

## ORIGINAL RESEARCH ARTICLE

## Efficacy of preperitoneal local anesthetic infiltration on post-operative analgesia following laparoscopic cholecystectomy

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### Abstract

**Introduction:** Post-operative pain significantly impairs recovery, delaying hospital discharge after laparoscopic cholecystectomy. Effective pain management facilitates early ambulation, which diminishes the probability of post-operative complications.

**Objective:** This study compares the analgesic efficacy of preperitoneal bupivacaine infiltration with dexamethasone and the transversus abdominis plane (TAP) block.

**Methods:** This prospective, randomized, double-blinded study included 40 patients undergoing laparoscopic cholecystectomy. Group 1 ( $n = 20$ ) received a TAP block, while Group 2 ( $n = 20$ ) received preperitoneal bupivacaine for analgesia. The primary outcomes were (i) the level of post-operative pain, assessed using the Visual Analog Scale every 15 min in the 1<sup>st</sup> post-operative hour, at 2-h intervals up to 12 h, and at 6-h intervals up to 24 h; (ii) time to first request for rescue analgesia; and (iii) the total dose of analgesia. Secondary outcomes included patient-reported sleep quality and the incidence of post-operative nausea and vomiting.

**Results:** The study found that the TAP block provided superior post-operative pain relief compared to preperitoneal infiltration with bupivacaine in patients who underwent laparoscopic cholecystectomy. The TAP block group exhibited significantly lower pain scores at 8 and 12 h postoperatively and experienced a delayed first request for rescue analgesia at  $14.6 \pm 2.52$  h on average, compared with  $7.1 \pm 1.02$  h in the preperitoneal group.

**Conclusion:** The findings establish that TAP block is a more effective analgesic technique than preperitoneal infiltration with bupivacaine for managing post-operative pain in laparoscopic cholecystectomy. Patients receiving TAP block

required fewer opioids, had delayed onset of rescue analgesia, and reported lower pain scores at critical post-operative intervals.

**Keywords:** Transversus abdominis plane block; Preperitoneal space; Cholecystectomy; Analgesia

## 1. Introduction

Laparoscopic cholecystectomy is a commonly performed procedure, typically associated with a short post-operative hospital stay.<sup>1</sup> Although laparoscopic cholecystectomy operations result in less post-operative pain than open cholecystectomy operations, severe and moderate pain are the most common concerns, particularly during the first 24 h. A critical objective for early hospital discharge is implementing appropriate pain management.<sup>2</sup> In general, multimodal analgesic techniques, such as intravenous patient-controlled analgesia and thoracic epidural analgesia, are implemented to mitigate pain.<sup>3</sup> A regional nerve blockade method known as the transversus abdominis plane (TAP) block, which has recently acquired popularity, is now a frequently used multimodal approach element in post-operative pain management.<sup>4</sup>

The TAP block is a regional anesthesia technique that involves injecting local anesthetics into the TAP, located between the transversus abdominis and internal oblique muscles. This technique has gained popularity due to its effectiveness in reducing post-operative pain and opioid consumption, particularly when ultrasound guidance is used to enhance precision. Studies have demonstrated that TAP block significantly prolongs the duration of analgesia, delaying the first request for rescue analgesia and improving overall patient comfort. However, its primary limitation is its inability to provide visceral pain relief, as it primarily targets somatic pain from the abdominal wall. In addition, its efficacy is highly operator-dependent, requiring technical expertise and ultrasound guidance for optimal results.<sup>5</sup>

Preperitoneal infiltration involves the administration of local anesthetics into the preperitoneal space, effectively targeting nociceptive pathways to reduce post-operative pain. This technique offers several advantages, including ease of administration under direct laparoscopic visualization and reduced dependence on specialized equipment like ultrasound. Furthermore, preperitoneal infiltration can minimize opioid requirements, thereby reducing the incidence of opioid-related side effects such as post-operative nausea and vomiting (PONV) and sedation. However, its analgesic duration is shorter than the TAP block, often necessitating earlier rescue

analgesia. In addition, the potential risk of inadvertent intraperitoneal injection or inconsistent drug spread may limit its effectiveness.<sup>6,7</sup>

Both TAP block and preperitoneal infiltration are associated with minimal complications. TAP block has been reported to have a favorable safety profile, with rare but potential risks including inadvertent needle injury to adjacent structures such as the liver or bowel. In addition, improper administration may result in incomplete analgesia or block failure. Preperitoneal infiltration, a simpler technique, carries a lower risk of technical complications but may be less effective in managing pain at later post-operative stages.<sup>8</sup>

This study compares the analgesic efficacy of preperitoneal infiltration with bupivacaine and dexamethasone and the TAP block in patients undergoing laparoscopic cholecystectomy. This comparison is based primarily on post-operative pain scores (Visual Analog Scale [VAS]) and the time for first request for rescue analgesia, which are critical metrics for evaluating pain management strategies.

## 2. Methodology

This randomized, prospective, double-blinded study was performed at the Department of Anesthesia and General Surgery of Al-Zahraa University Hospital and Minia University Hospital, Egypt. This study was approved by the Institutional Review Board and the Ethical Committee of the Faculty of Medicine for Girls, Al-Azhar University (Approval Number 1784/2023), and additionally by the Institutional Review Board of Minia University Hospital, according to the WMA Declaration of Helsinki. It was approved by the Ethical Committee of Al-Azhar Faculty of Medicine. The study was conducted for 6 months from February 2023 to August 2023. The trial was filed at the Pan African Clinical Trial Registry (pactr.samrc.ac.za) database (PACTR202504865598437).

The participants were informed of the study's objectives and instruments. This investigation was conducted with the approval of the institutional review board of the Faculty of Medicine for Girls Al-Azhar University (1784/2023).

The study was voluntary, and each participant had to provide informed written consent before enrollment. Each

participant was entitled to decline participation or resign from the study at any time without providing a rationale or affecting their right to medical care. In addition, participants' confidentiality was guaranteed through anonymous and coded data.

## 2.1. Inclusion criteria

The study included adult patients undergoing elective laparoscopic cholecystectomy. Participants were required to have normal laboratory parameters, including a complete blood count, coagulation profile, and normal liver and kidney function. They had to meet the American Society of Anesthesiologists' physical status classification of I or II and be willing to provide informed consent.

## 2.2. Exclusion criteria

Patients who refused and those with a history of allergic reactions to local anesthetic drugs, a history of chronic pain, a history of drug addiction, and those who had undergone complicated surgery were excluded from the study.

Complicated surgery refers to laparoscopic cholecystectomy procedures involving additional challenges beyond standard conditions, such as severe intra-abdominal adhesions, conversion to open surgery, significant bleeding requiring transfusion, and difficult anatomical variations that prolong operative time.<sup>9</sup> These cases were excluded to ensure homogeneity and minimize variables that could affect post-operative outcomes.

## 2.3. Randomization and blinding

The study employed a prospective, randomized, double-blind design. Using a computer-generated randomization sequence, participants were randomly allocated into two equal groups (TAP block or preperitoneal infiltration). Allocation concealment was maintained using sealed, opaque envelopes opened only by a designated team member uninvolved in patient care. Both patients and outcome assessors were blinded to group allocation. The anesthesiologist administering the block and the surgeon performing the infiltration were aware of the allocation but did not participate in outcome assessment, ensuring unbiased data collection.

Although the study is described as "double-blind," it is important to clarify that the blinding was maintained between the patients and the outcome assessors, not the surgical or anesthesia team. The surgeon and anesthesiologist were necessarily unblinded due to the nature of the interventions—TAP block and preperitoneal infiltration—which require direct procedural knowledge and expertise.

However, to minimize bias, outcome assessors (those collecting VAS scores, analgesic use, and post-operative metrics) were blinded to group assignment, and patients were unaware of their group allocation.

## 2.4. Allocation concealment

Allocation concealment was ensured via sealed opaque envelopes, and the treatment was administered by personnel not involved in outcome measurement. Forty adult cases had a laparoscopic cholecystectomy. The patients were randomly allocated into two equal groups.

### 2.4.1. TAP block group

The group was given a bilateral ultrasound-guided TAP block with 18 mL of the local anesthetic 0.25% bupivacaine and 8 mg of dexamethasone (total volume 20 mL).

### 2.4.2. Preperitoneal group

The group was preoperatively injected with local anesthetic through a preperitoneal local instillation of 18 mL of the local anesthetic 0.25% bupivacaine and 8 mg of dexamethasone (total volume 20 mL).

Preoperatively, laboratory investigations, such as a complete blood profile, coagulation profile, liver and kidney function, and age and weight, were conducted for all patients as part of their routine preoperative investigations. The patient had been fasting for 8 h before the procedure.

Patients enrolled were advised to have a fasting period of at least 8 h before surgery. All patients were given 8 mg of intravenous ondansetron 15 min before surgery, before the induction of anesthesia. Standard monitoring included pulse oximetry (Dräger Fabius plus monitor, Dräger Medical System, Inc., United States), electrocardiography, and non-invasive blood pressure measurement. General anesthesia was induced after 3 min of preoxygenation by intravenous injection of 1–2 µg/kg fentanyl (Sunny Pharmaceutical, Egypt), 2–3 mg/kg of propofol (B. Braun, Germany), and an induction dose of 0.5 mg/kg of atracurium (Sunny Pharmaceutical, Egypt). An endotracheal tube was inserted, and volume-controlled mechanical ventilation was initiated.

Anesthesia was maintained with sevoflurane 2% with controlled mechanical ventilation with 3L of oxygen and a maintenance dose of 0.1 mg/kg of atracurium. Positive pressure ventilation was initiated with an 8 mL/kg tidal volume and an altered respiratory rate to preserve end-tidal carbon dioxide between 45 and 35 mmHg. Baseline heart rate and mean arterial pressure measurements were documented and recorded every 10 min.

The surgery was conducted under general anesthesia by a single general surgeon, who adhered to a standardized

surgical approach. The intra-abdominal pressure was kept at 12 mm Hg for all cases. Before skin incision, the procedure was performed in the operating room using a fully aseptic technique.

For the TAP block group, a unilateral TAP block was performed on the surgery site utilizing 18 mL of 0.25% bupivacaine and 8 mg of dexamethasone (total volume of 20 mL) through a midaxillary approach under ultrasound guidance. The probe was positioned transversely between the costal margin and the iliac crest. The 22-G echogenic spinal needle, which was 8 cm long, was advanced in-plane. After the needle point reached the plane, the correct placement was confirmed by instilling 2 mL of anesthetic solution to view the hydrodissection. Subsequently, the entire drug volume was administered, resulting in the formation of a meniscus between the planes. To minimize operator variability, all TAP blocks were performed by the same consultant anesthesiologist with over 5 years of experience in ultrasound-guided regional anesthesia.

Preperitoneal infiltration was performed immediately after induction of general anesthesia. The procedure was performed under laparoscopic visualization after insertion of trocars and carbon dioxide gas insufflation. Digital pressure was applied to identify the injection site, and a blind injection was then performed, advancing the needle inserted until its tip was visible at the peritoneum. The needle was then withdrawn gently for about 0.5 cm, and the local anesthetic was injected. The surgeon administered 18 mL of 8 mg dexamethasone and 0.25% bupivacaine (total volume 20 mL) under laparoscopic vision.

To ensure that no intraperitoneal injections were administered, the injection site within the peritoneal cavity was examined, with an internal protrusion, also known as Doyle's bulge, serving as the definitive procedural landmark. To minimize operator variability, all preperitoneal infiltrations were conducted by the same senior laparoscopic surgeon under direct laparoscopic visualization. The injection site was identified after trocar insertion and insufflation.

Sevoflurane administration was discontinued at the conclusion of surgery, and spontaneous breathing resumed. The gas flow rate was increased to 7 L/min of oxygen, and the neuromuscular blockade was reversed with a standard dose of atropine (0.01 mg/kg) and neostigmine (0.05 mg/kg). The patient was extubated when they were able to respond to a verbal request and were able to breathe spontaneously with a tidal volume of 5–8 mL/kg. Subsequently, they were transferred to the recovery room.

While the TAP block used real-time imaging and the preperitoneal technique relied on visual laparoscopic

guidance, the involvement of experienced specialists and standardized procedural steps helped ensure consistency. We acknowledge that differing guidance methods (ultrasound vs. laparoscopic) may affect the reproducibility and accuracy of anesthetic spread, and we have added this as a potential limitation in the discussion section.

## 2.5. Protocol for post-operative analgesia

Additional analgesia was administered when patients reported a VAS score of  $\geq 4$ , indicating moderate to severe pain. The first-line rescue analgesic used was intravenous paracetamol (1 g) administered every 6 h, as needed. If pain persisted despite paracetamol, intravenous pethidine (50 mg) was given as a second-line agent. For each patient, the total dosage and frequency of administration were recorded to evaluate cumulative analgesic use.

## 2.6. Outcomes

### 2.6.1. Primary outcomes

#### 2.6.1.1. Visual Analog Scale scores

Pain intensity was measured using the VAS at six post-operative time points: 0, 2, 4, 8, 12, and 24 h. Patients rated their pain on a scale from 0 (no pain) to 10 (worst pain imaginable). This provided an objective assessment of pain severity over time for comparison between the two groups.

#### 2.6.1.2. Time to first rescue analgesia

The duration from the end of surgery until the patient's first request for additional analgesia was recorded. This measure reflects the analgesic efficacy and duration of pain relief provided by the intervention.

#### 2.6.1.3. Total analgesic dose

The cumulative dose of opioids required within the first 24 h postoperatively was documented. Lower opioid consumption indicated better pain control and effectiveness of the analgesic technique.

### 2.6.2. Secondary outcomes

#### 2.6.2.1. PONV

The occurrence of nausea and vomiting was monitored in both groups, as these are common side effects of anesthesia and opioid use. PONV incidences were compared to evaluate the influence of the analgesic technique on this outcome.

#### 2.6.2.2. Sleep quality

Post-operative sleep quality was assessed using a subjective scoring system, where patients rated their sleep on a scale from 0 (poor sleep) to 10 (excellent sleep). This score was

collected during the structured interview on the first post-operative morning. Patients were asked to consider factors such as ease of falling asleep, frequency of waking, and overall restfulness during the night.<sup>4</sup>

### 2.7. Sample size

Sample size calculation was based on the difference in post-operative pain incidence between the group with preperitoneal bupivacaine infiltration and the placebo group, retrieved from previous research.<sup>10</sup> The G\*Power program version 3.1.9.4 was used to calculate the sample size based on an expected 27% difference and a large effect size ( $f = 1.061195$ ). Using a two-tailed test,  $\alpha$  error = 0.05, and power = 90.0%, the total calculated sample size was 40 patients, divided into two equal groups (Figure 1).

### 2.8. Statistical analysis

The Statistical Package for the Social Sciences, version 23.0 (SPSS Inc., United States), was employed to analyze the recorded data. Parametric quantitative data distribution was represented as mean  $\pm$  standard deviation and ranges. Conversely, non-parametric variables were represented as median with inter-quartile range (IQR). In addition, qualitative variables were presented as percentages and numbers. The Shapiro–Wilk test and Kolmogorov–Smirnov test were employed to investigate the normality of the data.

The Mann–Whitney U test was performed for two-group comparisons in non-parametric data, while the independent-sample *t*-test of significance was employed when comparing two means. The Chi-square and Fisher’s exact tests were performed to compare groups with qualitative data, except when the expected count in any cell was  $<5$ . The margin of error accepted was 5%, and the confidence interval was 95%. Therefore, a  $p < 0.05$  was deemed significant.

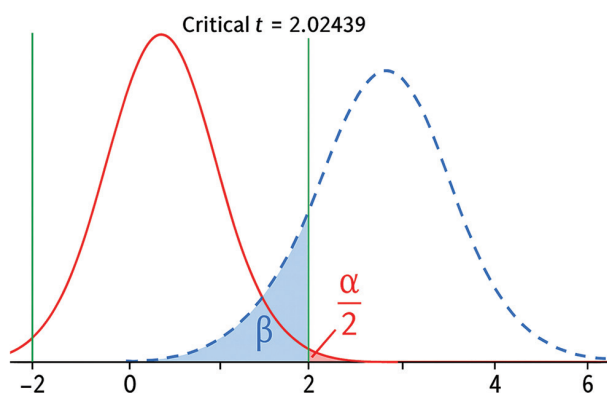


Figure 1. Distributions in a two-tailed *t*-test

### 3. Results

The subsequent tables and figures illustrate the findings of the current investigation. Table 1 reveals no significant differences in demographic characteristics between the TAP block and preperitoneal groups. Both groups were comparable in age, sex distribution, body mass index, American Society of Anesthesiologists physical status classification, and sleep quality. For instance, the average age in the TAP block group was  $42.45 \pm 12.37$  years; in the preperitoneal group, it was  $41.80 \pm 10.86$  years ( $p = 0.861$ ). Similarly, the body mass index was  $23.60 \pm 2.04$  kg/m<sup>2</sup> in the TAP block group and  $24.20 \pm 2.98$  kg/m<sup>2</sup> in the preperitoneal group ( $p = 0.462$ ).

Table 2 reveals no statistically significant difference in sleep quality between groups ( $p > 0.05$ ).

Table 3 and Figure 2 indicate that the VAS scores for post-operative pain were assessed at various intervals (0, 2, 4, 8, 12, and 24 h). Significant differences were observed at the 8- and 12-h marks, with the preperitoneal group reporting higher median pain scores than the TAP block group. At 8 h, the median VAS score was 3 (IQR 3–3) for the TAP block group and 4 (IQR 4–5) for the preperitoneal group ( $p = 0.027$ ). At 12 h, the median VAS score was 3 (IQR 3–4) in the TAP block group and 5 (IQR 4–6) in the preperitoneal group ( $p = 0.019$ ). The differences were not statistically significant at other time intervals (0, 2, 4, and 24 h).

Table 4 reveals no significant difference between the two groups regarding the occurrence of PONV. In the TAP block group, 60% of patients experienced PONV, compared to 50% in the preperitoneal group ( $p = 0.525$ ). This suggests that both analgesic techniques have a similar impact on PONV, highlighting that the advantage of TAP block lies primarily in its pain-relieving efficacy rather than in mitigating nausea or vomiting.

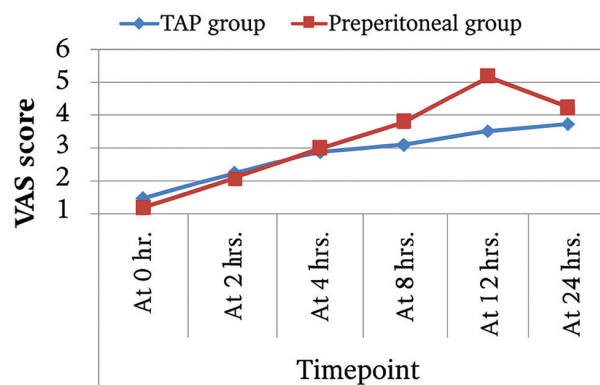


Figure 2. Comparison of the Visual Analog Scale between the transversus abdominis plane block and preperitoneal groups  
Abbreviation: hrs.: Hours

**Table 1. Demographic characteristics of the patient groups**

Demographic data	TAP block group (n=20)	Preperitoneal group (n=20)	Test value	p-value
Age (years)	20–60 (42.45±12.37)	20–60 (41.80±10.86)	0.031	0.861
Sex (%)				
Female	3 (15.0)	5 (25.0)	0.625	0.429
Male	17 (85.0)	15 (75.0)		
Body mass index (kg/m <sup>2</sup> )	20–26 (23.60±2.04)	20–29 (24.20±2.98)	0.552	0.462
ASA classification				
ASA1, n (%)	11 (55.0)	13 (65.0)	0.417	0.519
ASA2, n (%)	9 (45.0)	7 (35.0)		
Operative time (minutes)	33–51 (42.27±6.43)	34–54 (44.34±7.26)	0.955	0.346
Block duration (minutes)	4–7 (5.90±1.03)	5–8 (6.32±1.14)	1.223	0.229

Note: Data presented as range (mean±standard deviation), unless stated otherwise. Independent sample *t*-test for mean±standard deviation; Chi-square test for number (%) or Fisher's exact test, when appropriate.

Abbreviations: ASA: American Society of Anesthesiologists; TAP: Transversus abdominis plane.

**Table 2. Comparison of sleep quality between groups**

Group	Sleep quality score	Test value	p-value
TAP block group	5–9 (7.05±1.23)	0.129	0.721
Preperitoneal group	5–10 (7.20±1.40)		

Note: Data presented as range (mean±standard deviation), unless stated otherwise.

Abbreviation: TAP: Transversus abdominis plane.

Table 5 shows that the time to the first request for analgesia was significantly longer in the TAP block group compared to the preperitoneal group. Patients in the TAP block group required rescue analgesia after an average of 14.6 ± 2.52 h, whereas those in the preperitoneal group requested it after 7.1 ± 1.02 h (*p*<0.001). This highly significant result underscores the prolonged analgesic effect of the TAP block, providing extended pain relief and delaying the need for additional pain management interventions. In addition, there was a statistically significantly higher total dose of analgesia in the preperitoneal group compared to the TAP block group, with a *p*<0.05. Narcotics requirement was significantly less frequent among the TAP block group (Table 6). In addition, the total dose of opioids was significantly lower in the TAP block group (Table 7).

#### 4. Discussion

Cholecystectomy is one of the most commonly performed surgical procedures. The laparoscopic approach is becoming progressively popular due to its earlier recovery and shorter hospital stay, as well as its reduced post-operative pain and morbidity compared to open cholecystectomy surgery.<sup>2</sup>

During laparoscopic cholecystectomy, various perioperative causes, including pneumo-peritoneum,

**Table 3. Comparison of the Visual Analog Scale between groups**

Visual Analog Scale measurement timepoints	TAP block group (n=20)	Preperitoneal group (n=20)	Test value	p-value
0-h			1.862	0.572
Mean±SD	1.45±1.00	1.25±0.79		
Median (IQR)	2 (0–2)	2 (1–2)		
Range	0–3	0–3		
2-h			0.958	0.762
Mean±SD	2.04±0.82	1.95±0.69		
Median (IQR)	3 (2–3)	3 (1–3)		
Range	1–3	1–3		
4-h			1.175	0.386
Mean±SD	2.85±0.59	3.02±0.44		
Median (IQR)	3 (2–3)	3 (3–4)		
Range	1–4	3–4		
8-h			2.793	0.027*
Mean±SD	2.90±0.31	3.80±0.41		
Median (IQR)	3 (3–3)	4 (4–5)		
Range	2–3	3–4		
12-h			2.975	0.019*
Mean±SD	3.30±0.57	5.10±0.85		
Median (IQR)	3 (3–4)	5 (4–6)		
Range	2–4	3–7		
24-h			1.376	0.291
Mean±SD	3.50±1.00	4.05±0.89		
Median (IQR)	4 (3–4)	5 (3–5)		
Range	1–5	2–6		

Note: Statistical analysis conducted using the Mann–Whitney test for non-parametric data. \*indicates statistical significance at *p*<0.05.

Abbreviations: IQR: Interquartile; SD: Standard deviation; TAP: Transversus abdominis plane.

intra-abdominal cavity elongation, amount of blood left in the abdomen, and pelvic region dissection, may induce distinct types of pain.<sup>2</sup> Furthermore, patients who underwent laparoscopic procedures, which are renowned for their reduced pain, were found to experience excessive post-operative pain and receive inadequate pain alleviation in comparison to aggressive major operations.<sup>9,11</sup> Despite the procedure's minimal invasive nature, the post-operative pain that follows laparoscopic cholecystectomy is frequently difficult to manage, leading to delayed hospital discharge and increased opioid use.<sup>12</sup> In addition, patients who undergo abdominal interventions experience significant distress that is linked to somatic pain signals

that originate from the abdominal wall.<sup>13</sup> A prolonged hospital stay, myocardial ischemia, delirium, respiratory complications, and an elevated probability of chronic pain are among the numerous undesirable post-operative consequences that may result from poorly controlled pain following abdominal surgery, in addition to patient suffering and distress.<sup>14</sup>

Advantages of effective post-operative analgesia include reduced post-operative morbidity and stress response, increased patient satisfaction, and enhanced patient outcome.<sup>14</sup>

In this investigation, 40 patients were scheduled for laparoscopic cholecystectomy surgery and were categorized into two groups. The preperitoneal group ( $n = 20$ ) underwent trocar infiltration of local anesthetic, while the TAP block group ( $n = 20$ ) was given a TAP block under ultrasound guidance.

Our findings show no significant difference in sleep quality between the TAP block and preperitoneal groups. Moreover, regarding VAS and the first request of analgesia, the results showed that the 8- and 12-h VAS scores had a higher median value in the preperitoneal group than the TAP block group, with a statistically significant difference. The parameters were insignificant at 0-, 2-, and 4-h.

This study compared the analgesic efficacy of the TAP block and preperitoneal infiltration with bupivacaine in patients undergoing laparoscopic cholecystectomy. The findings demonstrated that the TAP block provided superior pain relief, as evidenced by significantly lower VAS scores at 8- and 12-h post-operation and a longer time to first rescue analgesia ( $14.6 \pm 2.52$  h in the TAP block group vs.  $7.1 \pm 1.02$  h in the preperitoneal group,  $p < 0.001$ ). In addition, patients in the TAP block group required

**Table 4. Comparison of post-operative nausea and vomiting between groups**

Presence of post-operative nausea and vomiting	TAP block group ( $n=20$ ) (%)	Preperitoneal group ( $n=20$ ) (%)	Test value	$p$ -value
No	8 (40.0)	10 (50.0)	0.404	0.525
Yes	12 (60.0)	10 (50.0)		

Note: Chi-square test for number (%) or Fisher's exact test, when appropriate.

Abbreviation: TAP: Transversus abdominis plane.

**Table 5. Comparison of time to first request for rescue analgesia between groups**

Group	Time to first request for rescue analgesia (hours)	Test value	$p$ -value
TAP block group	12–18 ( $14.60 \pm 2.52$ )	5.027	0.001*
Preperitoneal group	6–8 ( $7.10 \pm 1.02$ )		

Note: Data presented as range (mean  $\pm$  standard deviation), unless stated otherwise. Independent sample  $t$ -test for mean  $\pm$  standard deviation. \* indicates statistical significance.

Abbreviation: TAP: Transversus abdominis plane.

**Table 6. Opioid requirements and dosage among the studied groups**

Opioid requirement	TAP block group ( $n=20$ ) (%)	Preperitoneal group ( $n=20$ ) (%)	$p$ -value	Effect size, relative risk (95% confidence interval)
Required	2 (10.0)	5 (25.0)	0.037*	0.51 (0.23–1.09)
Not required	18 (90.0)	15 (75.0)		

Note: Effect size refers to the effect of the TAP block group relative to the preperitoneal group. \* indicates statistical significance.

Abbreviation: TAP: Transversus abdominis plane.

**Table 7. Opioid total dose in cases that required analgesia among the studied groups**

Group	Opioid total dose (mg)	$p$ -value	Effect size, mean $\pm$ standard error (95% confidence interval)
TAP block group ( $n=2$ )	50.0–75.0 ( $55.0 \pm 11.2$ )	0.007*	$-27.7 \pm 9.0$ ( $-46.9$ – $-8.5$ )
Preperitoneal group ( $n=5$ )	50.0–100.0 ( $82.7 \pm 18.8$ )		

Note: Statistical analysis using an independent  $t$ -test. Effect size refers to the effect of the TAP block group relative to the control. \* indicates statistical significance.

Abbreviation: TAP: Transversus abdominis plane.

significantly less total opioid consumption within the first 24 h postoperatively.

The results of our study agree with the findings of El sharkwy *et al.*<sup>15</sup> They determined that the TAP block is more efficacious in the early post-operative period in terms of pain scores and analgesia consumption than preperitoneal infiltration in surgical laparoscopy. Ghisi *et al.*,<sup>16</sup> discovered that the pain scores at rest and through movement were not lowered by ultrasound-guided TAP block through the first 24 h following laparoscopic hysterectomy, in contrast to the control group that received morphine patient-controlled analgesia as a treatment. This is in stark contrast to the findings of El sharkwy *et al.*<sup>15</sup>, who demonstrated the superiority of the TAP block over preperitoneal infiltration during the early post-operative period.

In a retrospective cohort study by Rivard *et al.*,<sup>17</sup> the intraperitoneal bupivacaine administration was associated with reduced post-operative narcotic use and lower patient-reported pain scores in minimally invasive surgery, such as cancer staging and hysterectomy. With respect to post-operative complications, no significant difference in PONV was indicated between the preperitoneal group and the TAP block group.

Badawy<sup>18</sup> compared the intraperitoneal local analgesia instillation before the trocars' removal in laparoscopic hysterectomy cases to the control group. Pain scores were significantly decreased within the first 24 h after surgery when an intraperitoneal local anesthetic was administered. This was demonstrated by the reduction in opioid consumption and post-operative analgesia. In addition, there was a reduction in the incidence of PONV.

None of the complications associated with the TAP block was encountered during our investigation. Furthermore, the TAP block has not been associated with any complications in the preponderance of all other studies. The primary benefit of the TAP block is its safety profile, although researchers have documented the incidence of liver and colon injury.<sup>19</sup>

In contrast, wound infiltration utilization by local anesthetics through laparoscopic surgery to mitigate post-operative pain has been documented since the early 1990s. Dec and Andruszkiewicz<sup>20</sup> were the first to disclose the use of wound infiltration by local anesthetics for minimally invasive cholecystectomies in the general surgery literature in 2016. A meta-analysis of 30 studies featuring laparoscopic cholecystectomies revealed a reduction in the quantity of analgesics administered postoperatively and a decrease in post-operative pain scores. Yoshiyama *et al.*,<sup>21</sup> found that the posterior TAP block was more efficient than the lateral TAP block

in providing pain relief to patients who underwent laparoscopic gynecologic surgery.

While our findings indicate that the TAP block provided longer-lasting analgesia and reduced opioid consumption compared to preperitoneal infiltration, it is important to emphasize that both techniques were clinically effective in managing post-operative pain following laparoscopic cholecystectomy.

Although the differences in VAS scores at 8 and 12 h were statistically significant, the absolute differences were modest. This suggests that while the TAP block may offer an advantage in the duration of pain relief, preperitoneal infiltration remains a viable and practical alternative, particularly when ultrasound resources or expertise are limited. These findings support the inclusion of either technique within a multimodal analgesia strategy, tailored to the clinical setting, provider experience, and patient-specific factors.

#### 4.1. Strengths

The study's randomized, double-blinded design enhances the reliability and validity of the findings by reducing selection and observer biases. Using objective measures, such as the VAS for pain assessment and quantification of opioid consumption, adds rigor to the evaluation of the analgesic techniques. Furthermore, the direct comparison between the TAP block and preperitoneal infiltration offers a practical perspective on optimizing pain management strategies. The study also controlled key procedural variables, such as surgical and anesthetic protocols, ensuring that observed differences were attributable to the analgesic methods rather than external factors. These methodological strengths provide a robust foundation for the study's conclusions.

#### 4.2. Limitations

Despite its strengths, the study has notable limitations. A notable limitation of this study is its relatively small sample size, which may reduce the generalizability of the findings and the statistical power to detect smaller but clinically meaningful differences. Although the observed trends favor the TAP block in terms of analgesic duration and opioid-sparing effect, these results should be interpreted with caution. The study focuses exclusively on laparoscopic cholecystectomy, and its applicability to other surgical procedures remains uncertain. The study examined only short-term outcomes within the first 24 h, omitting the potential for long-term complications, chronic pain, or extended recovery metrics. The homogeneity of the study population, with limited diversity in demographics or comorbidities, further narrows the scope of the conclusions.

Finally, while complications associated with TAP block were minimal in this study, it does not extensively address rare but potentially severe risks, such as inadvertent organ injury.

To validate these preliminary findings and better understand the comparative efficacy of these techniques, we recommend conducting larger, multicenter randomized controlled trials. Future studies should also explore long-term outcomes, cost-effectiveness, and patient satisfaction to provide more comprehensive clinical guidance.

## 5. Conclusion

The findings establish that the TAP block is a more effective analgesic technique compared to preperitoneal infiltration with bupivacaine for managing post-operative pain in laparoscopic cholecystectomy. Patients receiving TAP block required fewer opioids, had delayed onset of rescue analgesia, and reported lower pain scores at critical post-operative intervals. These results underline the TAP block's potential to enhance patient recovery by minimizing opioid-related side effects and expediting discharge. The study highlights the need to integrate the TAP block into routine perioperative care for laparoscopic procedures to improve pain control and patient outcomes.

Future research should focus on expanding the study to include larger and more diverse populations to validate these findings and assess their applicability to other surgical contexts. Long-term studies are necessary to explore the impact of these analgesic techniques on chronic pain, quality of life, and recovery trajectories. Moreover, conducting a cost-effectiveness analysis of TAP block versus other analgesic methods would provide a comprehensive understanding of its economic and clinical benefits.

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## Conflict of interest

The authors have no conflicts of interest to declare.

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## Ethics approval and consent to participate

This study was approved by the Institutional Review Board and the Ethical Committee of the Faculty of Medicine for Girls, Al-Azhar University (Approval Number 1784/2023), and additionally by the Institutional Review Board of Minia University Hospital, according to the WMA Declaration of Helsinki. Each participant was required to provide an informed written consent before enrollment.

## Consent for publication

Each participant was required to provide verbal consent before publication.

## Availability of data

The data used in the study are available from the corresponding author upon reasonable request.

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