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Original Research Article

Ultrasound-Guided Subcostal Transversus Abdominis Plane Block versus Port-Site Infiltration with Bupivacaine for Analgesia after Laparoscopic Cholecystectomy: A Randomised Assessor-Blinded Comparative Study

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Conflict of interest: Nil

Abstract

Background: Pain after laparoscopic cholecystectomy arises from trocar wounds, peritoneal irritation, diaphragmatic stimulation, and visceral manipulation. Port-site infiltration is simple and is recommended as a basic procedure-specific intervention, whereas ultrasound-guided subcostal transversus abdominis plane (TAP) block may provide wider somatic coverage but requires additional expertise.

Objective: To compare the analgesic efficacy and safety of bilateral ultrasound-guided subcostal TAP block with local port-site infiltration when the total bupivacaine dose and background multimodal analgesia are standardised.

Methods: This study describes a prospective, randomised, assessor-blinded, parallel-group study of 100 adults undergoing elective four-port laparoscopic cholecystectomy. Participants received either bilateral subcostal TAP block using 15 mL of 0.25% bupivacaine per side or full-thickness infiltration of the four port sites using 30 mL of 0.25% bupivacaine in total. The primary outcome was cumulative rescue tramadol during the first 24 postoperative hours. Secondary outcomes were pain scores at rest and with movement, time to first rescue analgesic, postoperative nausea or vomiting, shoulder-tip pain, satisfaction, and adverse events.

Results: In our study we found out, mean 24-hour tramadol consumption was 84.0 ± 71.7 mg after TAP block and 137.0 ± 80.1 mg after infiltration (mean difference -53 mg, 95% CI -83 to -23; p = 0.001; Cohen d = -0.70). Time to first rescue analgesic was longer after TAP block (408.3 ± 208.1 versus 233.1 ± 188.6 minutes; mean difference 175 minutes, 95% CI 96 to 254; p < 0.001). Rest and movement pain scores were lower through six hours, but group differences narrowed by 12 hours and were absent at 24 hours. Postoperative nausea or vomiting occurred in 22% and 32% of participants, respectively (risk ratio 0.69, 95% CI 0.36 to 1.33). No serious local-anaesthetic-related event occurred.

Conclusion: Within this study, ultrasound-guided subcostal TAP block produced an early opioid-sparing advantage over port-site infiltration despite an equal bupivacaine dose.

Keywords: Bupivacaine; Laparoscopic Cholecystectomy; Postoperative Analgesia; Port-Site Infiltration; Transversus Abdominis Plane Block; Ultrasound Guidance.

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Introduction

In the early recovery period after laparoscopic cholecystectomy, patients commonly describe a mixture of incisional discomfort, deep upper abdominal pain, and shoulder-tip pain. Trocar wounds generate somatic nociception, gallbladder dissection and peritoneal traction contribute visceral input, and residual carbon dioxide can irritate the diaphragm and produce referred pain. The result is a procedure-specific pain pattern that often peaks during the first postoperative hours and then declines unevenly (Bisgaard, 2006; Joris et al., 1995; Wills & Hunt, 2000). Contemporary perioperative practice therefore relies on multimodal analgesia. Paracetamol and a nonsteroidal anti-inflammatory drug or cyclo-oxygenase-2 inhibitor usually form the baseline, while dexamethasone may assist both analgesia and control of postoperative nausea and vomiting. Opioids are better reserved for rescue because sedation, nausea, dizziness, ileus, and respiratory depression work against rapid mobilisation and day-case discharge (Bourgeois et al., 2024; Chou et al., 2016; Gan, 2017). Local anaesthetic techniques fit naturally into this strategy because they target afferent input without adding central opioid effects. In port-site infiltration, the surgeon deposits long-acting local anaesthetic along the skin, fascia, muscle, and peritoneal end of each trocar tract. The method is inexpensive, quick, and embedded in wound closure. Updated PROSPECT recommendations continue to support port-site infiltration as a basic intervention, ideally with a long-acting agent and alongside non-opioid analgesics (Bourgeois et al., 2024). Its limitation is equally clear: analgesia is concentrated around small wound fields and cannot be expected to treat visceral or diaphragmatic pain.

The transversus abdominis plane is a neurofascial compartment between the internal oblique and transversus abdominis muscles. Injection within this plane can interrupt anterior abdominal-wall afferents before they divide into smaller terminal branches. Ultrasound guidance permits direct identification of the muscle layers, confirmation of needle position, and visualisation of local anaesthetic spread (Hebbard et al., 2007; McDonnell et al., 2007b).

Direct comparisons have not produced a single uncomplicated answer. Some randomised studies found better early analgesia and lower opioid use after subcostal TAP block than after port infiltration (Suseela et al., 2018; Tolchard et al., 2012), whereas other studies reported smaller or inconsistent gains once background multimodal analgesia was strong (Houben et al., 2019). A trial-sequential meta-analysis favoured TAP block overall, but differences in block approach, local anaesthetic dose, timing, rescue protocol, and pain measurement limited certainty (Grape et al., 2021).

Dose imbalance is a recurring methodological problem. A larger total volume or dose in the TAP group can make a technique appear superior even when the difference is pharmacological rather than anatomical. The present study therefore keeps the nominal bupivacaine dose constant and changes only its distribution. The primary hypothesis is that bilateral ultrasound-guided subcostal TAP block will reduce 24-hour rescue tramadol compared with full-thickness port-site infiltration. Secondary hypotheses concern early pain intensity, time to rescue, opioid-related symptoms, satisfaction, and safety.

Materials and Methods

The investigation is a prospective, randomised, assessor-blinded, parallel-group active-comparator trial. The study follows the logic of the CONSORT 2010 statement for parallel-group randomised trials and uses SPIRIT principles for protocol transparency (Chan et al., 2013; Schulz et al., 2010).

The study was conducted in accordance with the Declaration of Helsinki, national ethical guidance, and good clinical practice. Written informed consent has been obtained by an investigator who is not linked to the patient's clinical decision.

Methods

In the TAP group, a high-frequency linear ultrasound transducer is placed below the costal margin and moved medially to laterally until the rectus abdominis, transversus abdominis, and internal oblique layers are identified. A block needle is advanced in plane. After negative aspiration and a small test injection, 15 mL of 0.25% bupivacaine is deposited between the internal oblique and transversus abdominis muscles on each side. Correct injection produces a smooth hypoechoic separation of the fascial plane. In the infiltration group, the surgeon distributes 30 mL of 0.25% bupivacaine through the skin, subcutaneous tissues, fascial tract, muscle layers, and peritoneal end of the four port sites. The nominal dose in each group is 75 mg.

Inclusion Criteria: Adults aged 18 to 65 years with American Society of Anesthesiologists physical status I or II, weighing between 50 kilograms to 80 kilograms and scheduled for elective four-port laparoscopic cholecystectomy under general anaesthesia are eligible.

Exclusion Criteria:

1. Refusal
2. Pregnancy or lactation
3. Allergy to amide local anaesthetics
4. Clinically significant hepatic, renal, cardiac, neurological, or psychiatric disease
5. Chronic opioid use, coagulopathy
6. Infection at an injection site
7. Conversion to open surgery
8. Additional intra-abdominal procedure
9. Inability to use the numerical rating scale.

A computer-generated sequence with variable block sizes allocated participants in a 1:1 ratio. Sequentially numbered, opaque, sealed envelopes were used to preserve concealment until the intervention is prepared. Participants, post-anaesthesia care nurses, ward assessors, data analysts, and the investigator recording outcomes were unaware of allocation.

Standardised anaesthetic and surgical care was given to every patient.

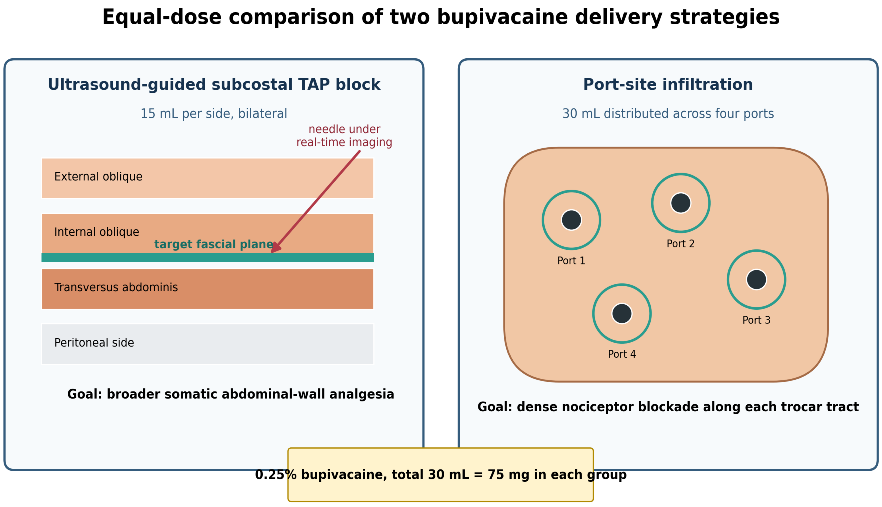

Figure 1: Anatomical and procedural comparison of bilateral ultrasound-guided subcostal TAP block and local port-site infiltration.

Outcomes and follow-up: The primary outcome is cumulative rescue tramadol in the first 24 postoperative hours. Pain intensity is recorded on an 11-point numerical rating scale from 0, no pain, to 10, worst imaginable pain, at arrival in recovery and at 1, 2, 4, 6, 12, and 24 hours. Scores are obtained both at rest and during a standardised movement such as sitting up or deep inspiration. Rescue tramadol is administered when NRS is at least 4 or when the participant requests additional analgesia, with dose intervals and maximum daily dose fixed in advance. Secondary outcomes are time to first rescue, proportion remaining rescue-free at six hours, postoperative nausea or vomiting, shoulder-tip pain, sedation, satisfaction on a five-point scale, and intervention-related adverse events.

Results

Participant flow and baseline characteristics: The study contains 112 patients, of whom 12 were excluded before randomisation. One hundred participants were allocated equally, received the assigned intervention, completed 24-hour follow-up, and were included in the intention-to-treat analysis.

Table 1: Baseline and perioperative characteristics. Values are mean ± SD or n (%). Baseline p values are descriptive.

Characteristic	USG-TAP (n = 50)	Port infiltration (n = 50)	p value
Age, years	42.3 ± 9.8	44.9 ± 9.0	0.177
Body mass index, kg/m²	26.0 ± 3.9	25.2 ± 3.4	0.297
Duration of surgery, min	64.8 ± 14.9	60.8 ± 11.5	0.137
Duration of anaesthesia, min	92.4 ± 16.4	90.6 ± 11.4	0.517
Intraoperative fentanyl, µg	107.3 ± 21.6	105.4 ± 17.9	0.625
Female sex	30 (60%)	31 (62%)	1.000
ASA physical status II	21 (42%)	20 (40%)	1.000

The two groups were similar in age, sex distribution, body mass index, ASA physical status, operative duration, anaesthesia duration, and intraoperative fentanyl exposure. Small numerical differences were not clinically concerning and no post-randomisation adjustment was triggered by the baseline profile.

Primary outcome and rescue analgesia: Mean 24-hour rescue tramadol consumption was 84.0 ± 71.7 mg in the TAP group and 137.0 ± 80.1 mg in the infiltration group. The mean difference was -53 mg (95% CI -83 to -23; p = 0.001), corresponding to a moderate standardised effect (Cohen d = -0.70). Median consumption was 75 mg (IQR 50 to 100) and 150 mg (IQR 100 to 200), respectively. Time to first rescue was prolonged by a mean of 175 minutes (95% CI 96 to 254; p < 0.001).

Twenty-eight TAP participants and eight infiltration participants remained rescue-free at six hours.

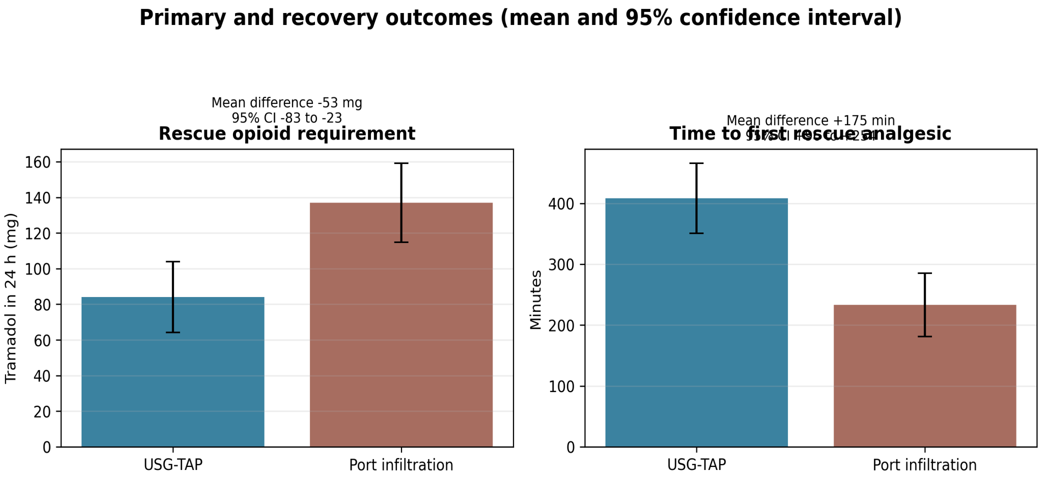

Figure 2: Twenty-four-hour rescue tramadol consumption and time to first rescue analgesic. Bars show means and 95% confidence intervals.

Pain intensity over time

Table 2: Postoperative numerical rating scale scores. Values are mean ± SD; pointwise p values are Mann-Whitney tests and should be interpreted as secondary analyses.

Time, h	Rest: TAP	Rest: infiltration	p	Movement: TAP	Movement: infiltration	p
0	3.12 ± 0.94	3.82 ± 0.80	<0.001	4.34 ± 1.06	5.10 ± 0.76	<0.001
1	2.80 ± 0.76	3.48 ± 0.93	<0.001	4.00 ± 0.70	4.72 ± 0.95	<0.001
2	2.40 ± 0.97	3.20 ± 0.78	<0.001	3.54 ± 1.05	4.48 ± 0.89	<0.001
4	2.08 ± 0.97	2.84 ± 0.87	<0.001	3.34 ± 1.21	4.02 ± 1.02	0.004
6	1.80 ± 0.76	2.34 ± 0.80	<0.001	3.10 ± 0.95	3.44 ± 0.99	0.079
12	1.56 ± 0.79	1.82 ± 0.80	0.081	2.70 ± 0.86	3.06 ± 0.93	0.047
24	1.12 ± 0.82	1.14 ± 0.83	0.898	2.34 ± 0.92	2.38 ± 0.95	0.734

Pain scores at rest were lower in the TAP group from recovery arrival through six hours. The largest observed mean rest difference occurred at two hours, when scores were 2.40 ± 0.97 after TAP block and 3.20 ± 0.78 after infiltration, a mean difference of -0.80 (95% CI -1.15 to -0.45). Movement pain followed a similar pattern and was approximately one point lower at two hours. By 12 hours, the rest difference was small, and by 24 hours both rest and movement scores were nearly identical. A participant-clustered repeated-measures study showed group-by-time interactions for pain at rest and with movement, consistent with an early benefit that attenuated over time.

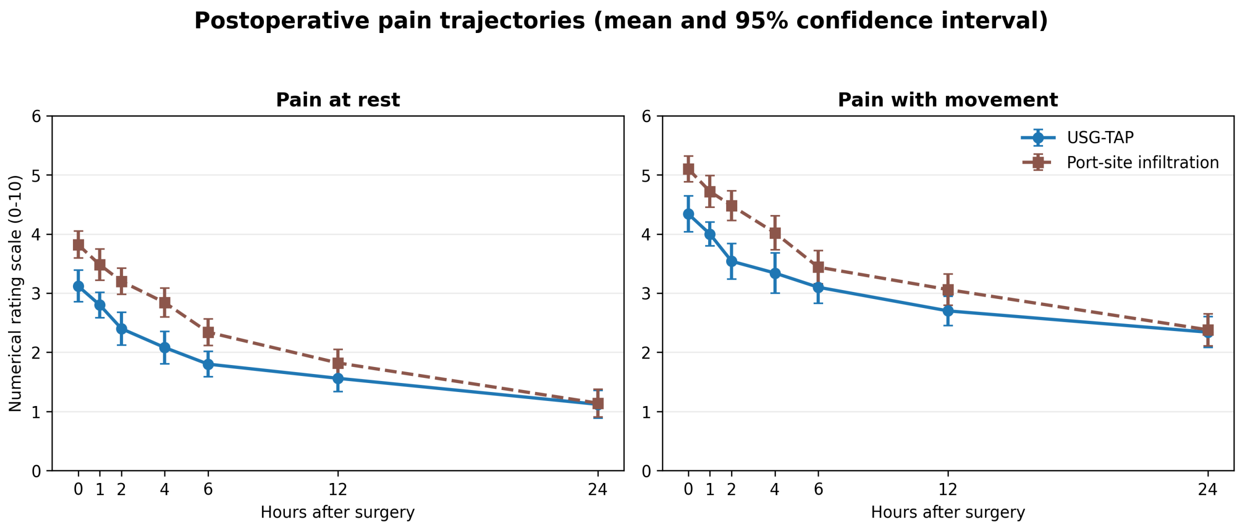

Figure 3: Pain trajectories at rest and with movement. Points show means; error bars show 95% confidence intervals.

Postoperative symptoms, satisfaction, and safety

Table 3: Primary, recovery, symptom, and safety outcomes. RR denotes risk ratio. Confidence intervals are unadjusted.

Outcome	USG-TAP	Port infiltration	Effect estimate (95% CI)	p value
24-h tramadol, mg	84.0 ± 71.7	137.0 ± 80.1	-53.0 (-83.2 to -22.8)	<0.001
Time to first rescue, min	408.3 ± 208.1	233.1 ± 188.6	175.2 (96.4 to 254.0)	<0.001
Satisfaction score, 1-5	4.2 ± 0.7	4.0 ± 0.7	0.2 (-0.1 to 0.5)	0.200
Postoperative nausea/vomiting	11 (22%)	16 (32%)	RR 0.69 (0.36 to 1.33)	0.368
Shoulder-tip pain	14 (28%)	17 (34%)	RR 0.82 (0.46 to 1.48)	0.666
Any recorded adverse event	50 (100%)	50 (100%)	Not estimable	1.000

Postoperative nausea or vomiting occurred in 11 of 50 participants after TAP block and 16 of 50 after infiltration. The risk ratio favoured TAP block numerically, but the confidence interval included substantial benefit and no effect. Shoulder-tip pain was also similar. Satisfaction was high in both groups and the small mean difference did not reach statistical significance. One transient bradycardic episode was represented in the infiltration group; no allergy, seizure, arrhythmia, suspected local anaesthetic systemic toxicity, persistent neurological symptom, haematoma, or block-site infection was recorded.

Discussion

The central finding of this study is a clinically interpretable reduction in rescue opioid requirement after ultrasound-guided subcostal TAP block. The estimated 53 mg decrease in 24-hour tramadol was accompanied by a roughly three-hour prolongation in time to first rescue and lower pain scores during the first six hours. The effect did not persist uniformly across the day. By 12 hours the groups were drawing closer, and at 24 hours their pain scores were essentially the same. That shape matters. It suggests a useful early recovery advantage rather than proof that TAP block abolishes every component of pain after laparoscopic cholecystectomy.

The pattern is biologically plausible. A subcostal TAP injection can expose multiple segmental nerves within a continuous fascial compartment before those nerves branch toward individual wounds. Port-site infiltration, in contrast, produces dense but spatially restricted blockade around the trocar tracts. Wider somatic coverage should be most visible when incisional pain is prominent, which is commonly the first several postoperative hours. Neither technique directly resolves gallbladder-bed visceral pain or diaphragmatic irritation, so later convergence and persistent shoulder symptoms are not surprising (Joris et al., 1995; Rozen et al., 2008; Tran et al., 2009).

The result is broadly consistent with trials by Tolchard et al. (2012) and Suseela et al. (2018), both of which reported superior postoperative analgesia with subcostal TAP block compared with port-site infiltration. It also aligns with Grape et al. (2021), whose procedure-specific meta-analysis found moderate-to-high level evidence favouring TAP block over wound infiltration, and with the more recent review by Park et al. (2024), which found lower pain scores and 24-hour opioid use after ultrasound-guided subcostal TAP block.

The literature is not uniformly favourable, however. Some well-conducted trials have found limited added value when background multimodal analgesia is comprehensive, and pooled estimates show heterogeneity in both magnitude and duration of benefit. Variation in TAP approach is a major reason. A lateral injection may miss upper subcostal ports, while an oblique subcostal injection can spread differently according to needle position, volume, tissue compliance, and operator technique. Wound infiltration is similarly variable: superficial injection alone is not equivalent to full-thickness tract infiltration, and pre-incisional infiltration may differ from injection at closure. Pooling these procedures under broad labels can make apparently contradictory results less surprising.

Updated PROSPECT guidance offers a useful clinical counterweight. Port-site wound infiltration is recommended as a basic, simple regional technique, whereas TAP and erector spinae plane blocks are positioned as second-line options when a higher pain burden is anticipated or when opioid-related risk justifies additional expertise and local anaesthetic exposure (Bourgeois et al., 2024). The study does not invalidate that hierarchy. A mean reduction in opioid requirement may be worthwhile for a patient with severe postoperative nausea, obstructive sleep apnoea, frailty, or previous difficult pain, yet it does not automatically make TAP block the most efficient choice for every uncomplicated day-case patient. Safety requires the same nuance. Ultrasound improves anatomical precision, but it does not make local anaesthetic risk disappear. Fascial-plane blocks often use relatively large volumes, and systemic absorption can be brisk. The operator must calculate total dose across every source, aspirate incrementally, observe spread, monitor the patient, and maintain immediate access to a local anaesthetic systemic toxicity response protocol and lipid emulsion (El-Boghdadly et al., 2018; Neal et al., 2018). In an equal-dose trial, adverse-event comparison is particularly informative because a higher dose is not being traded for better analgesia.

Pain-score interpretation also deserves restraint. The largest mean difference was around one point on a 0-to-10 scale. Depending on baseline pain and the individual patient, this may be meaningful, modest, or barely perceptible. Rescue consumption and time to rescue strengthen the argument because they reflect behaviour and treatment need, but they too are influenced by rescue thresholds, staff response time, and patient willingness to request medication.

Conclusion

In this study, bilateral ultrasound-guided subcostal TAP block reduced early postoperative pain and rescue tramadol compared with equal-dose port-site infiltration after laparoscopic cholecystectomy. The benefit was concentrated in the early recovery period and did not translate into clear differences in 24-hour pain, postoperative nausea or vomiting, shoulder pain, or satisfaction. The clinically responsible interpretation is selective rather than absolute: technically sound port-site infiltration remains a reasonable baseline intervention, while subcostal TAP block may be valuable when enhanced early somatic analgesia and opioid sparing justify additional regional expertise.

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