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ORIGINAL INVESTIGATION

Efficacy of modified thoracoabdominal nerve block through perichondrial approach following laparoscopic inguinal hernia repair surgery: a randomized controlled trial

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Abstract

Background: Modified thoracoabdominal nerve block through perichondrial approach is a novel fascial plane block and provides abdominal analgesia by blocking thoracoabdominal nerves. Our primary aim was to evaluate the efficacy of M-TAPA on quality of recovery and pain scores in patients who underwent laparoscopic inguinal hernia repair surgery (Trans Abdominal Pre-Peritoneal approach – TAPP).

Methods: Patients with American Society of Anesthesiologists (ASA) physical status I—II aged between 18 and 65 years scheduled for elective TAPP under general anesthesia were enrolled in the study. After intubation, the patients were randomized into two groups: M: M-TAPA group (n = 30) and the control group (n = 30). M-TAPA was performed with total 40 ml 0.25% bupivacaine in the M group. Surgical infiltration was performed in the control group. The primary outcome of the study was the global quality of recovery score, the secondary outcomes were pain scores, rescue analgesic demands, and adverse effects during the 24-h postoperative period.

Results: The global quality of recovery scores at 24 h were significantly higher in the M group ($p < 0.001$). There was a reduction in the median static and dynamic NRS for the first postoperative 8 h in the M group compared to the control group ($p < 0.001$). The need for rescue analgesia was significantly lower in the M group compared to the control group (13 patients vs. 24

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respectively, $p < 0.001$). The incidence of side effects was significantly higher in the control group ($p < 0.001$).
Conclusion: In our study, M-TAPA increased patient recovery scores, and provided pain relief in patients who underwent TAPP.
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Introduction

There are several methods of regional anesthesia for managing postoperative pain after abdominal surgeries.[1,2] Recently, Tulgar et al. defined that thoracoabdominal nerves through the perichondrial approach (TAPA) block reach a wider dermatomal area than other techniques such as Transversus Abdominis Plane (TAP) block, Oblique Subcostal TAP (OSTAP) block, and serratus intercostal plane block (SIPB).[3] After defining the TAPA block, Tulgar et al. modified it as the modified-TAPA (M-TAPA) block.[4] While TAPA is performed on both the upper and lower aspects of the costochondral chondrium at the 9^{th}–10^{th} costal levels, M-TAPA is performed only on the lower aspect of the chondrium at the same level under Ultrasound (US) guidance.[3,4] By injecting local anesthetic to the lower aspect of the costochondrium, M-TAPA targets T4/T5-T12/L1 thoracoabdominal nerves.[3-5] It provides abdominal analgesia by blocking anterior and lateral cutaneous branches.[2-6] Although there are reports about the analgesic efficacy of M-TAPA for minor and major abdominal surgeries,[3-11] randomized studies are limited.

Inguinal hernia repair surgery is one of the most common surgeries (15% of general surgery procedures).[11] Laparoscopic surgery is commonly used for inguinal hernia repair since the laparoscopic technique is minimally invasive and has a lower complication rate than open surgery.[12] Although the laparoscopic technique has these advantages, patients may have moderate-to-severe pain after surgery. Pain usually occurs because of factors such as port incision sites and insufflation into the abdominal cavity.[12,13] Therefore, pain control after laparoscopic inguinal hernia repair surgery (Trans Abdominal Pre-Peritoneal approach – TAPP) is an important issue.[11] Several regional anesthesia techniques may be used to achieve this goal.[1,2] However, there is no study on the efficacy of M-TAPA for pain management after TAPP.

In this prospective trial, we aimed to evaluate the efficacy of US-guided M-TAPA block in patients who underwent TAPP and investigate its impact on patient recovery and pain management compared with the periportal infiltration control group.

Methods

Study design

This was a single-center, prospective, and randomized trial. Ethical approval for this trial was provided by the Ethics and Research Committee of Istanbul Medipol University (06.01.2022, decision n°34). The study was registered with clinical trials.gov (NCT05199922). American Society of Anesthesiologists (ASA) physical status I–II patients aged between 18 and 65 years scheduled for elective TAPP under general anesthesia were enrolled in the trial. The study and block procedure were explained to the participants, and they signed a written informed consent. The Consolidated Standards of Reporting Trials (CONSORT) flow diagram chart was used for patient enrollment (Fig. 1). The study was performed at the Medipol University Hospital between January and July 2022. The exclusion criteria were bleeding diathesis, anticoagulant treatment, local anesthetics or opioid allergy, infection at the block area, refusal of the procedure, and inability to understand or use the verbal-rated pain-scoring system and Quality of Recovery-40 (QoR-40) questionnaire.

General anesthesia application

The patients were monitored with electrocardiography, non-invasive blood pressure, and pulse oximetry in the operation room. Propofol, fentanyl, and rocuronium intravenous (IV) were used for anesthesia induction (respectively; 2–2.5 mg.kg^{-1}, 1–1.5 μg.kg^{-1}, and 0.6 mg.kg^{-1}). Sevoflurane was used for anesthesia maintenance in a mixture of oxygen and fresh air and remifentanil infusion (0.01–0.1 μg.kg^{-1}.min^{-1}). All patients underwent unilateral/bilateral TAPP with the same procedure. Ibuprofen (400 mg) and tramadol (100 mg) were administered intravenously to all patients thirty minutes before the end of the surgery for multimodal analgesia. The patients were given 4 mg ondansetron for nausea and vomiting prophylaxis. Patients were extubated at the end of the operation and transferred to the Postanesthesia Care Unit (PACU).

Grouping and randomization

After intubation, the patients were randomly allocated into two groups: M: M-TAPA group (n = 30) and the periportal infiltration control group (n = 30). Randomization was performed using a computerized randomization program. A randomization table was created, and each patient enrolled in the study was assigned a random ID. All patients were blinded to the study. The postoperative outcome evaluations were performed by a blinded pain nurse anesthetist. The pain nurse anesthetist recorded the postoperative pain scores, need for rescue analgesia, rate of adverse events, and QoR-40 scores of the patients.

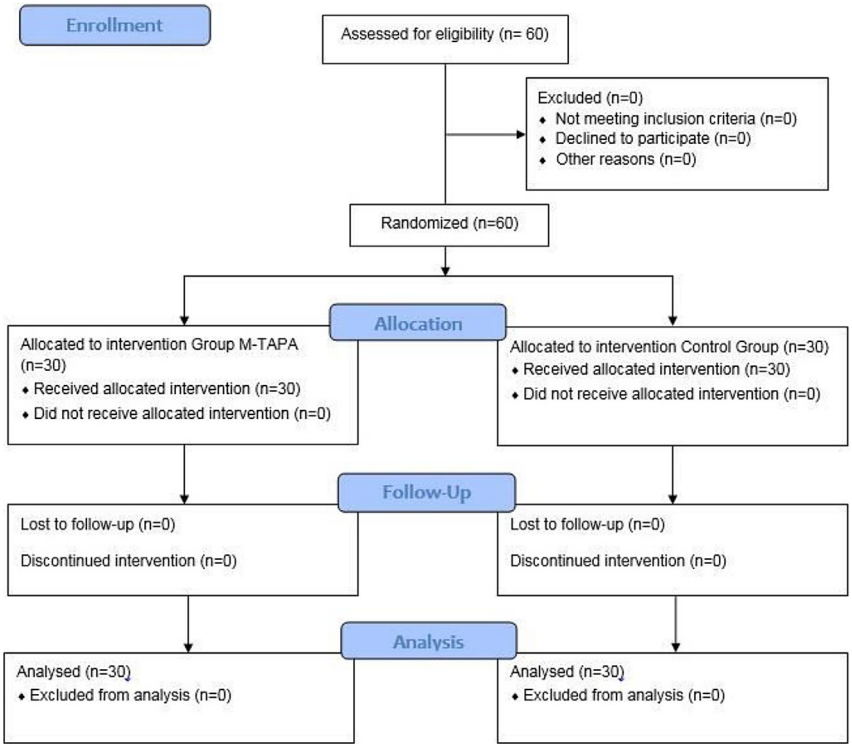

Figure 1 CONSORT flow diagram of the study.

Block procedure: M-TAPA technique

M-TAPA was performed at the end of the surgery before extubation. Under aseptic conditions, a high-frequency linear transducer (11—12 MHz) was used for the block procedure. The probe was placed on the costochondral angle in the sagittal plane.[4,6] It was slightly angled deeply to visualize the lower view of the perichondrium centrally (Fig. 2). A 22G × 80 mm block needle (Braun Stimuplex Ultra 360, Germany) was inserted. The needle tip was placed under the chondrium, and 5 ml saline was injected for correction. Twenty ml of 0.25% bupivacaine was injected into the lower aspect of the chondrium (Fig. 3). The same process was performed on the opposite side (in total, 40 ml of a local anesthetic).

In the periportal infiltration control group, the surgeon injected a dose of 0.25% bupivacaine (20 ml) around the incisional site ports.

Postoperative analgesia management and outcomes

Patients were administered ibuprofen 400 mg IV every 8 h in the postoperative period. Postoperative pain evaluation was performed by using the 11-point Numerical Rating Scale (NRS) (0 - meaning "no pain" to 10 - meaning "worst pain imaginable"). NRS (static-at rest/dynamic-while movement) was assessed at 0 (PACU), 2nd, 4th, 8th, 16th, and 24th hours. If the NRS was ≥4, patients received 1 mg.kg^{-1} tramadol IV as rescue analgesia.

The primary outcome of the study was the global quality of recovery score. We used the Turkish version of the 40-item Questionnaire (QoR-40) for the study. We evaluated the QoR-40 24 h postoperatively.

The secondary outcomes were the NRS scores, rescue analgesic demands, and adverse effects recorded during the 24-h postoperative period. The rescue analgesia demand was assessed as "used" or "not used" (yes/no). The incidence of nausea/vomiting/itching was assessed as "yes" or "no."

Sample size and statistical analysis

The sample size of the study was calculated using the G*Power program (V.3.1.9). We performed a preliminary study with 16 patients in our department. The power analysis was based on QoR-40 scores, which was the primary outcome of the study. In a previous study,[14] there was a difference of 10 points in QoR-40 scores between groups, and the authors accepted it as clinically meaningful. The mean of QoR-40 scores of the preliminary study was 154 points with SD = 8.35. Assuming α error = 0.05 (two-tailed) and β error = 0.01 with a power of 0.99, at least 27 patients for each group were required to acquire statistical significance. We included 30 patients per group, considering possible dropouts.

IBM SPSS Statistics for Windows (Version 22.0; IBM Corp., Armonk, NY, USA) was used for statistical analyses. The data distribution was analyzed with The Shapiro-Wilk test. The categorical data (gender, ASA physical status, rescue analgesic usage, incidence of adverse effects) were compared with the Pearson Chi-Square test between groups. Student's *t*-test was used to control for differences between the groups at the 5% significance level for the normally distributed

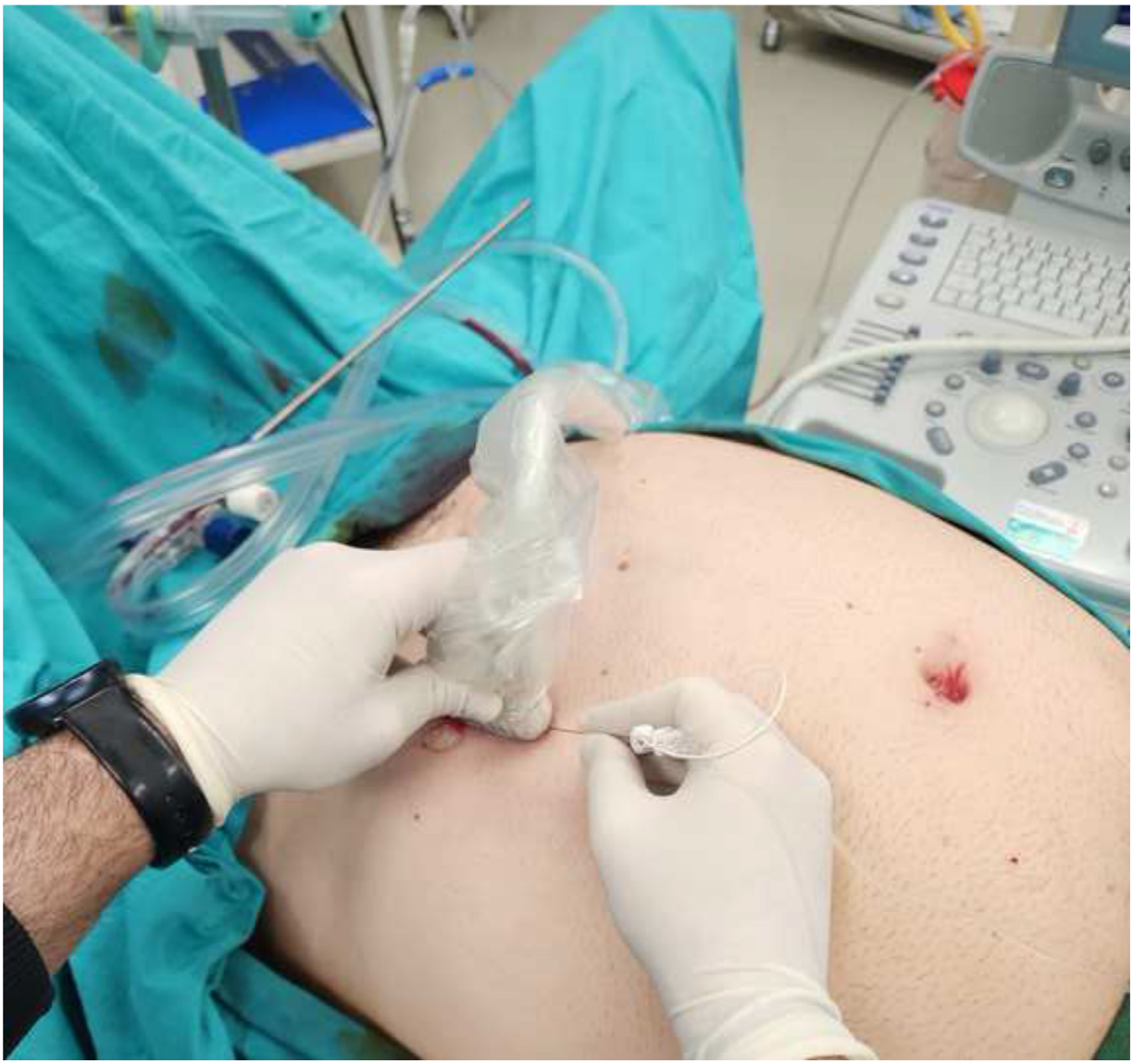

Figure 2 Patient and probe position during M-TAPA.

continuous variables (demographic data and duration times of surgery and anesthesia, and QoR-40). The Mann-Whitney U test was used for data without normal distribution (NRS). The statistical significance threshold was $p < 0.05$. Bonferroni correction was used for the analysis of NRS. Statistical significance was adjusted to $p < 0.0083$ due to measurements from six time points.

Results

Sixty patients were recruited, with 30 allocated randomly to each group during the study period (Fig. 1 CONSORT). There were no differences between groups in terms of demographic data, surgery type (unilateral/bilateral), and operation and anesthesia times (Table 1).

The static and dynamic NRS scores were significantly lower in group M compared to the periportal infiltration control group at the first postoperative 8 h ($p < 0.001$) (Table 2). There was a significant difference in terms of mean QoR-40 scores between groups. The mean QoR-40 score was 179.7 $\pm$ 14 in group M and 158.3 $\pm$ 8 in the periportal infiltration control group ($p < 0.001$) (Table 3). There was a significant difference in terms of scores of all dimensions except for physical independence (Table 3).

The rate of nausea/vomiting/itching was significantly higher in the periportal infiltration control group than in group M (7 vs. 19, 6 vs. 18, and 8 vs. 20 patients, respectively, $p < 0.001$). The number of patients who demanded rescue analgesia was significantly lower in group M than in the periportal infiltration control group (13 vs. 24 patients, $p < 0.001$) (Table 4).

Discussion

According to the results, global patient recovery scores were higher in the group M compared to the periportal infiltration

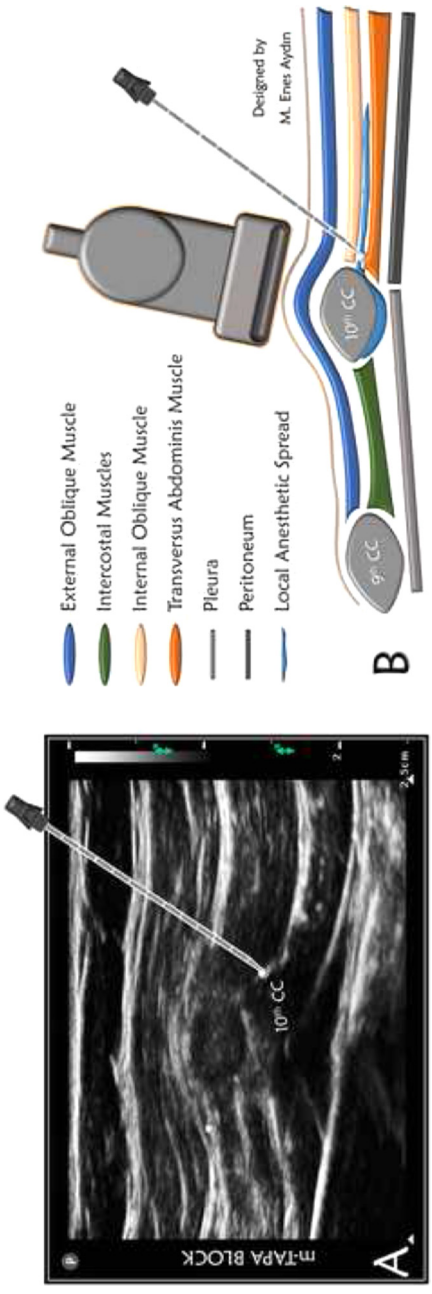

Figure 3 Sonographic visualization and anatomical illustration of M-TAPA. (A) Sonoanatomy of M-TAPA. (B) Corresponding anatomical landmarks of M-TAPA. The needle tip is between the internal oblique muscle and transversus abdominis muscle. CC, Costal Cartilage.

control group. The difference in the QoR-40 scores between groups was clinically meaningful in favor of the M group. NRS and rescue analgesia used were significantly lower in the group M compared to the periportal infiltration control group. The incidence of adverse effects was lower in the group M. All these factors contributed to increasing the quality of recovery following M-TAPA.

Patient recovery after surgery and anesthesia is an important issue, especially for daily surgeries such as laparoscopic operations.[15] Several factors, such as pain, mobilization, emotional status etc., affect recovery.[15,16] In recent years, patients have been evaluated from a general point of view in the postoperative period, instead of just analgesic or opioid consumption. QoR-40 provides this. That is why we decided to make our primary goal QoR-40. The QoR-40 was first described in 2000 and is the most take out commonly preferred measure for evaluating quality of recovery.[17] The QoR-40 is a useful objective measure in routine practice.[17,18] The QoR-40 includes the following items: 9-item emotional status, 12-item physical comfort, 7-item psychological support, 5-item physical independence and 7-item pain. In the literature, Altiparmak et al. evaluated the effect of the rhomboid intercostal block on the quality of recovery after breast surgery.[19] Yao et al. evaluated the effect of serratus anterior plane block for the same aim after breast surgery.[20] In the two studies, authors reported that the global QoR-40 score was higher in the regional anesthesia groups than in the control groups. According to the results of our study, M-TAPA provided higher quality recovery scores compared to the control group 24 h postoperatively.

The anterior and lateral abdominal regions are innervated by the anterior branches of the thoracoabdominal nerves (T7–T12), and L1.[1,2,21] Transversus Abdominis Plane (TAP) is the region between the internal oblique and transversus abdominis muscles. The branches of the T7-L1 spinal nerves present in the TAP region. Therefore, sensory blockade from T7 to L1 is provided by injecting local anesthetics into TAP.[1,2] There are several techniques with this aim.[1,2] TAP block is performed to provide abdominal analgesia. However, it has some disadvantages, such as insufficient pain control because TAP needs a more posterior injection to cover the T11 and T12 lateral cutaneous branches.[2] Oblique subcostal transversus abdominis plane (OSTAP) block provides sensory blockade of T7-L1 by blocking the mid-abdomen and a part of the lateral abdomen. However, OSTAP may have difficulties in application and requires a larger volume of local anesthetics (40–80 ml).[2] In addition, OSTAP may not block the lateral cutaneous branches of the thoracoabdominal nerves (T7–L1) in the lateral abdomen.[2,3] Erector Spinae Plane Block (ESPB) may be preferred for abdominal analgesia,[22] but it may be difficult to position the patient from a supine position to a lateral decubitus position.[3] M-TAPA is performed deep into the costochondral aspect at the 9^{th}–10^{th} costal level, the origin of the TAP.[4] Injecting the LA deep into the chondrium provides blockage of both the anterior and lateral cutaneous branches.[4,6] In inguinal hernia repair surgery, it is important to extend the interfascial block over T12–L1.[1,2,11] The anterior branch of L1 often receives a branch from T12. Blocking the T12 and L1 lateral cutaneous branches may be difficult since both nerves originate posteriorly and pass deeply before entering the TAP.[1,2] The administration of LA just below the ribs

Table 1 Comparison of demographic data and duration of surgery and anesthesia.

	Group M (n = 30)	Group Control (n = 30)	*p*	Mean difference	95% Confidence Interval of the difference
Gender (M/F)	20/10	18/12	0.789		
Age (years)	47 ± 13	48 ± 11	0.711	-1.2	-7.65 to 5.25
Weight (kg)	75 ± 10	80 ± 11	0.094	-4.8	-10.4 to 0.84
Height (cm)	169 ± 8	170 ± 7	0.574	-1.1	-5.2 to 2.95
ASA I/II	10/20	12/18	1		
Unilateral/Bilateral Surgery	14/16	11/19	1		
Duration of surgery (min)	58 ± 7	62 ± 6	0.264	-4.1	-7.7 to -0.5
Duration of anesthesia (min)	78 ± 7	76 ± 7	0.264	2.1	-1.6 to 6

Values are expressed as mean ± standard deviation or number.
Kg, kilogram; cm, centimeter; M, male; F, female; min, minutes; ASA, American Society of Anesthesiologists physical status.
p-value obtained with Student's *t*-test. (mean ± SD).
p-value obtained with Pearson's $\chi 2$ test (n).

Table 2 Comparison of the average Numerical Rating Scale scores.

NRS Static Hour	Group M (n = 30)	Control group (n = 30)	*p*
0	0 (0–1)	4 (4–5)	**<0.001**
2	1 (0–1)	3 (3–4)	**<0.001**
4	0 (0–1)	2 (2–3)	**<0.001**
8	0 (0–1)	2 (2–1)	**<0.001**
16	2 (2–3)	3 (2–3)	0.198
24	2 (1–2)	1 (1–2)	0.129

NRS Dynamic Hour			
0	1 (0–2)	6 (5–6)	**<0.001**
2	1 (0–2)	5 (3–5)	**<0.001**
4	1 (0–2)	3 (3–4)	**<0.001**
8	0 (0–1)	3 (3–4)	**<0.001**
16	3 (2–3)	3 (2–3)	0.797
24	2 (1–2)	2 (1–2)	0.200

Values are expressed as median (percentiles 25—75), NRS, Numerical Rating Scale; *p*-value, obtained with Mann-Whitney U test. Bonferroni correction was used for analysis of NRS.

through the endothoracic fascia was reported to achieve multilevel thoracoabdominal nerve block.[6,23] The dermatomal coverage of the T12 and L1 on the anterior side of the inguinal region may be due to cranial needle direction.[6] The application just below the ribs and cranial needle direction may be the responsible mechanism for M-TAPA. Ciftci et al. reported that M-TAPA extended a large area over TAP in their cadaveric examination.[5] Aikawa et al. performed sensory evaluation of M-TAPA in patients who underwent gynecological laparoscopic surgery.[6] They reported an average dermatomal area between T4–L1 in the anterior and T4–L1 in the lateral abdominal area. Although the authors emphasized that M-TAPA provided limited dermatomal coverage, and the anterior dermatomal area was better than the lateral, the success of interfascial plane blocks may vary due to several factors, such as the volume and spread of LA in the craniocaudal way.[6,24] Bilge et al. compared the efficiency of M-TAPA vs. control group after laparoscopic cholecystectomy surgery. They performed M-TAPA with 25 ml volume of 0.25% bupivacaine.[25] They reported that M-TAPA improved postoperative QoR scores and provided pain control after surgery. According to Bilge et al's study, M-TAPA provided pain relief for upper abdominal surgery. Our surgery type was TAPP and inguinal hernia surgery, lower abdominal surgery. Both surgeries are laparoscopic but there are differences in terms of surgical side. A question comes in mind if M-TAPA can provide analgesia for L1 dermatome. We did not evaluate

Table 3 The comparison of global and dimension QoR-40 score at postoperative 24th hour.

QoR-40	M-TAPA (n = 30)	Control (n = 30)	*p*	Mean difference	95% Confidence Interval of the difference
Physical comfort	53.7 ± 4.7	46.6 ± 2.27	**0.001**	7.1	5.19 to 9
Emotional status	40.1 ± 3.09	37.73 ± 2.53	**0.002**	2.4	0.93 to 3.86
Physical independence	21.33 ± 2.9	20.7 ± 1.08	0.193	0.63	-0.32 to 1.59
Psychological support	31.16 ± 3.62	26.16 ± 2.1	**0.001**	5	3.46 to 6.53
Pain	32.96 ± 2.44	27.1 ± 2.48	**0.001**	5.86	4.59 to 7.13
Global	179.76 ± 14.89	158.36 ± 8.64	**0.001**	21.4	15.1 to 27.69

Values are expressed mean ± standard deviation or number.
p-value obtained with Student's t-test. (mean ± SD).
p-value obtained with Pearson's $\chi 2$ test (n).

Table 4 Comparison of incidence of adverse effects, and the need for rescue analgesia.

	Group M (n = 30)	Group Control (n = 30)	*p*
Nausea (Y/N)	7/23	19/11	**<0.001**
Vomiting (Y/N)	6/24	18/12	**<0.001**
Itching (Y/N)	8/22	20/10	**<0.001**
Need for rescue analgesia (Y/N)	13/17	24/6	**<0.001**

†p-value obtained with Pearson's $\chi 2$ test (n).
*p-value obtained with Student's. t-test (mean ± SD).
Y, Yes; N, No.

dermatome levels, however in the M group, pain scores and rescue analgesia needs were lower than in the control group. Cranial needle direction and applied LA volume are related with the dermatome levels for M-TAPA.

In our study, the surgical technique was TAPP, and the cause of pain was T7–L1. Therefore, M-TAPA may be an effective analgesic method for TAPP.

Our study has some limitations. We used 20 ml volume of LA for each side. More studies are needed to evaluate different volumes. The number of patients in this study was relatively small. Studies with a larger sample size are needed to understand the exact effect of M-TAPA. We could not evaluate the dermatomal area. We only used the recovery scores and pain scores. Lastly, we did not evaluate the preoperative QoR-40 scores.

Conclusion

M-TAPA increases patients' recovery scores and provides pain relief in patients who undergo TAPP. However, more studies are needed to investigate the efficacy of M-TAPA.

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Ethics approval and consent to participate

This study was approved by the Istanbul Medipol University Ethics and Research Committee (06.01.2022, decision n° 34). Written informed consent was obtained from the participants. All methods were carried out in accordance with relevant guidelines and regulations.

Availability of data and material

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declaration of Competing Interest

The authors declare no conflicts of interest. This study had no funding.

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