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ORIGINAL RESEARCH

Is the application of subcostal transversus abdominis plane block effective for pain control in classical four-port laparoscopic cholecystectomy?

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Abstract

The utilization of transversus abdominis plane (TAP) block for postoperative pain management has proven to be efficacious. The purpose of this inquiry is to evaluate the effectiveness of right-sided TAP blockade guided by ultrasonography (USG) in managing pain subsequent to laparoscopic cholecystectomy. A total of 60 patients were equallydistributed into two groups. The control group was comprised of patients who did not receive a TAP block, whereas the TAP block group consisted of patients who underwent an ultrasound-guided, right-sided unilateral subcostal TAP block with 20 mL of 0.25% bupivacaine. A Verbal Numerical Rating Scale was administered to all participants for pain assessment at postoperative intervals of 0th, 6th, 12th and 24th hours. Additionally, the overall amount of supplementary analgesic used after surgery, age distribution among each gender classification and body mass index range categories as well as operation time duration; use or non-use of drain; and incidence rate for postoperative complications were recorded for each patient individually. The mean age of participants was 47.72 $\pm$ 13.80 years, with a female-to-male ratio of 41/19. The control group exhibited significantly higher pain scale measurements than the block group at the postoperative 0th and the postoperative 24th hour. Drain replacement yielded notably higher pain scores for both TAP and control groups at the postoperative 0th hour. Neither BMI nor operation duration had significant effects on postsurgical pain in either patient group—whether or not they received a TAP block treatment. Our research shows that the implementation of a TAP block and exclusion of surgical area drainage placement yield favorable results in mitigating postoperative pain. Notably, BMI and procedure duration do not exhibit any discernible impact on postoperative pain management.

Keywords

Laparoscopic cholecystectomy; Transversus abdominis plane block; Drain; Pain

1. Introduction

Laparoscopic cholecystectomy (LC), a minimally invasive surgical approach, is widely recognized as the optimal approach for treating cholelithiasis. Postoperative abdominal discomfort following laparoscopic surgery may result from various factors such as port-site incisions, diaphragmatic irritation caused by carbon dioxide (CO_2) insufflation, and inadequate evacuation of insufflated gas. The pain experienced after laparoscopic abdominal surgery can manifest in three forms: somatic pain (incisional pain), deep intra-abdominal visceral pain (visceral pain), and reflected visceral pain in the shoulder area [1].

Numerous techniques exist for controlling pain, including intravenous administration of analgesics, local anesthetic infiltration at the incision site, and the Transversus Abdominis Plane (TAP) block. First introduced by Rafi in 2001, the TAP block involves injecting a local anesthetic between the transversus abdominis and internal oblique muscles through locating the Petit triangle [2]. The TAP block provides postoperative analgesia for open and laparoscopic abdominal surgery as well as inpatient and outpatient surgical procedures. It can also serve as an analgesic option for Cesarean delivery (posterior or lateral approach) and open colorectal section (subcostal or lateral approach), particularly when contraindications to intrathecal morphine and thoracic epidural analgesia are apparent [3]. Clinical studies have demonstrated that using TAP blocks reduces intraoperative opioid use during laparotomy, colorectal surgery, cesarean section, and laparoscopic cholecystectomy procedures [4–8]. This technique is capable of inhibiting somatic pain pathways transmitted *via* ipsilateral thoracolumbar fibers [9–11].

The TAP block technique has been improved by integrating

ultrasound guidance, which ensures precise needle placement and reduces the likelihood of complications. Using ultrasonography (USG) during the procedure allows for direct visualization of the needle, providing the advantages of effectiveness and safety [6]. However, there are inefficiencies in the TAP block, with most approaches only providing somatic (*i.e.*, abdominal wall) and not visceral analgesia. Also, the transversus abdominis plane compartment's size requires a careful dose of local anesthetic to ensure sufficient postoperative pain control [12].

Some studies have explored the efficacy of ultrasound-guided TAP block in laparoscopic cholecystectomy, but the impact of drain usage, BMI, and operation time on its effectiveness remains unexplored. This study seeks to evaluate the efficacy of right-sided subcostal TAP block under USG for pain management and to examine the correlation between TAP block, drain usage, BMI, and operation time following laparoscopic cholecystectomy with regard to postoperative pain control.

2. Material and methods

This non-randomized controlled study was conducted from May to July 2023, after receiving approval from the Institutional Ethical Review Board. The inclusion criteria for this study were individuals aged 18 years or older, scheduled for elective laparoscopic cholecystectomy to treat cholelithiasis, American Society of Anesthesiologists (ASA) physical status of I or II, with no communication barriers, able to cooperate during the intervention, and understanding the use of relevant assessment scales. The exclusion criteria included individuals with contraindications to nerve block, such as infection at the puncture site; those diagnosed with malignancy; individuals suffering from severe liver and kidney diseases, coagulation dysfunction, or similar conditions; individuals with a history of previous abdominal surgery or trauma; long-term users of sedatives, or analgesics; individuals experiencing chronic pain; those with known allergies to the drugs used in the study; individuals with mental illnesses that interfere with perception and pain assessment; individuals taking analgesics prior to surgery; individuals with a body mass index (BMI) $\geq$35; patients who were converted from laparoscopic surgery to open surgery; perforation of the gallbladder during cholecystectomy; women who are pregnant or breastfeeding, and patients who withdrew their consent at any stage of the study.

Based on Ozciftci *et al.* [13] findings and using the calculator at https://www.istatistikakademisi.com/sayfa/nicel-verilerde-orneklem-buyuklugu-hesabi.html, a standard effect size was determined as 0.78 with a 5% margin of error and 80% power indicated the need for n = 26 cases in each group, resulting in 30 patients per group and a total of 60 patients in the study. Patients were equally divided into two groups and admitted to the hospital one by one. The control group (Group 1, n = 30) comprised patients who did not receive a TAP block, while Group 2 (n = 30) comprised patients who underwent a right-sided unilateral TAP block. One patient with malignant gallbladder pathology following LC, along with four patients who did not provide data or refused to participate in the study, were excluded, and five new patients were included.

During the study, the established institutional protocol for anesthesia induction, monitoring, and maintenance was followed. All patients underwent a standardized anesthesia induction process, which involved the use of 2–3 mg/kg of propofol, 0.6–1.2 mg/kg of rocuronium, and 1 μg/kg of fentanyl. After orotracheal intubation, patients were adjusted to maintain specific respiratory parameters, including a tidal volume of 8 mL/kg, an Inspiration: Expiration ratio of 1:2, a respiratory rate of 12/min, and an end tidal CO_2 level ranging from 30 to 40 mmHg in controlled ventilation mode. Anesthesia was maintained throughout the procedure, following the established institutional protocol for anesthesia induction, monitoring, and maintenance. Anesthesia was maintained using a blend of 60% oxygen and 40% air, in addition to sevoflurane (maintaining a minimum alveolar concentration of 2.5–3.0).

The surgical procedures were performed by two experienced senior surgeons with a consistent approach. A 10 mm midline incision was made 2 cm below the xiphoid, followed by a 10 mm periumbilical incision was made parallel to the pelvis. Two additional 5 mm right subcostal incisions were made for trocar insertion during laparoscopic cholecystectomy. All surgeries were conducted laparoscopically, and CO_2 was insufflated into the abdomen with a pressure limit of 13 mmHg throughout the procedure. If a drain was used during surgery, it was removed from the abdomen using the 5 mm trocar.

The TAP block was conducted in the post-anesthesia phase, prior to extubation. The procedure utilized an ultrasound system and a linear ultrasound transducer (6–12 Hz). To perform the TAP block, the linear probe was positioned 2 cm below the xiphoid to locate the rectus abdominis muscle and fascia. The external, internal, and transversus abdominis muscles, as well as fascia, were identified over the oblique subcostal angle by moving the probe downward and lateral. A 1–2 mL dose of 2% lidocaine was then administered to the peripheral block needle insertion site. The Braun Ultra 360 peripheral nerve block needle (100 mm, Germany) was carefully advanced from the medial to the inferolateral area of the probe, following the fascia of the transversus abdominis and internal oblique muscles, while the probe was in the oblique subcostal position. According to Lee *et al.*'s [14] research, the accuracy of the block area was verified by infiltrating 1–2 mL of 0.9% isotonic sodium chloride, which produced a hypoechoic and biconvex appearance, and 20 mL of 0.25% bupivacaine on the right side of the abdomen, in accordance with Sahin *et al.*'s [15] study.

All patients were given a 1 g intravenous infusion of paracetamol (Paracerol® 10 mg/mL, Polifarma, Istanbul, Turkey) three times after surgery: immediately, six hours later, and eighteen hours after that. For pain management, they also received regular intravenous administration of 50 mg dexketoprofen (Arveles®, 2205028, Menarini, Istanbul, Turkey) right after surgery and one hour later. The Verbal Numerical Rating Scale (VNRS) was used to assess pain at postoperative 0th, 6th, 12th and 24th hours, with scores ranging from 0 to 10. Patients received 0.5 mg/kg of Tramadol hydrochloride (Contramal®, 22A035, Grünenthal, Istanbul, Turkey) if they reported a VNRS score of 5 or higher at rest. Additionally, patient age, gender, BMI, operation duration, use of a drain, and postoperative complications were recorded, along with the total tramadol consumption post-surgery.

3. Statistical analysis

For statistical analysis, we used IBM's SPSS 22.0 in Armonk, NY, USA. Descriptive statistics for numerical variables included the mean, standard deviation, and rate. The Student *t* test was applied to normally distributed variables, while the Mann-Whitney U test was used for non-normally distributed variables. The Chi-Square test was employed for categorical variables. Kolmogorov-Smirnov tests were used to check for a normal distribution. The Chi-Square test was used to determine the relationship between pain score and drain usage. The Pearson correlation coefficient was utilized to assess the relationship between pain score, BMI, and length of operation. Correlation strength was interpreted as very weak (0.00–0.19), weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79) and very strong (0.80–1.0). A threshold of $p < 0.05$ was set for statistical significance.

4. Results

The study involved 60 patients, with an average age of 47.72 ± 13.80 years and a female-to-male ratio of 41/19. The control group comprised thirty patients who did not receive a TAP block, while the block group comprised thirty patients who did.

There were nonotable differences between the groups in terms of age, gender, BMI, operation time, drain use, postoperative complications, or pain scale measurements at 6 and 12 hours. The control group exhibited significantly higher pain scale measurements than the block group at the postoperative 0th (median pain intensity score 0 *vs.* 1 respectively) and 24th hours (median pain intensity score 0 *vs.* 0.5 respectively) (*p*: 0.023 and *p*: 0.020, respectively) (Table 1). Postoperative atelectasis was observed in two patients in the control group and one in the block group. Furthermore, two patients in the block group and one in the control group developed wound infections. Except for one patient in the control group who required 50 mg tramadol hydrochloride at the postoperative 6th hour, no additional analgesics were required.

Postoperative atelectasis was observed in two patients in the control group and one in the block group. Furthermore, two patients in the block group and one in the control group developed wound infections.

In-group analysis revealed that drain replacement resulted in significantly higher pain scores at the postoperative 0th hour in both the TAP and control groups (*p*: 0.007 and *p*: 0.032, respectively) (Table 2).

When patients were categorized into two groups by their BMI, one with a BMI of 30 or more and the other with a BMI of less than 30, no notable distinction was observed in within-group examinations for either the block group and the control group (Table 3). There were no significant variances in patient classification based on operation duration (cutoff 30 minutes). Nevertheless, an extended operation duration led to increased pain scores in the block group at the 0th hour post-surgery (Table 4).

There was no significant correlation found between the pain score at any given time and either BMI or operation duration. Furthermore, there is no link between pain score at any given time and drain usage (Table 5).

TABLE 1. The comparison of the parameters between block and control groups.

	Block Group (n: 30)	Control Group (n: 30)	*p* value
Age (yr) (mean ± SD)	48.80 ± 16.13	46.63 ± 11.18	0.548
Gender (n, %)			
Female	10 (33.30%)	9 (30.00%)	0.781
Male	20 (66.70%)	21 (70.00%)	
BMI (kg/m^2) (mean ± SD)	29.32 ± 3.86	29.82 ± 4.15	0.633
Operation duration (min) (median, Q1–Q3)	30.00 (23.75–38.75)	31.00 (25.00–40.00)	0.731
Using Drain			
Yes	10 (33.30%)	12 (40.00%)	0.592
No	20 (66.70%)	18 (60.00%)	
Postoperative Complication			
Yes	3 (10.00%)	3 (10.00%)	1.000
No	27 (90.00%)	27 (90.00%)	
Pain Scale (median, Q1–Q3)			
0th h	0.00 (0.00–1.00)	1.00 (1.00–1.00)	0.023*
6th h	0.00 (0.00–1.00)	0.50 (0.00–1.00)	0.317
12th h	0.00 (0.00–1.00)	0.00 (0.00–1.00)	0.436
24th h	0.00 (0.00–0.00)	0.50 (0.00–1.00)	0.020*

*BMI: Body mass index; Q: quartile; SD: Standard derivation; *: Statistically significant.*

TABLE 2. The in group pain scale comparison according to drain replacement.

	Block Group (n: 30)			Control Group (n: 30)		
	Drain (+) (n: 10)	Drain (−) (n: 20)	*p* value	Drain (+) (n: 12)	Drain (−) (n: 18)	*p* value
Pain Scale (median, Q1–Q3)						
0th h	1.00 (1.00–2.00)	0.00 (0.00–1.00)	0.007*	1.00 (1.00–1.50)	1.00 (1.00–1.00)	0.032*
6th h	0.50 (0.00–1.00)	0.00 (0.00–1.00)	0.381	1.00 (0.00–2.00)	0.00 (0.00–1.00)	0.200
12th h	0.50 (0.00–1.00)	0.00 (0.00–0.50)	0.292	0.00 (0.00–1.00)	0.50 (0.00–1.00)	0.611
24th h	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.950	1.00 (0.00–1.00)	0.00 (0.00–1.00)	0.330

*Q: Quartile; *: Statistically significant.*

TABLE 3. The in group pain scale comparison according to BMI.

	Block Group (n: 30)			Control Group (n: 30)		
	BMI ≥30 (n: 14)	BMI <30 (n: 16)	*p* value	BMI ≥30 (n: 15)	BMI <30 (n: 15)	*p* value
Pain Scale (median, Q1–Q3)						
0th h	0.00 (0.00–1.00)	0.50 (0.00–1.50)	0.631	1.00 (1.00–1.00)	1.00 (1.00–1.00)	0.300
6th h	0.00 (0.00–0.00)	0.50 (0.00–1.00)	0.144	1.00 (0.00–1.00)	0.00 (0.00–1.00)	0.071
12th h	0.00 (0.00–1.00)	0.00 (0.00–1.00)	0.921	0.00 (0.00–1.00)	1.00 (0.00–1.00)	0.472
24th h	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.788	1.00 (0.00–1.00)	0.00 (0.00–1.00)	0.869

BMI: Body mass index; Q: Quartile.

TABLE 4. The in-group pain scale comparison according to operation time.

	Block Group (n: 30)			Control Group (n: 30)		
	OT ≥30 min. (n: 20)	OT <30 min. (n: 10)	*p* value	OT ≥30 min. (n: 18)	OT <30 min. (n: 12)	*p* value
Pain Scale (median, Q1–Q3)						
0th h	1.00 (0.00–1.50)	0.00 (0.00–0.00)	0.053	1.00 (1.00–1.00)	1.00 (1.00–1.00)	0.731
6th h	0.00 (0.00–1.00)	0.00 (0.00–1.00)	0.816	0.50 (0.00–1.00)	0.50 (0.00–1.00)	0.576
12th h	0.00 (0.00–1.00)	0.00 (0.00–0.00)	0.188	0.50 (0.00–1.00)	0.00 (0.00–1.00)	0.659
24th h	0.00 (0.00–0.50)	0.00 (0.00–0.00)	0.327	0.00 (0.00–1.00)	1.00 (0.00–1.00)	0.211

OT: Operation time; Q: Quartile.

TABLE 5. The correlation analysis between pain score and BMI, operation duration and the association analysis between pain score and drain usage.

		r value	*p* value
BMI			
Block Group	0th h	0.082	0.666
	6th h	−0.020	0.915
	12th h	0.038	0.843
	24th h	0.165	0.382
Control Group	0th h	0.124	0.513
	6th h	0.243	0.196
	12th h	−0.128	0.502
	24th h	−0.102	0.591
Operation Duration			
Block Group	0th h	0.343	0.064
	6th h	−0.119	0.531
	12th h	−0.034	0.860
	24th h	−0.630	0.741
Control Group	0th h	0.343	0.064
	6th h	0.285	0.127
	12th h	0.089	0.640
	24th h	−0.018	0.923
Drain Usage			
Block Group	0th h	NA	0.071
	6th h	NA	0.543
	12th h	NA	0.108
	24th h	NA	0.741
Control Group	0th h	NA	0.439
	6th h	NA	0.135
	12th h	NA	0.654
	24th h	NA	0.401

BMI: Body mass index; NA: Not Applicable.

5. Discussion

The TAP block can offer substantial pain relief, but it may not entirely eliminate all symptoms. Its effectiveness depends on individual factors and the particular surgical procedure [3]. Our research discovered that patients who received a TAP block experienced lower pain scores. Additionally, the use of a drain negatively affected postoperative pain in both patient groups, regardless of whether they had a TAP block. However, neither BMI nor operation duration significantly impacted postoperative pain.

During the postoperative phase, the TAP block has become an essential component of multimodal analgesia. Previous research has demonstrated its ability to reduce the need for analgesics after various surgical procedures. Elnabtity *et al*. [16] investigated the use of unilateral TAP block in patients undergoing visceral and superficial pain-inducing unilateral ureteric extracorporeal shock wave lithotripsy (ESWL). Their findings showed that applying unilateral TAP block significantly reduced the patients' pain scores [16]. Hotujet and colleagues studied the effects of a unilateral TAP block administered through a single-port entry compared to a placebo in patients undergoing robotic gynecological surgery. The TAP block significantly reduced opioid usage during robotic surgery and also decreased pain [17]. However, a systematic review by Keir *et al*. [18] found that it did not show superiority over local port site infiltration with local anesthetics in reducing pain scores and opioid consumption. A meta-analysis by Peng *et al*. [19] revealed that TAP block led to reduced opioid usage, thereby mitigating associated adverse effects. Studies by Altıparmak *et al*. [20] and Baral *et al*. [21] showed that applying ultrasound-guided TAP blocks in subcostal areas resulted in lower consumption of tramadol and pethidine.

While some surgeons routinely use drains during LC, the generally accepted consensus in the literature is that routine drain use isn't advantageous in uncomplicated cases [22]. Park *et al*. [23] state that there's no proof that using a surgical drain before LC reduces morbidity or prevents localized complications such as surgical site infections. In fact, it may even increase the likelihood of these complications [23]. A meta-analysis and a retrospective study revealed that patients with surgical drain placement experienced higher rates of various complications, including fever, wound infections, hemorrhage, herniations, increased postoperative discomfort, and prolonged hospital stays [24, 25]. Tzovaras *et al*. [26] showed that routinely inserting drains in all elective cholecystectomies is countered by its correlation with higher rates of postoperative pain and biliary leakage. Our study found that using drains increased postoperative pain in all groups, regardless of whether a TAP block was performed.

Numerous studies have explored the link between pain and obesity [27]. Migraines and other types of pain have been associated with a higher BMI [28]. A comprehensive study revealed that a higher BMI was a predictor of inadequate postoperative pain management [29]. However, a separate study found no proof of a correlation between pain and BMI [30]. obese patients exhibited significantly higher VAS scores in the recovery room and at postoperative 1 and 6 hours compared to non-obese patients. The patients were divided into two groups based on their BMI (one with a BMI below 30 and the other with a BMI above 30) [27]. Our study found no difference in postoperative pain between patients who underwent a TAP block and those who did not, regardless of their obesity status.

The study has limitations including a small patient sample size and its failure to account for individual differences, such as genetic factors that influence pain sensitivity and analgesic responses. Additionally, since the TAP block was not administered before the induction of general anesthesia, it is now impossible to assess the parameters while under anesthesia.

6. Conclusions

Our study showed that patients who received a subcostal TAP block experienced lower pain scores. Furthermore, the use of the drainage system led to somewhat negative postoperative pain outcomes for both patient groups, regardless of TAP block

administration. Interestingly, factors like BMI or surgical procedure duration did not have a significant effect on post-operative pain levels. These results underscore the potential advantages of TAP blocks in pain management, while also emphasizing the adverse effect of drain use on postoperative pain, regardless of TAP block administration.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

AO—made conception and design, acquisition of data, analysis and interpretation of data, drafting the manuscript. NG—made analysis and interpretation of data and drafting the manuscript. BK—made acquisition of data and drafting the manuscript. MMS—made analysis and interpretation of data and revising it critically for important intellectual content. All of the authors approved the final version to be published.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Istanbul Training and Research Hospital Clinical Research Ethics Committee approved of the Institutional Ethical Review Board with the number: 126. Written informed consent was obtained from all participants.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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