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Assessment of ultrasound-guided abdominal wall nerve block for postoperative pain control and optimization of opioid utilization in patients undergoing abdominal surgery

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Abstract: This retrospective cohort study was conducted at the Affiliated Jinhua Hospital of Zhejiang University (Jinhua, Zhejiang, China) to evaluate the effects of ultrasound-assisted abdominal wall nerve block on postoperative pain and opioid use in abdominal surgery patients. A total of 104 patients were included, with 51 receiving traditional blind nerve block and 53 receiving ultrasound-guided nerve block. The results showed that the ultrasound-guided group had significantly lower pain scores at 6, 12 and 24 hours, as well as reduced opioid consumption within the first 24 hours. Additionally, patients in the ultrasound-guided group reported higher satisfaction on postoperative days 1 (9.05±1.21 vs. 8.22±1.34, P=0.001), 3 (9.97±1.32 vs. 9.11±1.45, P=0.002) and 7 (9.92±1.09 vs. 9.25±1.21, P=0.004). Statistical analysis was performed using SPSS 25.0 (SPSS Inc., Chicago, IL, USA), with t-tests for continuous variables and Chi-square tests for categorical variables. A corrected chi-square test was applied when $1 \leq T < 5$ and Fisher's exact test was used for small sample sizes. Results with P-values below 0.05 were considered statistically significant. Our findings suggest that ultrasound-guided nerve block is effective in reducing postoperative pain, opioid use, and enhancing patient satisfaction.

Keywords: Ultrasound-guided abdominal wall nerve block, postoperative pain scores, opioid consumption, abdominal surgery.

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INTRODUCTION

Abdominal surgery, ranging from simple appendectomies to complex organ resections, is a common surgical practice. Effective postoperative pain management is essential for optimizing patient outcomes and quality of care (Sharma *et al*., 2023; Tunay *et al*., 2023; Xue 2023). Despite advances in multimodal analgesia, postoperative pain remains a concern, often requiring opioids, which carry risks of respiratory depression, nausea, ileus and dependence (Polo-Paredes *et al*., 2023; Roberto *et al*., 2023; Salmonsen *et al*., 2024). Thus, there is increasing emphasis on alternative analgesic techniques to reduce opioid use and improve pain management (Okmen 2023). Ultrasound-guided abdominal wall nerve block is a promising technique for targeted analgesia in abdominal surgery patients (Peksoz *et al*., 2022; Rayamajhi *et al*., 2022). It precisely localizes and blocks peripheral nerves supplying the abdominal wall, interrupting nociceptive signals from surgical incisions and visceral manipulations (Ienello *et al*., 2022; Kanakarajan *et al*., 2022).

Literature suggests that ultrasound-guided regional anesthesia, including abdominal wall nerve blocks, is associated with favorable outcomes in reducing opioid use and improving postoperative pain control (Ferreira *et al*., 2022; Han and Pan 2022). However, how ultrasound-guided abdominal wall nerve blocks influence pain and opioid consumption in abdominal surgery patients remain debated (Espadas-Gonzalez *et al*., 2022; Ferreira *et al*., 2022). Prior studies report mixed results, with some showing significant reductions in pain scores and opioid use, while others find inconclusive outcomes (Michielsen *et al*., 2021; Alaman *et al*., 2022; Elshazly *et al*., 2022).

Given the importance of effective postoperative pain management and opioid stewardship, further research is needed to clarify ultrasound-guided abdominal wall nerve blocks' impact on pain scores and opioid use in abdominal surgery patients. This retrospective cohort research sought to gauge the efficacy and clinical implications of this technique to inform evidence-based practice and improve perioperative care.

MATERIALS AND METHODS

Sample group

Our retrospective research analyzed clinical information from 104 patients with abdominal surgery admitted to Zhejiang University Affiliated Jinhua Hospital from January 2023 to December 2023. Patients were divided into the traditional blind nerve block group (n=51) and the ultrasound-guided nerve block group (n=53) based on anesthesia method.

Inclusion and exclusion criteria

Inclusion criteria

Patients meeting the requirements for abdominal surgery;

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American Society of Anesthesiologists (ASA) physical status classification I-III; Complete clinical data; Clear consciousness and ability to communicate normally; Approval from the Medical Ethics Committee; Informed consent and signature from the patient and their family.

Exclusion criteria

Severe liver or kidney dysfunction; Coagulation abnormalities or concurrent bleeding disorders; Incomplete clinical data; Inability to communicate normally.

Study methods

Traditional blind exploration approach

Routine monitoring of non-invasive blood pressure (NBP), heart rate (HR), electrocardiogram (ECG), and pulse oxygen saturation (SpO2) was carried out as patients entered the operating room and received oxygen through a face mask. After establishing intravenous access, each patient was administered midazolam (0.02 mg/kg) intravenously. With the patient lying supine, the head was turned toward the healthy side and a puncture needle was inserted using the blind exploration method, with patients providing sensory feedback. Once confirmed that no blood, cerebrospinal fluid, or gas was present upon needle withdrawal, local anesthetic was injected.

Ultrasound-guided method

The standard endotracheal intubation protocol under general anesthesia was followed (Wu *et al*., 2019). Anesthesia induction included sufentanil (Yichang Renfu, National Drug Approval H20054171) at 0.5ug/kg and etomidate (Jiangsu Hengrui Medicine, National Drug Approval H32022379) at 0.3mg/kg were administered. After loss of consciousness, tracheal intubation and mechanical ventilation were initiated, maintaining an end-tidal carbon dioxide concentration (ETCO2) at 35-45 mmHg. Propofol (4-10mg·kg-1·h-1) together with remifentanil (0.05-0.2μg·kg-1·h-1) was administered for anesthesia maintenance, with cisatracurium added as needed for muscle relaxation. Drug dosages were adjusted to maintain a bispectral index (BIS) of 40-60. After intubation, an ultrasound probe was positioned along the anterior axillary line between the rib margin and iliac crest to locate abdominal muscles. A needle was inserted through the internal oblique muscle to the transverse fascia, and after confirming no blood, 20mL of 0.4% ropivacaine was injected. The process was repeated for the opposite side.

Scoring or grading methods

The ASA Classification Standard was utilized for evaluating patient health conditions, with classifications as follows: I - no systemic disease, no functional limitations; II - mild systemic disorder, without any functional impairments; III - severe systemic condition, involving certain functional deficits. Pain levels were examined employing the visual analog scale (VAS) at 6, 12 and 24 hours postoperatively, where 0 indicates no pain, 1-3 points represent mild, tolerable pain, 4-6 points indicate moderate pain affecting activities and comfort, 7-9 points represent severe pain requiring intervention and 10 points indicate extreme, intolerable pain necessitating urgent intervention. Patient satisfaction was assessed at 1, 3 and 7 days postoperatively with a 0-10 scale, where 0 signifies extreme dissatisfaction, significant impact and severe pain, while 10 indicates complete satisfaction, no impact and complete absence of pain.

Data collection

Data on patient demographics, baseline characteristics, surgical procedures, postoperative pain scores, opioid consumption and the electronic medical records provided the satisfaction scores. Variables incorporated gender, age, American Society of Anesthesiologists (ASA) classification, body mass index (BMI), surgical duration, pain scores at 6, 12 and 24 hours, total opioid use in the first 24 hours and satisfaction scores on days 1, 3 and 7 postoperatively.

Ethical approval

This study was approved by the Ethics Committee of Zhejiang University (Approval Number: ZJU20220810). All experimental procedures were conducted in compliance with the ethical guidelines for medical research involving human subjects and adhered to the principles outlined in the Declaration of Helsinki.

STATISTICAL ANALYSIS

SPSS 25.0 (SPSS Inc., Chicago, IL, USA) was exercised for data analysis. Categorical variables, represented as [n (%)], were analyzed using the chi-square test under the condition that the sample size was ≥40 and T ≥5; a corrected chi-square test was applied if 1≤T<5. In cases where the sample size was less than 40 or T <1, Fisher's exact test was applied. Normally distributed data were represented as (X±s), with non-normal distributions assessed via the Wilcoxon rank-sum test. Results with P-values below 0.05 were deemed statistically significant.

RESULTS

Patient demographics and baseline characteristics

The study results showed no notable statistical difference in demographics and baseline features between the Blind Exploration Group and the Ultrasound-Guided Group (fig. 1). Specifically, age (45.68±7.21 vs. 46.75±6.93 years, t=0.768, P=0.444), gender (χ^2=0.032, P=0.859), BMI (26.34±3.42 vs. 25.98±3.11 kg/m^2, t=0.556, P=0.580), ASA classification (χ^2=0.154, P=0.926), and procedure duration (112.45±15.67 vs. 110.32±14.98 minutes, t=0.710, P=0.479) were comparable. These findings confirm that the two groups were well-matched, supporting the validity of subsequent analyses.

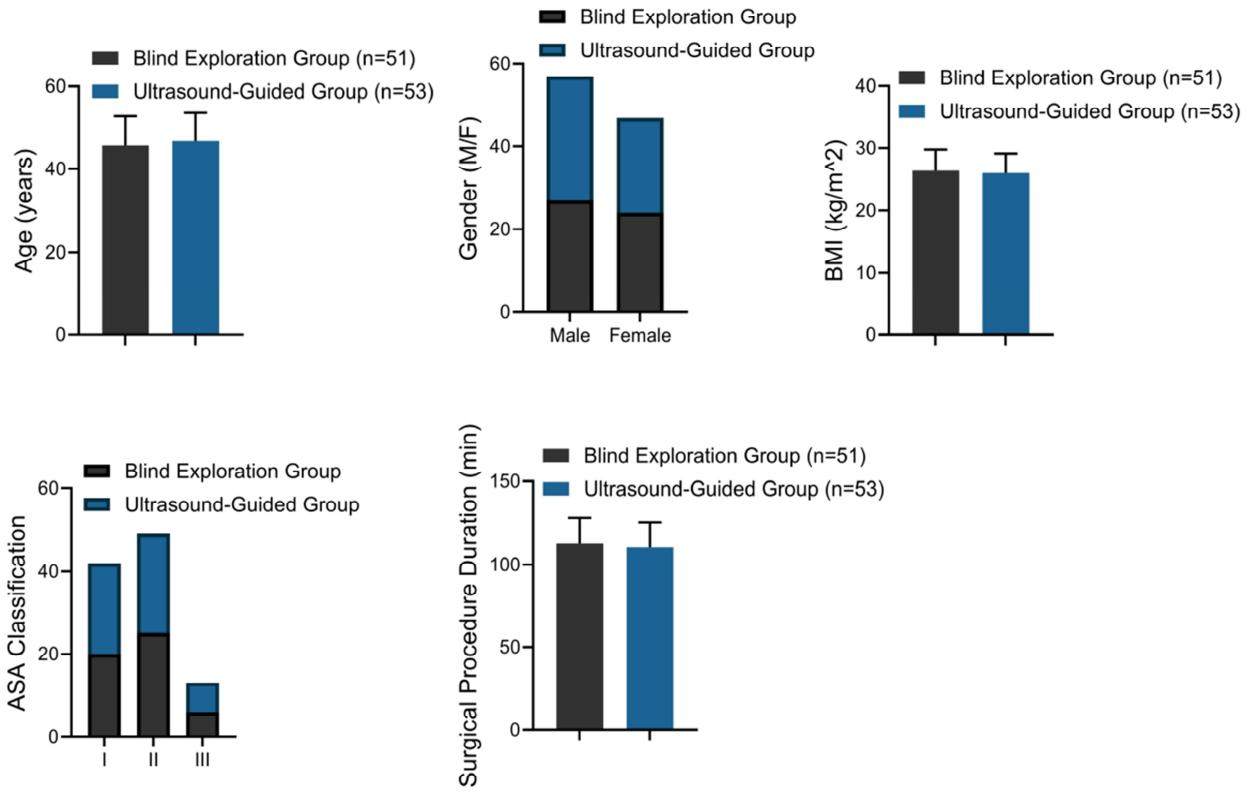

Fig. 1: Patient demographics and baseline characteristics in two groups

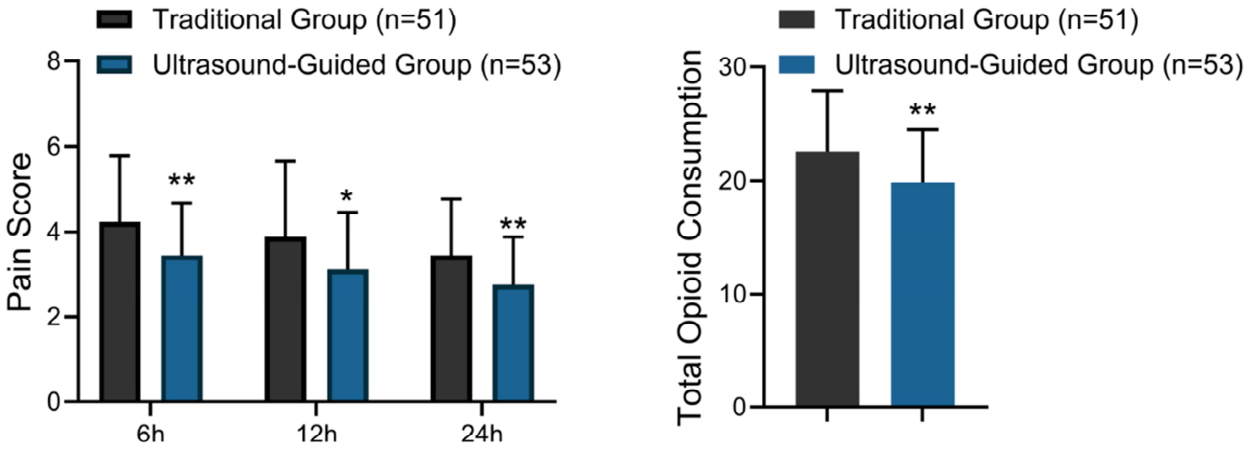

Fig. 2: Comparison of postoperative pain scores between the two groups

Postoperative pain scores

At 6 hours postoperatively, the mean pain score in the Ultrasound-Guided Group was appreciably dropped as against in the Traditional Group (3.45±1.23 vs. 4.23± 1.56, t=2.844, P=0.005) (fig. 2).

Significant differences were also observed at 12 hours (3.12±1.34 vs. 3.89± 1.78, t=2.494, P=0.014) and 24 hours (2.76±1.12 vs. 3.45± 1.32, t=2.880, P=0.005). The Ultrasound-Guided Group had lower total opioid usage (19.87±4.56 vs. 22.56± 5.34, t=2.758, P=0.007). These findings suggest that ultrasound-guided nerve block reduces postoperative pain and opioid utilization compared to traditional methods, supporting its effectiveness as an analgesic technique.

Opioid consumption

Comparison of opioid intake during the initial 24 hours post-abdominal surgery showed notably lessened usage in the Ultrasound-Guided Nerve Block group in contrast with the Blind Exploration group (fig. 3). The Ultrasound-Guided group had reduced consumption of butorphanol (20.89±4.21 vs. 23.45±5.67mg, t=2.604, P=0.011), oxycodone (13.76±3.01 vs. 15.32±3.98 mg, t=2.246,

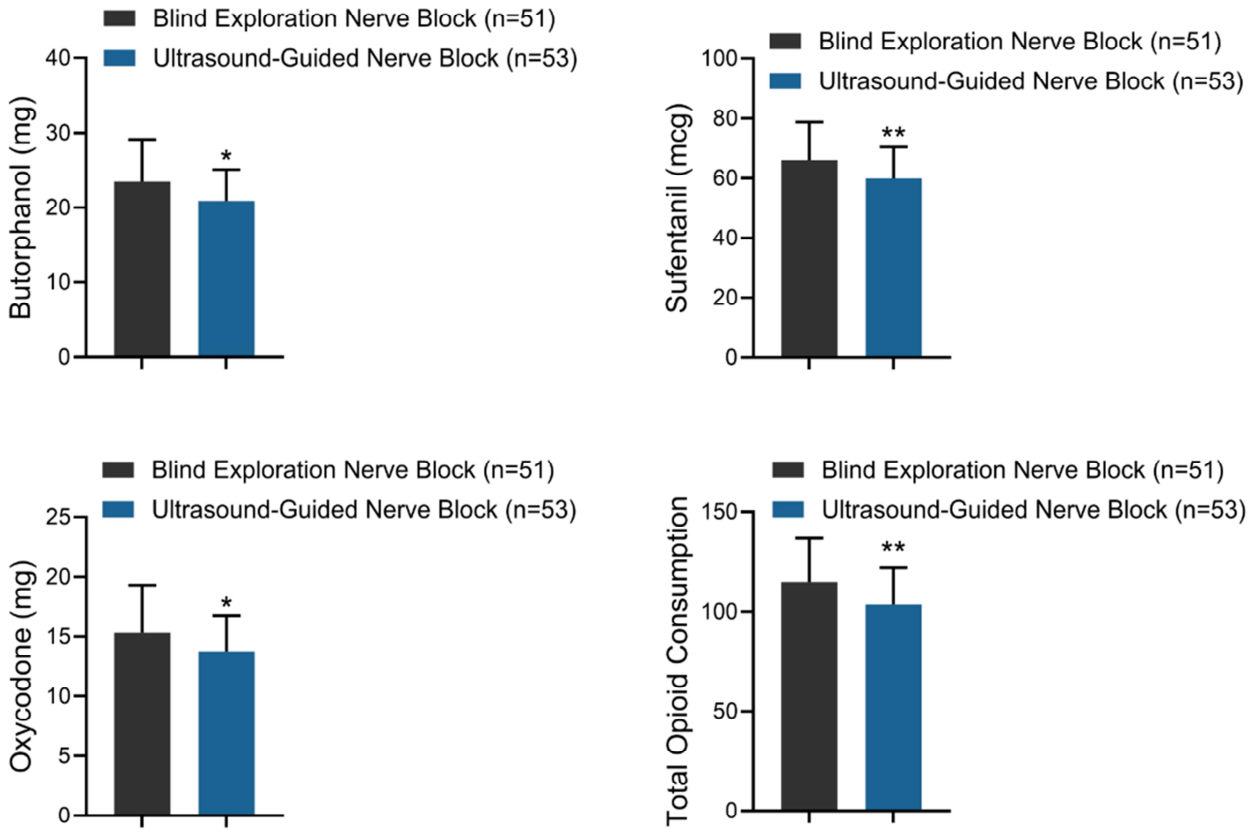

Fig. 3: Comparison of opioid consumption in the First 24 Hours between the two groups

P=0.027), sufentanil (59.87±10.54 vs. 65.98±12.76 mcg, t=2.657, P=0.009) and total opioid (103.55±18.46 vs. 114.96±21.86, t=2.870, P=0.005). These findings highlight the clinical relevance of ultrasound-guided nerve block in reducing opioid use and enhancing postoperative pain management.

Patient satisfaction scores (on a scale of 1-10)

Comparison of patient satisfaction scores showed significantly higher satisfaction in the Ultrasound-Guided Nerve Block group than in the Blind Exploration group (fig. 4). On day 1 postoperatively, satisfaction scores were higher in the Ultrasound-Guided group (9.05±1.21 vs. 8.22±1.34, t=3.317, P=0.001), with similar results on day 3 (9.97±1.32 vs. 9.11±1.45, t=3.172, P=0.002; day 7: 9.92±1.09 vs. 9.25±1.21, t=2.947, P=0.004). These results indicate that ultrasound-guided nerve block enhances patient satisfaction in the early postoperative period, improving the overall patient experience.

Correlation analysis

Correlation analysis revealed significant association between Ultrasound-guided abdominal wall nerve block and various clinical indices (table 1). Ultrasound-guided nerve block was negatively correlated with postoperative pain scores at 6, 12, and 24 hours (r=-0.272 to -0.275, P <0.05), total opioid consumption (r=-0.264, P=0.007), individual opioids (butorphanol, oxycodone, sufentanil; r=-0.218 to -0.255, P<0.05) and positively correlated with patient satisfaction on days 1, 3 and 7 (r=0.281 to 0.313, P<0.01). These observations demonstrate that ultrasound-guided nerve block reduces pain and opioid use while enhancing patient satisfaction, highlighting its potential as an effective analgesic strategy for abdominal surgery.

DISCUSSION

Management postoperative pain after abdominal surgery is challenging, requiring effective analgesic techniques to improve patient outcomes and quality of care (Freitag *et al*., 2021; Liu and Zhu 2021). This retrospective cohort study examined the influence of ultrasound-guided abdominal wall nerve block on postoperative pain and opioid use. Results revealed considerable diminution in pain scores and opioid consumption in sufferers undergoing ultrasound-guided blocks compared to traditional blind exploration, highlighting the potential of ultrasound-guidance as an effective perioperative analgesic strategy.

This study demonstrated that subjects in the ultrasound-guided nerve block group had much lower pain scores at 6, 12 and 24 hours upon surgery, along with reduced opioid depletion within the first 24 hours, compared to the traditional group. These results support evidence that ultrasound-guided regional anesthesia can reduce opioid

Table 1: Correlation analysis between each index and ultrasound-guided abdominal wall nerve block

Parameter	r	R^2	*P value*
Pain Score at 6 hours	-0.272	0.074	0.005
Pain Score at 12 hours	-0.241	0.058	0.014
Pain Score at 24 hours	-0.275	0.076	0.005
Total Opioid Consumption1	-0.264	0.07	0.007
Butorphanol	-0.251	0.063	0.01
Oxycodone	-0.218	0.048	0.026
Sufentanil	-0.255	0.065	0.009
Total Opioid Consumption	-0.274	0.075	0.005
Patient Satisfaction Scores (Day 1)	0.313	0.098	0.001
Patient Satisfaction Scores (Day 3)	0.3	0.09	0.002
Patient Satisfaction Scores (Day 7)	0.281	0.079	0.004

needs and improve postoperative pain control (Elsharkawy *et al*., 2021; Fernandes *et al*., 2021), aligning with goals of opioid stewardship and minimizing opioid-related side effects.

The drop in postoperative pain scores and opioid utilization with ultrasound-guided abdominal wall nerve block is due to the precise targeting of peripheral nerves supplying the abdominal wall (Calice *et al*., 2021). By blocking nociceptive signals from surgical sites, this technique offers effective localized pain management, reducing the need for systemic opioid administration and associated risks (Yayik *et al*., 2020). The superior analgesic efficacy observed highlights the clinical value of ultrasound-guided nerve blocks in enhancing perioperative pain management and patient outcomes.

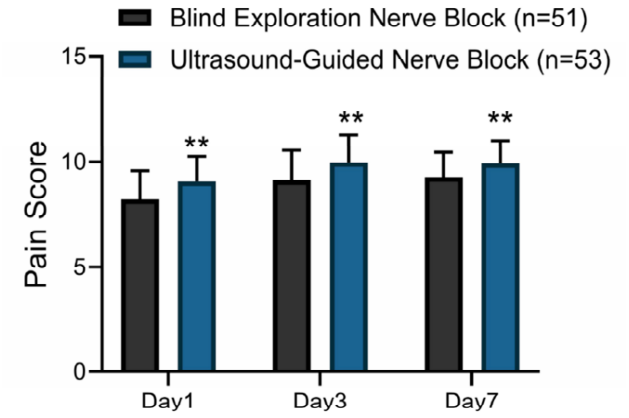

Fig. 4: Comparison of patient satisfaction scores between the two groups

Our study revealed a positive correlation between ultrasound-guided nerve block and higher patient satisfaction scores at 1, 3 and 7 days postoperatively. Patients who received ultrasound-guided blocks reported greater satisfaction, underscoring the technique's impact on the early postoperative experience. Enhanced satisfaction reflects both effective pain management and a holistic, patient-centered approach, suggesting this technique may improve comfort, recovery and overall satisfaction with care.

However, ultrasound-guided technology may face practical limitations in resource-limited settings, especially in low-resource countries or regions. The high cost of ultrasound equipment and the need for specialized training may limit the widespread adoption of this technology. Nevertheless, as the cost of ultrasound equipment decreases and training resources increase, the application of ultrasound-guided techniques is expected to gradually expand in these environments. We suggest that future research should include a discussion of these practical limitations, evaluate how to overcome these barriers and further promote the global adoption of this technology.

The favorable outcomes of ultrasound-guided abdominal wall nerve block in our study support existing literature on the efficacy of regional anesthesia in abdominal surgery. Ultrasound-guided nerve blocks are recognized for reducing opioid usage, postoperative pain and opioid-correlated side effects, thus enhancing perioperative care. Our findings align with previous research, highlighting the value of ultrasound-guided nerve blocks as an adjunct to multimodal analgesia, aiding efforts to minimize opioid use and improve patient-centered pain management (St James *et al*., 2020; Peksoz *et al*., 2022).

When interpreting the results of this study, several limitations should be considered. The retrospective design may introduce selection bias and limit causal inference. Although efforts were made to ensure cohort comparability, not all factors affecting pain and opioid use could be controlled. Additionally, the generalizability of the findings is limited by the specific patient population and surgical procedures studied. The sample size is relatively small and increasing the sample size would help improve statistical power and enhance the generalizability of the results. Another limitation is the lack of blinding, particularly in the assessment of subjective outcomes such as pain scores and satisfaction, which may lead to observer bias. Future studies could reduce this bias by blinding assessors and data analysts, thereby enhancing the objectivity and reliability of the results. Furthermore, our study did not collect long-term feedback from patients

following ultrasound-guided pain management, which limits the ability to evaluate the sustained effectiveness of the treatment. Future research should include longer follow-up periods to assess the long-term benefits and durability of the ultrasound-guided nerve block. In addition, we did not perform subgroup analyses based on surgical types or baseline pain levels, which may provide further insights into the differential effects of the ultrasound-guided nerve block across different patient groups. Future studies should include such subgroup analyses to better understand the impact of these variables on the effectiveness of the treatment. Further research with diverse patient cohorts and surgical contexts is recommended to validate the applicability of these findings.

CONCLUSION

In conclusion, this study demonstrates that ultrasound-guided abdominal wall nerve block reduces postoperative pain, opioid consumption and improves patient satisfaction. These findings suggest its potential as an effective analgesic technique for perioperative care.

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