	3 (1-4)	0.140
NRS ACTIVE hour 8	3 (2-4)	3 (2-5)	0.657
NRS ACTIVE hour 16	3 (2-4)	3 (1-4)	0.591
NRS ACTIVE hour 24	2.5 (1-3)	3 (1-3)	0.902

Data are presented as median (25-75). Between-group comparisons were performed using the Mann-Whitney U test.

suggested a nonsignificant trend favoring group M for the 24-0 hour change (Hodges-Lehmann median difference: 1; 95% CI: 0-2; $P=0.013$); statistical significance was lost once Holm correction was applied (adjusted $P=0.052$). The corresponding comparisons at 24-2 and 24-4 hours yielded no significant differences in passive NRS change between groups. Similarly, active NRS change scores across all examined intervals were comparable in the 2 groups after correction (**Table 4**).

Adverse events occurred at low and broadly similar rates in both groups. Postoperative nausea was documented in 7 patients (23.3%) in group M and in 13 patients (43.3%) in group T; this difference did not reach statistical significance ($P=0.100$). Vomiting affected an identical proportion in each group, with 5 patients (16.7%) in each group, yielding $P>0.99$. Pruritus was reported in only 1 patient (3.3%) and only in the subcostal group T, with no occurrences in group M; the difference was not statistically meaningful ($P>0.99$). No block-related complications, including local anesthetic systemic toxicity,

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Table 4. Comparison of changes in numerical rating scale (NRS) scores between the 2 groups: Group M: modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA); and Group T: subcostal transversus abdominis plane (TAP) block.

	Group M (n=30)	Group T (n=30)	HL median difference (M-TAPA - TAP), 95% CI	*P* value	Adjusted *P* value (Holm)
Δ passive NRS 24-0	0 (-1 to 1)	-1 (-2 to 0)	1 (0 to 2)	0.013	0.052
Δ passive NRS 24-2	-0.5 (-1 to 0)	-1 (-2 to 0)	0 (0 to 1)	0.219	0.230
Δ passive NRS 24-4	-1 (-1 to 0)	-1 (-1 to 0)	0 (0 to 1)	0.633	1.000
Δ active NRS 24-0	0 (-2 to 2)	0 (-2 to 3)	0 (-1 to 1)	0.947	1.000
Δ active NRS 24-2	-1 (-2 to 0)	0 (-2 to 1)	-1 (-2 to 0)	0.115	0.230
Δ active NRS 24-4	-1 (-2 to 0)	-0.5 (-2 to 0)	0 (-1 to 0)	0.196	0.588

Data are presented as median (25-75). Δ = NRS at 24 hours - NRS at the earlier time point; negative values indicate a reduction in pain score. Between-group comparisons were performed using the Mann-Whitney U test. Effect size is expressed as the Hodges-Lehmann (HL) median difference with 95% CI. Holm-adjusted *P* values were computed within the pre-specified family of within-subject NRS change-score comparisons (ΔNRS [24-2], ΔNRS [24-0], and ΔNRS [24-4]), performed separately for the rest and movement domains.

Table 5. Comparison of adverse effects between the 2 groups: Group M: modified thoracoabdominal nerves block through the perichondrial approach (M-TAPA); and Group T: subcostal transversus abdominis plane (TAP) block.

	Group M (n=30)	Group T (n=30)	Effect estimate (95% CI)	*P* value
Nausea (Y/N)	7/23	13/17	RR 0.54 (0.27-1.16)	0.100
Vomiting (Y/N)	5/25	5/25	RR 1.00 (0.34-2.92)	>0.99
Pruritus (Y/N)	0/30	1/29	NA	>0.99
Block-related complications (Y/N)	0/30	0/30	NA	NA

Values are numbers. Between-group comparisons were performed using the Pearson chi-square test and Fisher exact test, as appropriate. Effect estimates are relative risks (RR), M-TAPA vs TAP. RR not estimable owing to zero events in the M-TAPA group; risk difference -3.3% (95% CI -16.7% to 8.3%). Y, yes; N, no; NA, not applicable.

hematoma, intravascular injection, peritoneal puncture, or injection-site infection, were observed in either group throughout the study period (**Table 5**).

Discussion

In this prospective, randomized trial, the M-TAPA block did not provide superior quality of recovery compared with the subcostal TAP block: QoR-15 scores at 24 hours were similar between the groups (median 118.5 vs 119.5; *P*=0.847). Postoperative NRS pain scores and total rescue analgesic consumption were likewise comparable. The principal between-group difference was that significantly fewer patients in the M-TAPA group required rescue analgesia (30.0% vs 60.0%; *P*=0.020). Thus, although the 2 blocks yielded comparable patient-reported recovery and overall analgesic demand, M-TAPA reduced the number of patients who required supplementary opioids.

Pain following laparoscopic cholecystectomy can be attributed to 3 principal sources: somatic discomfort generated at the cutaneous surgical incisions, intra-abdominal visceral pain stemming from operative manipulation and excision of the gallbladder, and shoulder pain produced by diaphragmatic irritation during pneumoperitoneum. The visceral component of postoperative pain is especially prominent and is driven by inflammation of the peritoneum, tissue injury at the operative site, regional acidosis, and ischemia of the visceral mucosa, all consequences of elevated intra-abdominal pressure during CO2 insufflation [6].

The published literature suggests that the M-TAPA block can offer analgesic advantages in patients having laparoscopic cholecystectomy. In a study by Erten et al, laparoscopic surgery patients receiving M-TAPA experienced reduced opioid intake, lower static and dynamic pain ratings, and improved postoperative QoR-15 results [7]. Comparable findings were described by Güngör et al, who showed that the M-TAPA block decreased the need

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for analgesics and reduced opioid usage, while simultaneously enhancing QoR-15 scores in laparoscopic cholecystectomy patients [8]. Beyond these individual reports, a meta-analysis comparing M-TAPA with alternative fascial plane blocks in this surgical population highlighted favorable effects on postoperative pain levels, opioid intake, and the incidence of nausea and vomiting [9].

The subcostal/transversus abdominis plane (TAP) block, on its own, has also been associated with diminished opioid use and faster recuperation following laparoscopic cholecystectomy. Grape et al found that the TAP block produced clear reductions in both pain scores and opioid consumption after surgery [10]. Dai et al similarly reported lower opioid consumption, while Shim et al observed that the TAP block decreased the requirement for additional analgesics and led to better QoR-15 scores [11,12]. In addition, a pooled analysis of 1983 patients concluded that the TAP block exerted more favorable effects on early postoperative pain management and on patient satisfaction [13].

When directly compared, the M-TAPA and TAP techniques have generally produced equivalent results in terms of postoperative pain ratings and opioid usage following laparoscopic cholecystectomy. In line with this, Bilge et al observed comparable postoperative recovery as reflected by QoR-15 scores between patients given M-TAPA and those given the TAP block [14]. One plausible explanation for the absence of a clear advantage of either block over the other, whether in pain scores, opioid use, or recovery quality, is that the spread of local anesthetic with both approaches is predominantly anteromedial and shows limited lateral extension.

A noteworthy and seemingly paradoxical observation was the dissociation between the proportion of patients requiring rescue analgesia and the total rescue dose: fewer M-TAPA patients needed any rescue medication (30.0% vs 60.0%; $P=0.020$), yet the cumulative dose was virtually identical ($P=0.943$). Because rescue meperidine was administered as a fixed weight-based bolus (0.5 mg/kg) whenever NRS scores reached 4 or above, the total dose reflects both the number of patients treated and the number of repeated boluses per patient. A similar cumulative dose despite fewer treated patients suggests that the minority of M-TAPA patients who did require rescue tended to need repeated doses, whereas in the TAP group more patients each required comparatively fewer doses. This pattern is consistent with M-TAPA providing adequate analgesia in most patients but, owing to inter-individual variability in the spread of the block failing in a small subset, the subcostal TAP block more often leaves patients with borderline analgesia requiring a single top-up. Supporting this interpretation, Genç et al reported that the M-TAPA block generated more reliable sensory blockade across the epigastric, periumbilical, and mid-abdominal areas in laparoscopic cholecystectomy [15]. In a comparative evaluation of the subcostal TAP block and M-TAPA, Cho et al attributed the comparable clinical outcomes of the 2 blocks to a relatively restricted lateral spread of M-TAPA [16], and Ohgoshi et al demonstrated that an M-TAPA block delivered at the tenth costal cartilage failed to extend to the lateral cutaneous branches [17]. Importantly, the lower proportion of patients requiring rescue is itself clinically relevant, as it reduces opioid decision points, nursing workload, and patient exposure to opioid-related adverse effects even when the aggregate dose is unchanged. As rescue analgesia was a secondary endpoint for which the trial was not powered, these observations should be regarded as hypothesis-generating.

Neither the M-TAPA nor the subcostal TAP block produces paravertebral spread, which restricts their efficacy against visceral pain. This limitation may, in part, account for the comparable clinical outcomes seen between the 2 methods in the present study. It is worth noting, however, that the difference in pain scores recorded at hour 0 fell only marginally above the conventional significance threshold once Holm correction had been applied to control the type I error inherent in multiple testing (uncorrected $P=0.013$; corrected $P=0.052$), which positions the observation as statistically borderline despite its clinical visibility. Furthermore, since QoR-15 was the primary endpoint of this trial, the early pain difference might reasonably be regarded as a secondary observation. Differences in the temporal onset of analgesia between the 2 techniques may also play a role in explaining this early disparity. Reports indicate that the M-TAPA block establishes sensory block at the T7 dermatome in approximately 70% to 90% of patients within 30 minutes [18], whereas the subcostal TAP block reaches 100% T7 sensory block at the equivalent interval [19]. In our protocol, the initial postoperative evaluation was generally conducted within 30 minutes of attaining an Aldrete score above 9, so the small differential observed at hour 0 may simply reflect differences in the spread and onset characteristics of the 2 blocks.

Limitations

Several methodological limitations of this work warrant acknowledgment. To begin with, all data were collected at a single institution, and the external validity of the findings may therefore be restricted. Larger sample sizes and multicenter studies may be needed. Second, performance of the blocks under general anesthesia made it impractical to objectively confirm block success or to map dermatomal sensory distribution. Third, the trial did not include a control group without regional anesthesia, which prevented the absolute quantification of the analgesic contribution made by each block. Fourth, anatomical variability among individuals can influence the spread of local anesthetic, and given the inherently multifactorial character of postoperative pain, it remains challenging to isolate the exact analgesic contribution of either block. In operations such

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as laparoscopic cholecystectomy, in which pain originates from several distinct sources, embedding these blocks within a multimodal analgesic protocol may well optimize overall pain control. Finally, the sample-size calculation was derived from a small pilot cohort of only 7 patients per group, in which a large between-group difference in QoR-15 was observed (127.72±8.67 vs 109.13±15.33); effect-size estimates from such small samples are inherently imprecise and prone to overestimation, so the true effect may have been smaller than assumed, and the trial may have been underpowered to detect modest but clinically meaningful differences in QoR-15, meaning a type II error cannot be excluded. Larger, adequately powered and ideally multicenter trials are therefore warranted to confirm these findings and to detect smaller between-group differences that the present sample size may have been unable to reveal.

Conclusions

In summary, in patients undergoing laparoscopic cholecystectomy, the M-TAPA and subcostal TAP blocks were associated with broadly similar clinical outcomes in terms of postoperative analgesia and recovery quality. Therefore, both techniques may be used as part of a multimodal pain management strategy, according to clinician preference. Future research incorporating direct assessment of block spread patterns and dermatomal sensory mapping will contribute to a clearer understanding of these findings.

Department and Institution Where Work Was Done

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Informed Consent

Written informed consent was obtained from the patients enrolled in the study.

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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