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Original Research Article

Ultrasound-guided versus transversus abdominis plane (TAP) block versus No TAP block in laparoscopic cholecystectomy; a randomized double-blind controlled trial

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Abstract: Postoperative pain following laparoscopic cholecystectomy remains a clinically significant concern despite the minimally invasive nature of the procedure. Inadequately controlled pain can delay ambulation, increase opioid consumption, and negatively impact postoperative recovery. Regional analgesic techniques such as the transversus abdominis plane (TAP) block have been shown to improve postoperative pain control and reduce opioid requirements. Among these, ultrasound-guided subcostal TAP block offers accurate local anesthetic deposition and enhanced analgesic efficacy. However, limited data exist comparing ultrasound-guided TAP block with no TAP block in laparoscopic cholecystectomy, particularly in resource-limited tertiary care settings. Aim: To evaluate the analgesic efficacy of ultrasound-guided subcostal TAP block compared with no TAP block in adult patients undergoing elective laparoscopic cholecystectomy. Methods: This randomized, double-blind, controlled trial was conducted over nine months (March 2025 to December 2025) at the Department of Anaesthesiology and General Surgery, Government Medical College Doda. A total of 100 adult patients scheduled for elective laparoscopic cholecystectomy under general anesthesia were randomized into two groups. Group USTAP (n = 50) received ultrasound-guided subcostal TAP block using 0.25% ropivacaine, while Group Control (n = 50) received no TAP block. General anesthesia was standardized for all patients using fentanyl, propofol, atracurium, and maintenance with oxygen–nitrous oxide and isoflurane. The primary outcome was postoperative pain assessed using the Visual Analog Scale (VAS) at 1, 4, 8, 12, and 24 hours. Secondary outcomes included total opioid consumption in the first 24 hours, time to first rescue analgesic requirement, incidence of postoperative nausea and vomiting, hemodynamic stability, and length of hospital stay. Results: Patients in the ultrasound-guided TAP block group had significantly lower postoperative VAS pain scores at all assessed time points compared to the control group ($p < 0.001$). Total 24-hour opioid consumption was markedly reduced in the USTAP group, and the time to first rescue analgesic request was significantly prolonged. The incidence of postoperative nausea and vomiting was also lower in patients receiving TAP block. Hemodynamic parameters remained stable in both groups, and no block-related complications were observed. Length of hospital stay was shorter in the USTAP group compared to controls. ***Conclusion***: Ultrasound-guided subcostal TAP block provides effective postoperative analgesia following laparoscopic cholecystectomy, significantly reducing pain scores and opioid consumption while improving overall recovery outcomes. Incorporation of ultrasound-guided TAP block as part of a multimodal analgesia protocol can enhance postoperative pain management and patient satisfaction without increasing complications.

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Keywords: Ultrasound-guided TAP block, subcostal TAP block, laparoscopic cholecystectomy, postoperative pain, regional anesthesia, multimodal analgesia

INTRODUCTION

Laparoscopic cholecystectomy is currently regarded as the standard surgical treatment for symptomatic gallstone disease because of its advantages over open cholecystectomy, including shorter hospital stay, reduced postoperative morbidity, and faster return to normal daily activities [1]. Despite being minimally invasive, postoperative pain following laparoscopic cholecystectomy remains a significant clinical concern. This pain is multifactorial in origin, consisting of somatic pain from trocar site incisions and visceral pain due to gallbladder manipulation, pneumoperitoneum, and peritoneal stretching [2]. Inadequate control of postoperative pain can delay mobilization, impair respiratory function, increase opioid requirements, and adversely affect patient satisfaction and overall recovery [3].

Effective postoperative analgesia is therefore a critical component of perioperative care in laparoscopic cholecystectomy. Multimodal analgesic strategies aim to reduce reliance on systemic opioids by combining regional anesthesia techniques with non-opioid analgesics, thereby minimizing opioid-related adverse effects such as nausea, vomiting, sedation, and delayed ambulation [3]. Among regional analgesic techniques, the transversus abdominis plane (TAP) block has gained widespread acceptance for abdominal surgeries due to its ability to provide effective analgesia of the anterior abdominal wall.

The TAP block targets the thoracolumbar nerves (T6–L1) that traverse the fascial plane between the internal oblique and transversus abdominis muscles, supplying sensory innervation to the anterolateral abdominal wall [4]. The subcostal approach to TAP block is particularly well suited for upper abdominal procedures, including laparoscopic cholecystectomy, as it provides coverage of higher thoracic dermatomes involved in subcostal port placement [5]. By depositing local anesthetic along the subcostal margin, the subcostal TAP block effectively attenuates somatic pain arising from trocar incisions.

Ultrasound guidance has significantly improved the safety and efficacy of TAP block by allowing real-time visualization of abdominal wall layers, needle advancement, and local anesthetic spread [6]. This technique enhances block accuracy, reduces the risk of inadvertent intraperitoneal or visceral injury, and improves the consistency of analgesic outcomes. Several randomized trials and meta-analyses have demonstrated that ultrasound-guided TAP block is associated with lower postoperative pain scores, reduced intraoperative and postoperative opioid consumption, and prolonged time to first rescue analgesic requirement following laparoscopic cholecystectomy [7].

Although systemic analgesia alone remains widely practiced, growing evidence suggests that the addition of ultrasound-guided TAP block can significantly improve early postoperative recovery. Pain following laparoscopic cholecystectomy can impair deep breathing and coughing, increase the risk of pulmonary complications, and negatively affect early mobilization, particularly during the first postoperative day [2,3]. Therefore, identifying a safe, effective, and reproducible regional analgesic technique is essential for optimizing postoperative outcomes.

The present randomized double-blind controlled trial was designed to compare the analgesic efficacy of ultrasound-guided subcostal TAP block with no TAP block in adult patients undergoing elective laparoscopic cholecystectomy. By evaluating postoperative pain intensity, opioid consumption, time to first rescue analgesic requirement, and recovery-related outcomes, this study aims to provide evidence-based support for the incorporation of ultrasound-guided subcostal TAP block into routine multimodal analgesia protocols for laparoscopic cholecystectomy.

MATERIALS AND METHODS

This randomized, double-blind, controlled clinical study was conducted in the Department of Anaesthesiology and General Surgery at Government Medical College (GMC) Doda over a period of nine months, from February 2025 to November 2025. Approval was obtained from the Institutional Ethics Committee prior to the commencement of the study, and written informed consent was obtained from all participants after explaining the study protocol in their local language.

Study design and sample size

A total of 100 adult patients scheduled for elective laparoscopic cholecystectomy under general anesthesia were enrolled in the study. Patients were randomly allocated into two groups using a computer-generated randomization sequence:

* Group USTAP (n = 50): Ultrasound-guided subcostal transversus abdominis plane block
* Group Control (n = 50): No TAP block

Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes prepared by an independent anesthesiologist who was not involved in patient management or data collection.

Inclusion criteria
Patients aged 18–65 years of either sex, belonging to ASA physical status I or II, scheduled for elective laparoscopic cholecystectomy, and willing to provide written informed consent were included in the study.

Exclusion criteria
Patients were excluded if they had a body mass index greater than 35 kg/m², known allergy to local anesthetics, infection at the block site, pregnancy, coagulopathy, psychiatric illness, chronic opioid use, severe hepatic or renal impairment, history of upper abdominal surgery, or conversion to open cholecystectomy.

Blinding
Patients, surgeons, postoperative care staff, and the investigator recording postoperative outcomes were blinded to group allocation. The anesthesiologist performing the TAP block was aware of the group assignment but was not involved in postoperative assessment or data analysis.

Preoperative assessment
All patients underwent a standardized pre-anesthetic evaluation, including detailed medical history, systemic examination, airway assessment, and routine laboratory investigations. Patients were kept fasting for six hours prior to surgery.

Premedication with oral ranitidine 150 mg was administered on the night before surgery. Standard monitoring, including electrocardiography, non-invasive blood pressure, and pulse oximetry, was instituted upon arrival in the operating room.

Anesthetic technique
General anesthesia was standardized for all patients. Induction was achieved using intravenous fentanyl (2 µg/kg), propofol (2–2.5 mg/kg), and atracurium (0.5 mg/kg) to facilitate endotracheal intubation. Anesthesia was maintained with oxygen–nitrous oxide mixture and isoflurane. Additional doses of atracurium were administered as required based on neuromuscular monitoring and clinical judgment. Intraoperative analgesia was supplemented with intravenous paracetamol and fentanyl as needed.

TAP block technique
Group USTAP (Ultrasound-guided subcostal TAP block):
After induction of anesthesia and prior to surgical incision, a bilateral ultrasound-guided subcostal TAP block was performed. A high-frequency linear ultrasound probe was placed parallel to the costal margin. The rectus abdominis and transversus abdominis muscle layers were identified, and a 22G needle was advanced using an in-plane technique. After negative aspiration, 20 ml of 0.25% ropivacaine was injected into the transversus abdominis plane on each side.

Group Control:
No TAP block was administered. Patients received standard systemic analgesia as per institutional protocol.

Postoperative analgesia
All patients received intravenous paracetamol 1 g every eight hours postoperatively. Rescue analgesia was provided with intravenous tramadol 50 mg whenever the Visual Analog Scale (VAS) pain score exceeded 4. Total opioid consumption during the first 24 postoperative hours was recorded. Postoperative nausea and vomiting were treated with intravenous ondansetron 4 mg as required.

Outcome measures
Primary outcome:
Postoperative pain intensity assessed using the Visual Analog Scale (VAS) at 1, 4, 8, 12, and 24 hours at rest and during movement.

Secondary outcomes:
* Total opioid requirement in the first 24 hours
* Time to first rescue analgesic request
* Incidence of postoperative nausea and vomiting
* Hemodynamic parameters
* Duration of surgery
* Length of hospital stay
* Block-related complications

All assessments were performed by a blinded investigator.

Statistical analysis
Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation and compared using the independent Student's t-test.

Categorical variables were presented as frequencies and percentages and analyzed using the chi-square test

or Fisher's exact test as appropriate. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 100 patients scheduled for elective laparoscopic cholecystectomy were enrolled and all completed the study. Patients were randomly allocated into two groups: Group USTAP (n = 50), who received ultrasound-guided subcostal TAP block with 0.25% ropivacaine, and Group Control (n = 50), who received no TAP block. No patient required conversion to open surgery. No complications related to TAP block were observed.

Baseline demographic characteristics and intraoperative variables were comparable between the two groups, with no statistically significant differences, ensuring homogeneity for outcome analysis.

Table 1. Demographic and baseline characteristics of patients

Parameter	USTAP (n = 50)	Control (n = 50)	p-value
Age (years), mean ± SD	41.9 ± 10.1	41.2 ± 10.8	0.74
Gender (M/F)	19/31	21/29	0.68
BMI (kg/m²), mean ± SD	25.3 ± 3.0	24.9 ± 3.2	0.56
ASA I/II	27/23	26/24	0.84
Duration of surgery (min), mean ± SD	59.1 ± 12.3	60.4 ± 13.1	0.61
Baseline VAS score	0.0	0.0	--

Postoperative pain scores assessed using the Visual Analog Scale were significantly lower in the USTAP group at all time intervals during the first 24 hours when compared with the Control group.

Table 2. Mean VAS pain scores at rest (0–10 scale)

Time interval	USTAP	Control	p-value
1 hour	2.4 ± 0.9	4.7 ± 1.2	<0.001
4 hours	3.0 ± 1.1	5.3 ± 1.3	<0.001
8 hours	3.5 ± 1.0	6.0 ± 1.2	<0.001
12 hours	3.2 ± 0.8	5.7 ± 1.1	<0.001
24 hours	2.8 ± 0.7	4.8 ± 1.0	<0.001

Patients in the USTAP group required significantly less opioid analgesia during the first 24 hours postoperatively. The time to first rescue analgesic request was significantly prolonged in patients receiving ultrasound-guided TAP block.

Table 3. Opioid consumption and timing of rescue analgesia

Parameter	USTAP	Control	p-value
Total tramadol use (mg, 0–24 h)	64.1 ± 19.2	136.7 ± 29.4	<0.001
Time to first analgesic request (hours)	7.3 ± 1.7	3.3 ± 1.3	<0.001

The incidence of postoperative nausea and vomiting was significantly lower in the USTAP group. Hemodynamic parameters remained stable in both groups throughout the observation period, with no clinically significant variations.

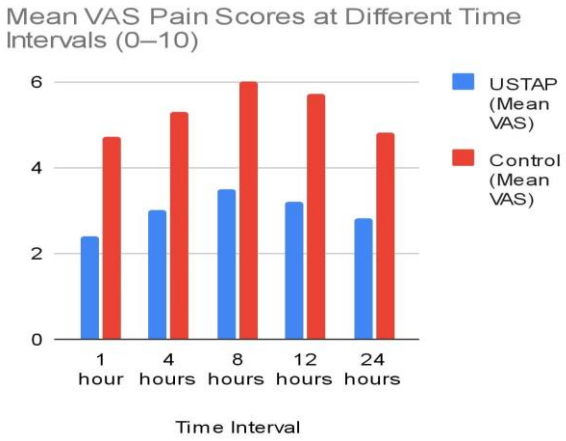
Table 4. PONV and hemodynamic parameters

Parameter	USTAP	Control	p-value
PONV incidence (%)	16%(8/50)	38% (19/50)	0.01
Mean HR (first 2 hrs)	82.1 ± 6.9	87.2 ± 8.0	0.02
Mean MAP (first 2 hrs)	89.2 ± 7.2	94.1 ± 7.6	0.01

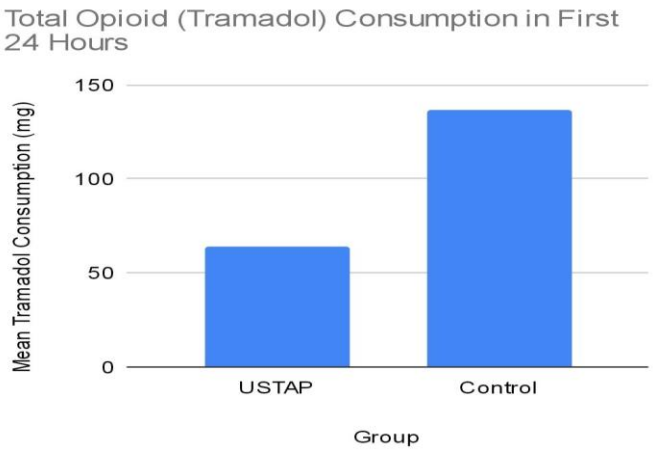
Patients receiving ultrasound-guided TAP block had a significantly shorter postoperative hospital stay. No block-related or major postoperative complications were observed in either group.

Table 5. Hospital stays and postoperative complications

Parameter	USTAP	Control	p-value |
Length of hospital stay (days)	1.5 ± 0.5	2.3 ± 0.7	<0.001
Block-related complications	None	Not applicable	--
Other postoperative complications	4% (2/50)	14% (7/50)	0.09



Bar graph: Pain Scores Postoperatively



Bar graph 2: Total Opioid Consumption.

DISCUSSION

This randomized, double-blind controlled trial evaluated the analgesic efficacy of ultrasound-guided subcostal transversus abdominis plane (TAP) block compared with standard systemic analgesia in patients undergoing elective laparoscopic cholecystectomy. The findings demonstrate that ultrasound-guided subcostal TAP block significantly reduced postoperative pain scores, opioid consumption, and incidence of postoperative nausea and vomiting while prolonging the time to first rescue analgesic requirement during the first 24 postoperative hours. These results support the role of ultrasound-guided TAP block as an effective component of multimodal analgesia for upper abdominal surgery [8].

Postoperative pain following laparoscopic cholecystectomy is primarily somatic in origin due to trocar site incisions and abdominal wall stretching, with a smaller visceral component. Regional analgesic techniques targeting the abdominal wall nerves therefore play a crucial role in early postoperative pain control. In the present study, patients receiving ultrasound-guided TAP block consistently reported significantly lower VAS pain scores at all measured time intervals compared with the control group. Similar findings were reported by Petersen et al., who demonstrated that ultrasound-guided TAP block provides superior analgesia by ensuring accurate deposition of local anesthetic within the transversus abdominis plane, thereby improving block reliability

and duration of analgesia [9].

The analgesic superiority of ultrasound-guided TAP block observed in this study can be attributed to real-time visualization of anatomical structures, allowing precise identification of muscle layers and the correct fascial plane. This reduces the likelihood of intramuscular injection and block failure. Previous imaging-based studies have shown that ultrasound guidance significantly improves the success rate and consistency of TAP block compared with landmark-based or indirect techniques [10].

A key outcome of this trial was the significant reduction in opioid consumption in the ultrasound-guided TAP block group. Patients receiving TAP block required substantially less tramadol in the first 24 postoperative hours and experienced a longer pain-free interval before requesting rescue analgesia. These findings are consistent with systematic reviews and meta-analyses demonstrating that TAP block reduces postoperative opioid requirements following laparoscopic abdominal surgeries [11]. The opioid-sparing effect is particularly important in minimizing opioid-related adverse effects and enhancing early recovery.

The incidence of postoperative nausea and vomiting was also lower in the TAP block group, which is likely related to reduced opioid exposure. Opioids are a well-recognized risk factor for PONV, and strategies that decrease opioid use contribute significantly to improved postoperative comfort. Similar observations were reported by Sandeman et al., who noted a reduction in opioid-related side effects in patients receiving TAP block for laparoscopic procedures [12].

Hemodynamic parameters remained stable in both study groups, and no clinically significant cardiovascular changes were observed. Importantly, no block-related complications such as local anesthetic toxicity, hematoma, or visceral injury were encountered. This confirms that ultrasound-guided subcostal TAP block is a safe technique when performed under direct visualization by trained anesthesiologists, consistent with previously published safety profiles of ultrasound-guided regional blocks [13].

Overall, the results of this study indicate that ultrasound-guided subcostal TAP block provides effective postoperative analgesia following laparoscopic cholecystectomy, with clear advantages over systemic analgesia alone. Its ability to reduce pain intensity, opioid consumption, and postoperative side effects makes it a valuable addition to perioperative pain management protocols, particularly in settings aiming to enhance recovery and patient satisfaction [14].

CONCLUSION

This randomized controlled study demonstrates that ultrasound-guided subcostal transversus abdominis plane block provides effective and reliable postoperative analgesia in patients undergoing laparoscopic cholecystectomy. Patients receiving the ultrasound-guided TAP block experienced significantly lower postoperative pain scores at all assessed time points, reduced opioid consumption within the first 24 hours, and a longer duration before the need for rescue analgesia when compared with patients who received standard systemic analgesia alone.

The opioid-sparing effect observed in the ultrasound-guided TAP block group was associated with a lower incidence of postoperative nausea and vomiting, contributing to improved patient comfort and quality of recovery. Hemodynamic parameters remained stable in both groups, and no block-related complications were observed, indicating that the technique is safe when performed under ultrasound guidance by trained anesthesiologists.

Overall, incorporation of ultrasound-guided subcostal TAP block as part of a multimodal analgesic strategy can significantly enhance postoperative pain control following laparoscopic cholecystectomy. Its routine use has the potential to reduce opioid-related adverse effects, facilitate early recovery, shorten hospital stay, and improve overall patient satisfaction in clinical practice.

Conflict of interest: Nil
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