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Efficacy of unilateral laparoscopic-guided abdominal wall block compared to local infiltration in postoperative analgesia following laparoscopic cholecystectomy: a single-center randomized controlled trial

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Conflict of interest

The Authors declare no conflict of interest.

AI usage declaration

Artificial intelligence was not used in the preparation of this manuscript.

Abstract

Introduction: Effective postoperative analgesia is crucial for recovery after laparoscopic cholecystectomy (LC). Although local anaesthetic infiltration (LAI) is commonly used, transversus abdominis plane (TAP) block may offer improved outcomes.

Aim: To evaluate the efficacy and safety of unilateral laparoscopy-assisted TAP (L-TAP) block, and their combination (L-TAP block+LAI), for postoperative pain management after LC.

Materials and methods: In this prospective, randomised clinical trial, patients undergoing LC were allocated into 4 equal-sized groups: L-TAP, LAI, L-TAP+LAI, and control, and were blinded to group assignment. The primary outcome was pain intensity measured using the Numerical Rating Scale (NRS) at 2, 6, and 24 hours postoperatively. The pain intensity at the umbilical, subcostal, and substernal wounds, the number of patients needing analgesics, and local complications assessed postoperatively were secondary outcomes.

Results: Forty patients were randomised to each group and analysed. The L-TAP group had lower NRS scores at 2, 6, and 24 hours postoperatively than the LAI group (*P*=0.003, *P*=0.015, and *P*=0.046, respectively). Similarly, subcostal pain was lower in the L-TAP group than in the LAI group (*P*=0.008, *P*=0.01, and *P*<0.001, respectively). No major complications were noted. The ecchymosis occurred most frequently in the LAI group (*P*=0.03).

Conclusions: Laparoscopic-guided unilateral TAP block is a safe and effective method for postoperative analgesia in LC. It provides superior pain control and fewer wound-related complications than LAI, supporting its use as a practical intraoperative alternative to trocar-site infiltration.

Keywords: laparoscopic cholecystectomy; local anaesthetic infiltration; postoperative regional anaesthesia; transversus abdominis plane block.

Introduction

Gallbladder stones (cholelithiasis) are a common condition, with epidemiological studies reporting a global prevalence of 6% (5-11%, depending on continent) [1]. Laparoscopic cholecystectomy (LC) is widely considered the gold standard treatment for symptomatic gallstone disease [2]. Effective postoperative analgesia is crucial for patient comfort and optimal clinical outcomes. Although opioids remain an important option for managing severe postoperative pain, their use is limited by significant adverse effects, including respiratory depression, sedation, nausea, vomiting, and delayed gastrointestinal recovery. Therefore, alternative regional anaesthesia techniques are routinely used for postoperative pain control [3].

The most basic approach involves local anaesthetic infiltration (LAI) at the surgical wound sites. A more recent and increasingly adopted method is the transversus abdominis plane (TAP) block, first introduced in 2001 as a pre-emptive analgesic technique [4]. This approach provides analgesia by blocking the spinal nerves from T6 to L2 [4]. The original TAP block technique involved a "blind" needle insertion using the loss-of-resistance method to identify anatomical landmarks within Petit's triangle. Subsequent advancements introduced ultrasound guidance, allowing for more precise and safe deposition of local anaesthetics [5]. More recently, laparoscopy-assisted TAP (L-TAP) block administration has been implemented. Initially employed in nephrectomy procedures in 2011 [6], this approach has since been incorporated into LC protocols during the early phase of surgery [7].

Given the significant impact of postoperative pain on recovery, continuous evaluation and optimisation of regional anaesthesia strategies are essential to identify the most effective approaches for routine surgical practice.

Aim

The aim of the present study was to assess the efficacy and safety of unilateral L-TAP block, LAI, and their combination (L-TAP block+LAI) for postoperative pain management following LC.

Materials and methods

Study design

This prospective, randomised clinical study was conducted at XXX, XXX, Poland, between September 2021 and June 2023.

Ethical considerations

The study protocol was approved by the Institutional Bioethics Committee XXX (approval no. 31/2021/VIII of 13.09.2021), and all procedures were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to inclusion. The study was registered on ClinicalTrials.gov (ID: NCT07176299).

Study population

Eligible participants were between 20 and 85 years of age, classified as American Society of Anesthesiologists (ASA) physical status I or II, and scheduled to undergo LC for symptomatic cholelithiasis confirmed by ultrasonography. Exclusion criteria included ASA physical status III–IV, contraindications to laparoscopy, preoperative or perioperative diagnosis of acute cholecystitis, chronic analgesic use, spinal degenerative joint disease, allergy to local anaesthetics, opioid or alcohol dependence, psychiatric or neurological disorders, or lack of consent. Preoperative data included the following demographic and clinical characteristics: age, sex, height, weight, body mass index (BMI), prior surgeries, comorbidities, tobacco use, and previous opioid exposure.

Allocation

Patients were randomised the day before surgery using a simple 1:1 allocation sequence generated in Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA). The randomisation sequence was generated by an independent investigator not involved in patient recruitment or outcome assessment. Group assignments were placed in sequentially numbered, opaque, sealed envelopes prepared by a study coordinator and opened just before the surgery by a surgeon not involved in postoperative pain assessment. The statistician and participants were blinded to group allocation. Participants retained the right to withdraw from the study at any stage without consequences. Participants were allocated into one of the four groups: LAI (local anaesthetic infiltration of surgical wounds), L-TAP, L-TAP+LAI (a combination of both techniques), and control (no regional anaesthesia). Postoperative pain was assessed by nursing staff unaware of group allocation.

Perioperative care and surgical treatment

All patients received standardised preoperative medication consisting of oral midazolam (7.5 mg) 1 hour before surgery and intravenous fluid boluses calculated at 1 mL/kg of body weight per hour of preoperative fasting. General anaesthesia was induced with intravenous propofol and remifentanil. Following preoxygenation, patients received propofol (2 mg/kg), atracurium (1 mg/kg), and fentanyl (1 μg/kg), followed by endotracheal intubation and mechanical ventilation. Anaesthesia was maintained with sevoflurane at 1 minimum alveolar concentration in a 50:50 oxygen-to-air mixture and continuous remifentanil infusion (0.25–1 μg/kg/min), with continuous haemodynamic monitoring.

Laparoscopic cholecystectomy was performed using a standardised four-port technique: an 11-mm optical trocar above the umbilicus, an 11-mm working trocar below the xiphoid process, and two 5-mm working trocars below the right costal margin. The procedure involved pneumoperitoneum induction (12 mmHg), introduction of laparoscopic instruments, dissection of Calot's triangle, gallbladder separation from the liver bed, and extraction of the specimen through the umbilical port. The drain was inserted through the 5-mm side port in case the operator deemed it necessary (due to damage to the liver capsule and damage to the gallbladder wall with bile leakage). For regional anaesthesia, 20 mL of 0.25% bupivacaine diluted with saline was used. To ensure consistency across groups, all patients receiving regional techniques were administered the same volume and concentration of local anaesthetic during the initial intraoperative phase.

Treatment

In the LAI group, the fascia at the optical trocar site was infiltrated with local anaesthetic after the skin incision and before trocar insertion. The remaining anaesthetic was administered into the interfascial planes at the other trocar sites under laparoscopic visualisation. The total 20-mL dose of 0.25% bupivacaine was evenly distributed among the four port sites. In the L-TAP group, a unilateral block was performed immediately after laparoscope insertion into the peritoneal cavity. A needle was inserted 2 cm below the costal margin along the right mid-axillary line (1–2 fingerbreadths below the palpable lower edge of the 10th rib), targeting the plane between the internal oblique and transversus abdominis muscles at the T6 dermatome. Correct needle placement was confirmed by the appearance of Doyle's bulge, characterised by distension of the internal oblique muscle fibres visualised through the parietal peritoneum. A total of 20 mL of 0.25% bupivacaine was used for the L-TAP block. In the L-TAP+LAI group, a combination of both techniques was employed. Ten millilitres of 0.25% bupivacaine were used for the L-TAP block, and the remaining 10 mL were administered via wound infiltration following the same protocol as the LAI group. The total volume of 0.25% bupivacaine (20 mL) was similar between LAI, L-TAP, and L-TAP+LAI groups. In the control group, no regional anaesthesia was administered, and postoperative pain was managed exclusively with intravenous agents. All patients received standardised postoperative analgesia. Metamizole was administered at 6, 12, 18, and 24 hours postoperatively, except when the pain intensity was 0–1 on the NRS or if a patient received oxycodone. Paracetamol was added when pain intensity exceeded 4, and oxycodone when pain intensity exceeded 6 on the NRS. In the case of strong pain represented by NRS exceeding 8, the patients received a combination of paracetamol and oxycodone. The patients were brought into a vertical position in the 4th hour after the procedure of LC.

Study outcomes and outcome measures

The primary outcome was the pain intensity measured using the Numerical Rating Scale (NRS) after the surgery and at 2, 6, and 24 hours postoperatively. The time points were selected based on the duration of action of bupivacaine [8], and in the case of 24 hours – on the basis of the concept of pre-emptive analgesia, which assumes that blocking the generation of pain stimuli in the initial phase of the procedure (during the period of active action of bupivacaine) limits the development of peripheral and central sensitisation, reducing the intensity of pain after the direct pharmacological effect of the drug has subsided [9]. The secondary outcomes were as follows: (i) the number of patients requiring postoperative administration of metamizole, paracetamol, or oxycodone at 6, 12, 18, and 24 hours after the surgery; (ii) localized pain intensity at umbilical, substernal, and subcostal wound sites measured with NRS after the surgery and at 2, 6, and 24 hours postoperatively; (iii) local postoperative complications assessed by Clavien-Dindo classification. Data on gallbladder calculus size, drain insertion, and the duration of surgery were recorded for each patient.

Sample size and statistical analysis

Participants were recruited consecutively from eligible patients scheduled for laparoscopic cholecystectomy during the study period. Descriptive statistics for demographic and clinical characteristics were presented according to the data distribution. The normality of data distribution was assessed with the Shapiro-Wilk test. Group comparisons for categorical variables were compared using the chi^2 test or the Fisher-Freeman-Halton test for contingency tables with low expected frequencies (<5). For non-normally distributed continuous variables, the Kruskal–Wallis test was applied. Following a significant result, post hoc pairwise comparisons were conducted using Dunn's test to control for multiple testing. $P<0.05$ was accepted as being statistically significant. Analysis was done using Statistica Software version 13 (StatSoft Polska Sp. z o.o.) and R Studio Statistical Software version 4.0.2 (2020-06-22).

Results

Characteristic of the study population

A total of 177 patients were assessed for eligibility, of whom 160 were randomised and included in the study. The reasons for exclusion from the study were as follows: ASA physical status III–IV, acute cases of cholecystitis, and lack of consent. Forty patients were allocated to each group: LAI, L-TAP, L-TAP+LAI, and control, as shown in Figure 1. The median age was 59.5 years (IQR: 46.0–71.0). Women comprised 68.1% of the study population (n=109). Thirty-five patients (21.2%) were smokers, and 42 (26.2%) had a BMI of 30 kg/m^2 or higher. The median BMI was 27.3 kg/m^2 (IQR: 24.2-30.1).

There were no significant differences among the four groups in terms of baseline demographics, ASA status, surgical complications, gallbladder calculus size, or drain insertion, and the duration of surgery. Bupivacaine was administered 3 to 7 minutes after the beginning of the surgery. Detailed characteristics of patients are presented in Table 1.

Primary outcome

Significant differences in NRS score between groups were found at 2, 6, and 24 hours after the surgery (Kruskal-Wallis test, $P<0.05$) but not directly after the surgery. Post hoc analysis using Dunn's test showed that at 2 hours after the surgery the median NRS score was significantly lower in the L-TAP vs. the LAI group (median [IQR]: 3.0 [2.0-4.0] vs. 4.0 [3.5-5.0], $P=0.003$), while no other pairwise differences were observed. At 6 hours, it was lower in the L-TAP vs. LAI (3.0 [2.0-4.0] vs. 3.0 [3.0-5.0], post hoc Dunn's test *P*=0.015) and the L-TAP+LAI (3.0 [2.0-4.0] vs. 3.0 [3.0-4.0], post hoc Dunn's test *P*=0.046) groups. At 24 hours, pain intensity was significantly lower in the L-TAP group vs. the LAI group (1.0 [0.0-2.0] vs. 2.0 [2.0-3.0], post hoc Dunn's test *P*<0.001), the L-TAP+LAI group (1.0 [0.0-2.0] vs. 2.0 [1.5-3.0], post hoc Dunn's test *P*<0.001), and the control group (1.0 [0.0-2.0] vs. 2.0 [1.0-3.0], post hoc Dunn's test *P*=0.009) (Figure 2). Pain scores in each group declined with time (*P*<0.001).

Secondary outcomes

Analgesic use was similar across groups, except for highest paracetamol use in the control group at 6 hours postoperatively (*P*<0.001) and lowest metamizole use in the control group at 24 hours postoperatively (*P*<0.001) (Table 2).

Pain intensity at individual wound sites (umbilical, subcostal, and substernal) showed significant differences between the LAI and L-TAP groups. In the L-TAP group the median NRS score at umbilical and substernal wound at 24 hours post-surgery was lower than in the LAI group (median [IQR]: 1.0 [0.5-2.0] vs 2.0 [1.5-3.0], post hoc Dunn's test *P*=0.007 and 2.0 [1.0-3.0] vs 1.0 [0.5-2.0], post hoc Dunn's test *P*<0.001, respectively). Subcostal pain was lower in the L-TAP group than in the LAI group at 2, 6, and 24 hours postoperatively (3.0 [2.0-3.0] vs. 3.0 [3.0-5.0], post hoc Dunn's test *P*=0.008, 2.0 [2.0-3.0] vs 3.0 [2.0-4.0], post hoc Dunn's test *P*=0.01, and 1.0 [0.5-2.0] vs. 2.0 [1.0-3.0], post hoc Dunn's test *P*<0.001, respectively). A significant difference in subcostal pain at 6 hours was noted between the LAI and control groups (post hoc Dunn's test *P*=0.002). There were no differences between other groups and timepoints (Table 3).

The most frequent postoperative complication was ecchymosis at the regional anaesthesia site, observed in 12 patients. No wound dehiscence was reported. All complications were classified as grades I or IIa in Clavien-Dindo classification. Group-specific complications are summarised in Table 4.

Discussion

This randomised study compared the analgesic effectiveness and safety of unilateral L-TAP block, LAI, and their combination in patients undergoing LC. The results demonstrated that unilateral L-TAP block provided the most consistent pain relief, with a significantly lower NRS score within 24 hours postoperatively. Importantly, many studies employed ultrasound-guided TAP-blocks [10-13] and bilateral L-TAP blocks [14-26], whereas unilateral L-TAP block in LC is rarely investigated [27,28]. Cevikkalp et al. compared the analgesic effectiveness of bilateral L-TAP block, unilateral L-TAP block, LAI, and standard anaesthesia in LC. The results did not show considerable differences in pain score (apart from lower pain score in bilateral L-TAP block 1 hour postoperatively) and no differences in rescue analgesic use. The study by Venkatraman et al. demonstrated that unilateral L-TAP block was a suitable alternative to ultrasound-guided block in LC. Therefore, our findings together with the available literature on unilateral L-TAP block suggest that a single, intraoperative, unilateral L-TAP block can offer postoperative pain control in LC comparable to or better than other techniques. This approach may reduce procedural time and cost, aligning with Enhanced Recovery After Surgery (ERAS) principles that emphasise efficiency and opioid-sparing analgesia [29]. In this context, intraoperative nerve-targeted analgesia has been proposed as an adjunct to multimodal pain management in minimally invasive procedures [30-32].

The superiority of the L-TAP block over LAI observed in our study is consistent with previous trials. Ra et al. [10] reported significantly lower pain scores at all time points within the first 24 hours following bilateral ultrasound-guided TAP with levobupivacaine. A meta-analysis of 668 patients across 10 randomized controlled trials reported that TAP block significantly reduced resting and movement-associated pain scores, as well as opioid consumption, with a lower incidence of postoperative nausea and vomiting [14]. Similarly, a randomized, double-blind trial in 80 patients found lower NRS scores in the TAP group compared to the periportal LAI, both at rest and during coughing [15]. Another trial including 86 patients undergoing LC showed that a bilateral subcostal L-TAP block with 0.25% bupivacaine provided superior pain relief at 30 minutes postoperatively, with 37% of patients requiring no rescue analgesia [16]. Importantly, this approach was approximately 20 times less costly than ultrasound-guided TAP, while offering similar analgesia [16]. Soytürk et al. [17] also reported no difference in pain intensity or opioid consumption between laparoscopic and ultrasound-guided TAP, suggesting the potential cost-effectiveness of the laparoscopic approach.

The L-TAP and LAI combination in our study did not enhance pain relief, which was observed also by others. This finding should be interpreted in the context of split local anaesthetic volumes used in the combined group (10 mL per technique). Therefore, this comparison reflects the effect of combined techniques at reduced individual volumes rather than a pure assessment of potential synergistic benefit. Di Mauro et al. [18] reported no additional benefit from combining TAP with LAI. A separate trial from Sri Lanka even found higher pain scores at 6 hours postoperatively in the combined group compared to LAI alone [19]. Importantly, the effectiveness of the TAP block has been reported to rely on the volume rather than the concentration of the local anaesthetic [20]. Therefore, the weaker analgesic effect in the L-TAP+LAI group may have resulted from the fact that the volumes administered during L-TAP and into the interfascial plane were 2 times lower (10 mL) than volumes in groups treated by either LAI or L-TAP (20 mL). Although the total volumes and concentration of bupivacaine were similar in all groups, the dispersion of this drug may have differed.

Our study's assessment of wound-specific pain offers additional insight. The L-TAP group experienced significantly lower subcostal pain than the LAI group at multiple time points. This finding aligns anatomically with the TAP block effect on the thoracolumbar nerves (T6–L1), which innervate the subcostal and substernal regions [4, 33]. However, the sensory coverage of a TAP block can vary based on the approach used. Cadaveric and imaging studies have shown that classic TAP blocks typically cover T7–L1, while ultrasound-guided approaches more commonly span T10–L1 [34,35]. In contrast, LAI primarily targets peripheral nociceptors at the incision site, effectively reducing somatic incisional pain but potentially offering less relief for deeper or more complex innervation patterns [36].

In our study, overall analgesic requirements declined over time across all groups; however, total opioid and non-opioid consumption did not differ significantly between them. In contrast, pain intensity showed significant differences and was lowest in the L-TAP group starting from 2 hours postoperatively. These findings are consistent with previous studies demonstrating improved pain scores with TAP blocks without a corresponding reduction in total analgesic use [15]. Although not demonstrated in our study, there is growing evidence supporting the ability of TAP blocks to reduce opioid requirements, particularly during the critical first 24 hours when pain is most intense. Minimising opioid exposure remains a clinical priority due to associated risks such as nausea, delayed gastrointestinal recovery, and dependency [29,37]. A meta-analysis in laparoscopic colorectal surgery confirmed the benefit of TAP blocks in reducing postoperative opioid use on day one, without increasing the incidence of complications [38]. Another meta-analysis including 48 clinical studies on TAP block during LC reported that TAP block decreases opioid consumption significantly and provides effective analgesia [39].

Comparative studies between TAP block and trocar-site LAI remain limited. This represents an important gap, as port-site LAI continues to be a widely used practice [40-43]. In one study, unilateral subcostal ultrasound-guided TAP block was reported to be associated with lower opioid consumption than port-site LAI [40], whereas in the study by Cevikkalp et al. [27] no differences between these 2 techniques were found in terms of pain score and use of rescue analgesics. Three studies concerning comparison of other block types with LAI demonstrated that blocking procedures provide superior analgesia to LAI (external oblique intercostal and rectus sheath block [41], erector spinae plane block [42], and thoracoabdominal nerve block [43]). Moreover, LAI has been also shown to provide less pain relief comparing to epidural analgesia in surgical hepatectomy [44].

Complication data reaffirm the safety of TAP blocks, which are associated with a low rate of adverse events [45]. In our study, ecchymosis occurred significantly more frequently in the LAI group, probably due to the superficial nature and multiple punctures inherent in LAI, in contrast to the single, deeper injection used in the L-TAP approach. Signs of local wound irritation, such as redness and swelling, appeared only in the LAI and L-TAP+LAI groups. While not classifiable as wound infections, these findings suggest greater tissue reactivity with techniques involving multiple punctures. The L-TAP block, characterised by a single deep injection, appeared to be better tolerated and may offer a more favourable safety profile in the early postoperative period. Rates of haematoma and wound dehiscence were low across all groups and consistent with earlier reports [46,47].

Key strengths of this study are the randomised design with balanced distribution of participants across intervention arms and the inclusion of three regional techniques within the same study framework. Moreover, evaluation of postoperative pain at multiple anatomical sites offers a nuanced understanding of analgesic effectiveness across different wound locations. The study's main limitations include the lack of a formal *a priori* sample size calculation and the small, relatively homogeneous study population, which may hinder the analysis and the detection of secondary outcomes, especially differences in opioid consumption. The extrapolation of the study results to higher-risk patients or to those undergoing emergency surgery is also difficult. The single-centre study design may also limit the generalisability of the results. The follow-up period was restricted to 24 hours, precluding conclusions about chronic pain, delayed recovery, and long-term safety. Another limitation, already addressed above, is that in the L-TAP+LAI group the bupivacaine volumes administered during L-TAP and into the interfascial plane were 2 times lower than in the LAI or L-TAP groups, which could have introduced differences in the drug dispersion in tissue. Finally, the observed pain reduction in the L-TAP group was not large and lower than values considered clinically significant by some authors [48,49], but it still indicates that L-TAP block is at least as good as other regional anaesthesia techniques studied.

Conclusions

Unilateral, L-TAP proved to be a safe and effective analgesic technique for patients undergoing LC during first 24 hours after the surgery. It resulted in lower pain scores and fewer wound-related complications compared to LAI. Importantly, the combination of L-TAP and LAI at split volumes did not provide better analgesic effect than L-TAP alone. The use of L-TAP may be a practical alternative to more complex or invasive regional anaesthesia techniques.

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Contribution statement

ŁD - Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Writing – Original Draft

MK - Writing - review & editing, Project administration

KO - Data analysis, Formal analysis

ND-G - Writing - review & editing, Supervision

JG - Writing - review & editing, Supervision

All authors read and approved the final manuscript.

AI statement

Artificial intelligence was not used in the preparation of this manuscript.

Conflict of interest

The Authors declare no conflict of interest

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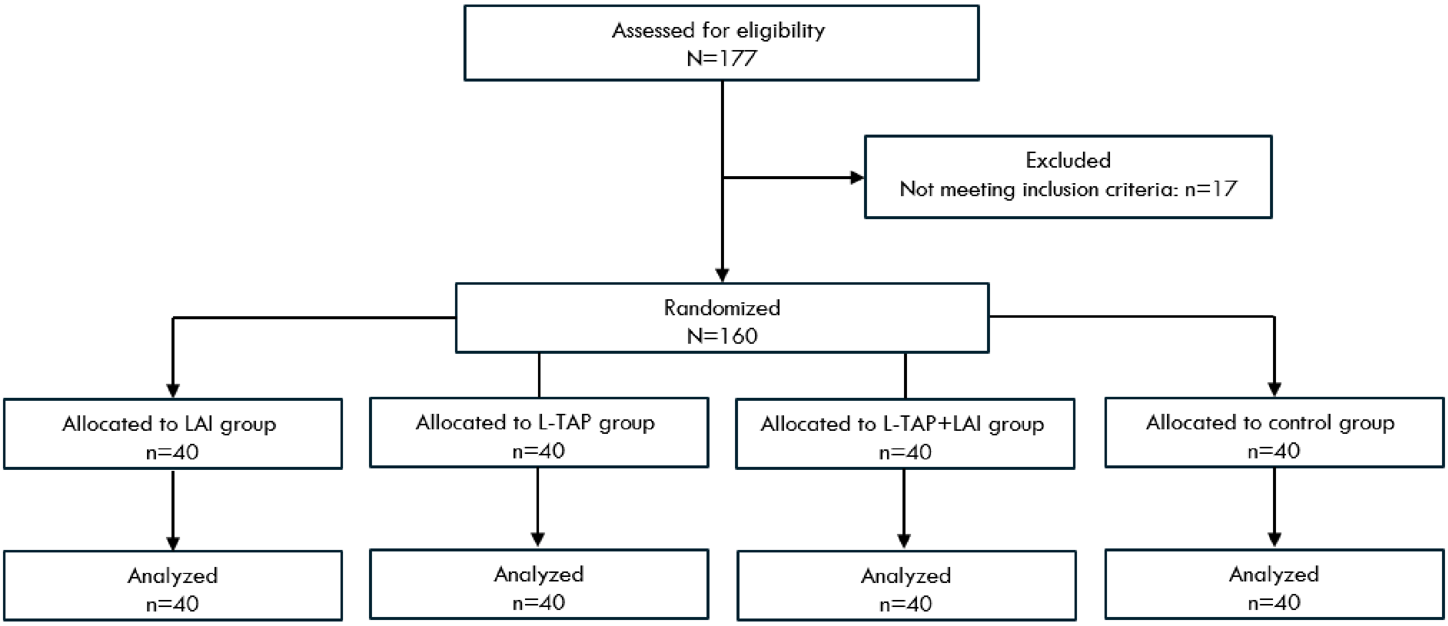

Figure 1. Patient flow diagram (according to Consolidated Standards of Reporting Trials [CONSORT]). LAI – local anaesthetic infiltration; L-TAP – laparoscopy-assisted transversus abdominis plane block; L-TAP+LAI – combination of laparoscopy-assisted transversus abdominis plane block and local anaesthetic infiltration.

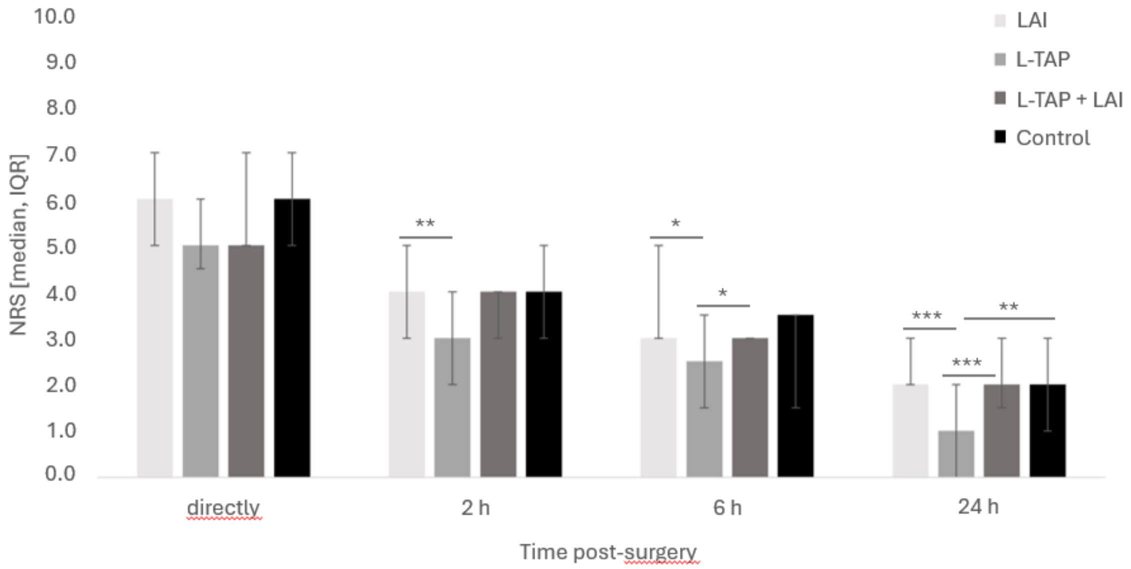

Figure 2. The intensity of pain in the study groups measured by Numerical Rating Scale (NRS) directly, 2 hours, 6 hours, and 24 hours postoperatively. The statistical significance of the differences is indicated by asterisks: * $p<0.05$; ** $p<0.01$; *** $p<0.001$ (Kruskal-Wallis test). IQR – interquartile range; LAI – local anaesthetic infiltration; L-TAP – laparoscopy-assisted transversus abdominis plane block; L-TAP+LAI – combination of laparoscopic-assisted transversus abdominis plane block and local anaesthetic infiltration; NRS - Numerical Rating Scale.

Table 1. Characteristics of patients in the four study groups.

		LAI (n=40)	L-TAP (n=40)	L-TAP+LAI (n=40)	Control (n=40)	*P*-value
Age, years	median (IQR)	62.0 (47.0-72.0)	62.0 (45.0-71.2)	58.0 (52.0-71.2)	56.0 (44.2-63.0)	0.37[a]
Sex	female, n (%)	24 (60.0)	24 (60.0)	32 (80.0)	29 (72.5)	0.14[b]
	male, n (%)	16 (40.0)	16 (40.0)	8 (20.0)	11 (27.5)	
BMI, kg/m^2	median (IQR)	27.8 (25.8-30.5)	27.7 (24.6-30.9)	25.6 (23.9-28.7)	26.5 (23.8-31.5)	0.43[a]
Smoking	smokers, n (%)	11 (27.5)	4 (10.0)	12 (30.0)	7 (17.5)	0.10[b]
	non-smokers, n (%)	29 (82.5)	36 (90.0)	28 (70.0)	33 (82.5)	
ASA classification	median (IQR)	2 (1-2)	2 (1-2)	2 (1-2)	2 (1-2)	0.97[a]

Drain insertion, n (%)	yes no	19 (47.0) 21 (53.0)	16 (40.0) 24 (60.0)	22 (55.0) 18 (45.0)	16 (40.0) 24 (60.0)	0.48[b]
Size of gallbladder calculi, mm	median (IQR)	15.0 (10.0-20.0)	15.0 (10.0-25.0)	20.0 (15.0-30.0)	17.5 (9.0-30.0)	0.06[a]
Duration of surgery, min	median (IQR)	55.0 (50.0-70.0)	55.0 (50.0-65.0)	55.0 (50.0-65.0)	55.0 (45.0-65.0)	0.93[a]
Complications during surgery, n (%)	yes no	0 (0.0) 40 (100.0)	0 (0.0) 40 (100.0)	0 (0.0) 40 (100.0)	1 (2.0) 39 (98.0)	1.00[b]

Abbreviations: BMI – body mass index; IQR – interquartile range; LAI – local anaesthetic infiltration; L-TAP – laparoscopy-assisted transversus abdominis plane block; L-TAP+LAI – combination of laparoscopic-assisted transversus abdominis plane block and local anaesthetic infiltration; NA – not applicable.

[a]Kruskal–Wallis test, [b]chi^2 test, or Fisher-Freeman-Halton test.

Table 2. The numbers of patients needing analgesics.

Medication type	**Time post-surgery**	**LAI (n=40)**	**L-TAP (n=40)**	**L-TAP+LAI (n=40)**	**Control (n=40)**	***P*-value[a]**
Metamizol, n (%)						
	6 h	40 (100.0)	38 (95.0)	36 (90.0)	37 (92.5)	0.25
	12 h	39 (97.5)	37 (92.5)	35 (87.5)	40 (100.0)	0.08
	18 h	37 (92.5)	35 (87.5)	36 (90.0)	32 (80.0)	0.45
	24 h	36 (90.0)	32 (80.0)	34 (85.0)	21 (52.5)	<0.001
Paracetamol, n (%)						
	6 h	5 (12.5)	3 (7.5)	7 (17.5)	19 (47.5)	<0.001
	12 h	7 (17.5)	4 (10.0)	11 (27.5)	9 (22.5)	0.21
	18 h	6 (15.0)	0 (0.0)	5 (12.5)	6 (15.0)	0.04
	24 h	1 (2.5)	1 (2.5)	4 (10.0)	2 (5.0)	0.53
Oxycodone, n (%)						
	6 h	6 (15.0)	4 (10.0)	3 (7.5)	9 (22.5)	0.26
	12 h	3 (7.5)	1 (2.5)	2 (5.0)	3 (7.5)	0.88
	18 h	1 (2.5)	0 (0.0)	1 (2.5)	0 (0.0)	1.00
	24 h	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.00

Abbreviations: LAI – local anaesthetic infiltration. L-TAP – laparoscopy-assisted transversus abdominis plane block; L-TAP+LAI – combination of laparoscopy-assisted transversus abdominis plane block and local anaesthetic infiltration.

[a] Fisher-Freeman-Halton test.

Table 3. Pain intensity at umbilical, substernal, and subcostal wounds.

Pain localization	**Time post-surgery**	**LAI (n=40)**	**L-TAP (n=40)**	**L-TAP+LAI (n=40)**	**Control (n=40)**	***P*-value[a]**
Umbilical wound, NRS median (IQR)						
	directly	6.0 (5.0-7.0)	5.0 (4.5-6.0)	5.0 (4.5-6.0)	6.0 (5.0-7.5)	0.05
	2 h	5.0 (4.0-5.0)	4.0 (3.0-5.0)	4.0 (3.0-5.0)	5.0 (3.0-6.0)	0.28
	6 h	4.0 (3.0-5.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)	3.0 (1.5-4.0)	0.04
	24 h	2.0 (1.5-3.0)	1.0 (0.5-2.0)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.009
Substernal wound, NRS median (IQR)						
	directly	3.0 (3.0-4.0)	3.0 (2.0-3.0)	3.0 (3.0-4.0)	3.0 (2.0-4.0)	0.02
	2 h	3.0 (3.0-3.0)	3.0 (2.0-3.0)	3.0 (3.0-3.0)	3.0 (2.0-4.0)	0.05
	6 h	3.0 (2.0-3.0)	2.0 (2.0-3.0)	3.0 (2.0-3.0)	2.0 (1.0-3.0)	0.05
	24 h	2.0 (1.0-3.0)	1.0 (0.5-2.0)	2.0 (1.0-2.0)	1.0 (0.0-3.0)	<0.001
Subcostal wound, NRS median (IQR)						
	directly	3.0 (3.0-5.0)	3.0 (2.0-4.0)	3.0 (2.5-5.0)	4.0 (2.0-4.0)	0.19
	2 h	3.0 (3.0-5.0)	3.0 (2.0-3.0)	3.0 (3.0-4.0)	3.0 (2.0-4.0)	0.004
	6 h	3.0 (2.0-4.0)	2.0 (2.0-3.0)	3.0 (2.0-3.0)	2.0 (1.0-3.0)	<0.001

24 h	2.0 (1.0-3.0)	1.0 (0.5-2.0)	2.0 (1.0-2.0)	1.0 (0.0-3.0)	<0.001

Abbreviations: IQR – interquartile range; LAI – local anaesthetic infiltration; L-TAP – laparoscopy-assisted transversus abdominis plane block; L-TAP+LAI – combination of laparoscopy-assisted transversus abdominis plane block and local anaesthetic infiltration; NRS – Numerical Rating Scale.

[a]Kruskal–Wallis test.

Table 4. Local postoperative complications.

Postoperative complication	**LAI (n=40)**	**L-TAP (n=40)**	**L-TAP+LAI (n=40)**	**Control (n=40)**	***P*-value[a]**
Ecchymosis at the injection site, n (%)	8 (20.0)	1 (2.5)	3 (7.5)	NA	0.04
Postoperative wound infection, n (%)	2 (5.0)	0 (0.0)	2 (5.0)	0 (0.0)	0.33
Postoperative wound hematoma, n (%)	0 (0.0)	0 (0.0)	1 (2.5)	1 (2.5)	1.00
Other complications, n (%)	2 (5.0)	0 (0.0)	0 (0.0)	1 (2.5)	0.62

Abbreviations: LAI – local anaesthetic infiltration; L-TAP – laparoscopy-assisted transversus abdominis plane block; L-TAP+LAI – combination of laparoscopy-assisted transversus abdominis plane block and local anaesthetic infiltration; NA – not applicable.

[a]Fisher-Freeman-Halton test.

Short title

Unilateral laparoscopic-guided abdominal wall block in cholecystectomy