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Research Article

Bilateral Ultrasound-Guided TAP Block Effects Before and After Laparoscopic Cholecystectomy Surgery on Postoperative Pain Reduction: A Randomized Double-Blind Controlled Trial

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ABSTRACT

Background: The goal of this study is to compare the effects of the TAP (transversus abdominis plane) block, guided by ultrasound, before the commencement of surgery and after its completion, on reducing postoperative pain in patients undergoing laparoscopic cholecystectomy.

Methods: The present study was conducted as a randomized, double-blind clinical trial. The study population included patients scheduled for laparoscopic cholecystectomy at Imam Khomeini Hospital in Sari, Mazandaran, Iran. Patients were randomly assigned to two groups: TAP block before the operation and after the operation. The pain intensity and consciousness level at 0, 2, 4, 6, 8, 12, and 24 hours post-surgery, as well as the time of the first analgesic request, time of first pain expression after surgery, and the amount of morphine consumption within 24 hours for each patient, were documented.

Results: 120 patients were included in this study; 60 of them were in the pre-op group and 60 in the post-op group. There was no statistically significant difference in terms of duration of surgery and total morphine consumed between the study groups. The time of the first analgesic request and the time of the first pain expression were significantly longer in the post-op group. Pain intensity was significantly lower in the post-op group.

Conclusion: Bilateral ultrasound-guided TAP block after surgery in patients undergoing laparoscopic cholecystectomy leads to a reduction in pain intensity and incidence of vomiting and an increase in the time of analgesic request and pain expression after surgery.

Introduction

Laparoscopic cholecystectomy (LC) is the current gold standard treatment for symptomatic gallbladder disorders, including gallstones and cholecystitis [1-2]. Despite being a minimally invasive procedure, LC is associated with postoperative pain, especially in the first 24 hours. This pain is typically controlled using opioids, which may have adverse consequences such as postoperative nausea and vomiting (PONV) and excessive sedation. Since these side effects

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may prolong hospitalization, effective treatment of pain and management are crucial for improving clinical outcomes and early postoperative mobility [3-5]. In addition to opioid-related side effects including respiratory depression, ileus, nausea, vomiting, dizziness and itching, determining the appropriate dose and achieving a uniform concentration of these drugs is also challenging [6]. Therefore, regional analgesia techniques have recently received much attention [7]. The most common complaint following laparoscopic cholecystectomy is pain, which also serves as the primary cause of extended recuperation and hospitalization [8]. Incisional pain, visceral pain, and transferred shoulder pain are the three different parts of this discomfort. Therefore, throughout the past 20 years, research has focused on a multifaceted approach to postoperative pain control following laparoscopic cholecystectomy [4]. Visceral pain has been the most common source of postoperative discomfort in LC. Somatic or parietal pain in LC is less intense than visceral pain. The rationale for this is because the trocar site has small abdominal incisions (4-1 cm) and there is limited damage to the abdominal wall, but it can be addressed as part of a comprehensive pain management plan [9]. Therefore, a TAP block can be an appropriate approach. The transverse abdominis plane (TAP) block, also known as the lateral TAP block, has become a popular method for inducing analgesia since its introduction by Rafi in 2001 [10]. This fascial plane block is done by injecting local anesthetic (LA) into the spaces between the transverse abdominal (TA) and internal oblique (IO) muscles, or, in the case of subcostal TAP block, between the TA muscle and the posterior sheath of the rectus abdominis (RA) [11]. Recent studies have shown that this method is particularly effective in reducing postoperative pain scores and the need for opioids after abdominal surgery [12-20]. The purpose of this study is to compare the preventive effect of TAP block after anesthesia induction and before the commencement of surgery versus TAP block after operation completion on patients' pain levels.

Methods

A single-center, double-blind, randomized clinical trial was used to carry out the current investigation. The CONSORT guidelines have been followed in the reporting of the current study [21]. The study included 120 patients aged 18-65 with ASA I-II physical status, who were scheduled for elective cholecystectomy. Exclusion criteria were coagulopathy, sensitivity to bupivacaine, opioid use or tolerance, neurological or muscular diseases, psychiatric conditions, sleep apnea, systemic diseases, or any psychiatric or drug-related issues.

A computer-generated randomization process was used to assign patients to the preoperative or postoperative TAP block groups. The allocation sequence was created by an independent statistician who was not involved in patient recruiting or analysis. Both the patients and the assessors evaluating postoperative pain outcomes were blinded to the group assignments. The anesthesiologist performing the TAP block was aware of the allocation but was not involved in postoperative patient assessments or data collection. In the operating room, an 18G cannula was placed in each patient. Premedication involved midazolam (0.03 mg/kg) and fentanyl (2 µg/kg), administered 15 minutes before anesthesia induction. Propofol (2 mg/kg) and atracurium (0.5 mg/kg) were used for tracheal intubation, with a 7.5 mm tube for women and an 8 mm tube for men. Tube placement was confirmed via capnography, and patients were ventilated to maintain normocapnia with an isoflurane-oxygen-air mixture. BIS, electrocardiography, capnography (ETCO2), pulse oximetry, and non-invasive blood pressure (NIBP) were all utilized in monitoring, with ETCO2 maintained at 30-35 mmHg and BIS at 40-60. Four surgical entry points (1-5 cm) were made, with CO_2 insufflation at 13-15 mmHg. Post-surgery, patients were reversed with neostigmine and atropine, extubated, and managed according to care standards. The TAP block was administered using ultrasound guidance with a 5-13 MHz linear probe, either before surgery in the pre-operative group or after surgery in the post-operative group. The probe was placed longitudinally near the navel, targeting the transversus abdominis and internal oblique muscles. A 90 mm, 22-gauge spinal needle was inserted in-plane, and the needle tip was positioned between the fascial layers of the transversus abdominis and internal oblique muscles. Patients received 17 mg of 0.25% bupivacaine combined with 1 µg/kg dexmedetomidine, which were administered bilaterally. Since the patient was anesthetized during the TAP block, block failure couldn't be assessed. However, since an expert performed the block in both groups, the risk of failure was considered equal. Post-anesthesia care was provided in the PACU for all patients. Pain management was done via patient-controlled analgesia (PCA) with morphine, including a 1 mg loading dose, a 10-minute lockout interval, and a 4-hour limit at a dose of 25.0 mg/kg without a basal injection. IV-PCA continued for 24 hours post-surgery. The time from TAP-Block to the first request for analgesia, marking the first dose of morphine, was recorded. Pain was assessed using the visual analog scale (VAS), rated from 0 (no pain) to 10 (worst pain), with 1-3 indicating mild pain, 4-6 moderate to severe pain, and 7-9 very severe pain. VAS was used to evaluate pain levels. An evaluator unaware of the patient groups conducted assessments. The number of morphine boluses and pain levels were recorded at PACU admission (hour zero) and at 2, 4, 6, 8, 12, and 24 hours post-surgery. Total morphine use over 24 hours was also documented. Nausea and vomiting were evaluated using

the PONV scale at two intervals: zero to two hours and two to 24 hours after surgery. Patients with no nausea or vomiting received a score of 0; those with nausea but no vomiting scored 1; a score of 2 was for those who vomited once, and a score of 3 for those who vomited multiple times. The OAA/S scale assessed post-surgery consciousness levels, with scores ranging from 5 (responds easily to a normal tone) to 1 (no response to gentle shaking). Vital signs, including mean arterial blood pressure (MAP), oxygen saturation (SPO2), heart rate (HR), and respiratory rate (RR), as well as nausea, vomiting, consciousness, and sedation (OAA/S), were measured at the same intervals.

Statistical Analysis

The distribution of quantitative variables was initially investigated using the Shapiro-Wilk test. Qualitative factors were described using frequencies (percentages). An independent samples t-test was used to compare normally distributed data from two groups, whereas non-normally distributed data was analyzed using the Mann-Whitney U test. To investigate changes over time, repeated measures ANOVA was used for normal data and generalized estimating equations (GEE) for non-normal data. A two-tailed P value less than 0.05 was considered statistically significant in all circumstances. Statistical analysis was performed using the SPSS version 26 program.

Results

Patients' Characteristics:

Out of 137 screened patients, 17 people met the exclusion criteria. 120 patients were analyzed in the study, with ages ranging from 30 to 60 years (median age 49). The group was 68.3% male and 31.7% female, with a mean BMI of 26.1 ± 9.29 kg/m². Half of the patients were ASA class I, and the other half were class II. Sixty patients received a preoperative TAP block, and 60 underwent a postoperative TAP block. Both groups were similar in age, sex, BMI, and health status, with no significant differences (Table 1).

Pain Scores and Analgesic Requirements:

The pain intensity at PACU admission (VAS0) and 24 hours post-surgery (VAS24) showed no significant difference between the pre- and post-operative TAP block groups. However, the pain was significantly lower in the postoperative group at 2, 4, 6, 8, and 12 hours after surgery. Controlling for age (P = 0.713) and gender (P = 0.810), pain remained significantly lower in the postoperative group (P = 0.001). There was no significant difference in the median total morphine dose between the groups, but the postoperative group experienced a longer time to first pain and requested analgesics later, both statistically significant (P = 0.040) (Table 2).

Operative Details

According to the results of the above table, the median duration of surgery in the pre- and post-operative groups was 57.7 and 75 minutes, respectively. There was no statistically significant difference in the duration of surgery between the study groups. There were no documented intraoperative or postoperative problems or negative consequences associated with TAP block (Table 3).

Alertness and Sedation of Postoperative Patients

In the Post-Anesthesia Care Unit (PACU), assessments showed that 50% of patients in the pre-operative TAP block group were alert, 26% had light sedation, and 23% were moderately sedated. In the post-operative group, 46% of patients were alert, 33% had light sedation, and 20% were moderately sedated. There was no significant difference in alertness between the two study groups either before surgery (p = 0.846) or 2 hours after (p = 0.837). At 2 hours post-surgery, 73% of patients were alert, 23% had light sedation, and 3.3% were moderately sedated. Assessments at 4, 6, 8, 12, and 24 hours post-surgery showed all patients were alert.

Table 1- Baseline characteristics of the patients

Variable	Pre-operative	Post-operative	Total	P value
Age (yr)				0.519
Min	33	30	30	
Median	49	48.5	49	
Max	60	60	60	
Sex				0.781
Male	40(66.7%)	42(70%)	82(68.3)	
Female	20(33.3%)	18(30%)	38(31.7)	
BMI				0.279
Median(sd)	29.7(1.5)	30.2(1.9)	29.9(1.7)	
ASA Classification				0.606

I	32(53.3%)	28(47.7%)	60(50%)
II	28(47.7%)	32(53.3%)	60(50%)

Table 2- Pain Scores and Analgesic Requirements

Variable	Pre-operative	Post-operative	P value
Pain score at 0 h	6	6	0.921
Pain score at 2 h	5	4	0.001
Pain score at 4 h	5	4	0.001>
Pain score at 6 h	4	3	0.001>
Pain score at 8 h	4	2.5	0.001>
Pain score at 12 h	3	2	0.001>
Pain score at 24 h	1	1	0.792
Total dose of Morphine	6	5.75	0.113
first postoperative pain manifestation(sd)	287.3(100.9)	338.6(69.3)	0.025
first request of analgesics(sd)	377.3(110.4)	431.3(87.1)	0.04

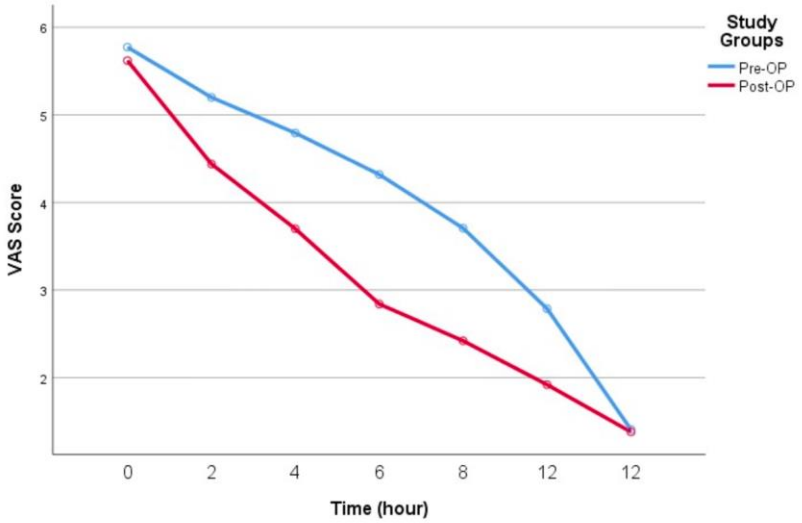

Figure 1-Pain Intensity Examination Based on VAS in the Study Groups

Table 3- Operative details and postoperative recovery

Variable	Pre-operative	Post-operative	P value
Duration of surgery			0.300
Min	60	60	
Median	77.5	75	
Max	100	95	
Length of hospital stay			0.665
Min	1	1	
Median	2	2	
Max	3	4	
PONV 0-2			0.017
without nausea and vomiting	14(23.3%)	34(56.7%)	
nausea without vomiting	18(30%)	18(30%)	
one time vomiting	22(36.7%)	6(10%)	
more than one-time vomiting	6(10%)	2(3.3%)	
PONV 0-2			0.027
without nausea and vomiting	26(43.3%)	46(76.7%)	
nausea without vomiting	22(36.7%)	10(16.7%)	

one time vomiting	12(20%)	4(6.7%)
more than one-time vomiting	0	0

Postoperative Hemodynamics

Based on the results, there was no statistically significant difference in terms of heart rate (HR), mean arterial pressure (MAP), and peripheral capillary oxygen saturation (SPO2) at baseline, 2 hours, 4 hours, 6 hours, 8 hours, 12 hours, and 24 hours after surgery between the study groups (Table 4).

Postoperative Recovery

After surgery, 46% of patients in the pre-operative TAP block group experienced vomiting, which dropped to 13.3% in the post-operative group. In the first 24 hours, vomiting occurred in 20% before and 6.7% after the surgery, a statistically significant reduction. The median hospital stay for both groups was 2 days, with no significant differences, and no patients required readmission within 30 days.

Discussion

Multiple studies have demonstrated that ultrasound-guided TAP block (USG TAP) provides a component of multimodal postoperative pain management, leading to better pain relief, higher satisfaction, and reduced opioid consumption [22-24]. Given that patients undergoing laparoscopic cholecystectomy experience maximum pain in the first 24 hours after surgery at trocar insertion sites, determining the optimal timing for performing TAP block either before or at the end of surgery is clinically important to enhance block efficiency [22]. However, few studies have compared the analgesic effect between pre- and post-operative USG TAP blocks on pain relief after LC. In the present study, the effect of the USG TAP block was conducted after anesthesia induction (preoperative) and at the end of the operation (postoperative) and before extubation. The results of this study indicated that the USG TAP block reduces VAS scores in the PreOP group compared to PostOP up to 24 hours after the operation, especially in the first 12 hours postoperatively, which was inconsistent with previous studies (Figure 1). In a study by Rashid et al., no significant difference in pain relief was observed between the two groups when performing bilateral TAP block and local infiltration anesthesia at the port sites [25]. Kalu et al. [26] examined how postoperative opioid usage was affected by TAP block before and after surgery. Although there was no discernible difference in the groups' opioid usage, the results indicated that the TAP block reduced postoperative pain in both [26]. The findings of the present study were consistent with the results of the study by Tikuisis et al. [27]. The results of this study indicate that the TAP block reduces pain scores at 2, 4, 6, 8, and 12 hours after the operation. When used as part of multimodal pain management, the TAP block can significantly alleviate postoperative pain.

Table 4- Postoperative Hemodynamics

Variable	Pre-operative	Post-operative	P value
SPO_2			
Base	97	97	0.894
2h	97	97.5	0.373
4h	97	97	0.497
6h	97.5	97	0.234
8h	97.5	97	0.386
12h	97	97	0.571
24h	97	98	0.487
MAP			
Base	100	98	0.083
2h	99	98	0.096
4h	99	98	0.405
6h	99	97	0.125
8h	99	98	0.274
12h	98	97	0.499
24h	98	96.5	0.210
HR			
Base	95.5	93.5	0.982
2h	95	90	0.136
4h	95	92	0.407

6h	94.5	92.5	0.790
8h	94.5	93.5	0.584
12h	91.5	94	0.455
24h	93.5	95.5	0.548

However, the Teblind TAP block approach, which is based on an anatomic landmark, can cause difficulties and even damage to abdominal organs, such as liver injury and intestinal perforations [28].

In the current investigation, no adverse events associated with the TAP block were detected, most likely due to the simultaneous use of ultrasound guidance for the TAP block. Furthermore, there were no vital anatomical structures in this region. Proper postoperative pain treatment reduces the negative effects of analgesics, such as dizziness, nausea, vomiting, and itching. The current study indicated that, by selecting an adequate local anesthetic dose for the TAP block, it can be utilized to reduce postoperative pain without causing side effects.

Furthermore, some studies have reported the beneficial effect of USG TAP block on pain relief in the first 48 hours after surgery, perhaps as a result of the small vascular structures seen in the abdomen wall's neurovascular plane, as these structures play a crucial role in drug clearance. Consequently, systemic toxicity resulting from local anesthetics using USG-TAP block has significantly decreased [17, 29].

In the current study, USG TAP block reduced opioid consumption and its side effects, especially PONV, which showed a statistically significant reduction in the PostOP group. In fact, in this group, the time to the first request for analgesia and the time to the first pain complaint after surgery were longer compared to the PreOP group. Our study indicated that TAP block after surgery is more effective in longer pain relief and lower pain scores compared to preoperative conditions.

Conclusion

In patients having laparoscopic cholecystectomy, bilateral ultrasound-guided TAP block after surgery results in a decrease in pain intensity and vomiting frequency, as well as an increase in the amount of time patients take to request analgesics and express pain.

Limitations

The present study was conducted as a single-center randomized clinical trial with a small sample size. Nevertheless, evaluating the effects of local anesthetics with different doses and concentrations and sensory assessment of the TAP block for further investigation in future studies with a larger sample size is recommended.

WHAT IS KNOWN

- Previous studies have indicated the importance of monitoring pain scores and the need for analgesics post-surgery.
- The transverse abdominis plane (TAP) block, also known as the lateral TAP block, has become a popular method for inducing analgesia.

WHAT IS NEW

- The postoperative group required analgesics later than the preoperative group, suggesting a potential benefit of postoperative TAP blocks.
- The study found no statistically significant differences in the duration of surgery or complications between groups but highlighted that postoperative TAP blocks might improve recovery by reducing pain more effectively than preoperative TAP blocks.

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Registration

This study's protocol has been officially recorded in the Iranian Registry of Clinical Trials. (IRCT20211011052726N2).

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