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EVALUATION OF MULTIMODAL ANALGESIA VERSUS OPIOID-BASED ANALGESIA IN POSTOPERATIVE PAIN MANAGEMENT

Anaesthesiology

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ABSTRACT

Background: Optimal postoperative pain control remains a cornerstone of recovery following general surgical procedures. Conventional opioid-based regimens, though effective, are frequently associated with adverse effects such as sedation, nausea, and delayed mobilization. Multimodal analgesia, which combines agents acting through different pharmacological pathways, offers a promising alternative by enhancing analgesic efficacy and reducing opioid-related complications. **Objectives:** This study aims to compare the effectiveness of multimodal analgesia with traditional opioid-based analgesia in managing postoperative pain among patients undergoing general surgery. **Methods:** A prospective comparative study was conducted on postoperative patients divided into two groups: one receiving multimodal analgesia comprising non-opioid agents and adjuvant analgesics, and the other managed with opioid-based therapy. Pain intensity was measured using the Visual Analogue Scale (VAS) at multiple intervals, while opioid requirement, adverse effects, and recovery parameters such as ambulation time and hospital stay were recorded. **Results:** Patients receiving multimodal analgesia exhibited significantly lower VAS scores and reduced opioid consumption compared to the opioid-only group. The multimodal regimen also demonstrated fewer opioid-related side effects, earlier mobilization, and shorter hospital stays, indicating improved functional recovery. **Conclusion:** Multimodal analgesia is a safer and more effective strategy for postoperative pain control in general surgical patients. Its adoption can enhance patient satisfaction, minimize opioid dependence, and promote faster rehabilitation.

KEYWORDS

Multimodal analgesia, Opioid-based analgesia, Postoperative pain, General surgery, Recovery outcomes, Visual Analogue Scale (VAS), Opioid-sparing effect

INTRODUCTION

Effective management of postoperative pain remains a cornerstone of surgical care and is critical for optimizing patient comfort, accelerating recovery, and preventing postoperative complications. Uncontrolled pain following surgery can adversely affect multiple physiological systems, leading to impaired pulmonary function, sympathetic overactivity, delayed ambulation, and increased risk of thromboembolic events [1]. Additionally, inadequate pain relief may predispose patients to chronic post-surgical pain, sleep disturbances, and poor overall satisfaction with their surgical experience [2].

For decades, opioid-based analgesia has been the primary modality for treating moderate to severe postoperative pain. While opioids effectively suppress nociceptive transmission via μ-receptor activation, their use is associated with several dose-dependent adverse effects, including respiratory depression, nausea, vomiting, constipation, urinary retention, and sedation [3]. The emergence of the "opioid crisis" and recognition of opioid-induced hyperalgesia, tolerance, and dependence have necessitated a paradigm shift towards safer, more balanced analgesic strategies [4]. Furthermore, reliance on opioids often prolongs recovery, delays ambulation, and contributes to longer hospital stays and higher healthcare costs [5].

To overcome these limitations, multimodal analgesia (MMA) has been proposed as a comprehensive and evidence-based approach to postoperative pain control. MMA involves the combination of two or more analgesic agents or techniques that act through distinct mechanisms within the pain pathway, thereby achieving additive or synergistic effects [6]. This strategy typically integrates non-opioid systemic agents (such as acetaminophen, nonsteroidal anti-inflammatory drugs, and gabapentinoids), regional anesthesia (nerve blocks or wound infiltration with local anesthetics), and adjuvant agents such as ketamine or dexmedetomidine [7]. By targeting different aspects of nociceptive transmission—peripheral sensitization, spinal modulation, and central perception—multimodal analgesia effectively reduces the total opioid requirement and minimizes side effects [8].

The implementation of MMA has shown clear advantages across several surgical disciplines, including orthopaedic, gynecologic, and colorectal surgeries. Studies report lower pain scores, earlier mobilization, improved patient satisfaction, and reduced hospital stay durations compared to traditional opioid-based regimens [9]. Moreover, MMA aligns closely with the principles of the Enhanced Recovery After Surgery (ERAS) protocols, which emphasize multimodal, opioid-sparing strategies to improve perioperative outcomes and shorten convalescence [10]. However, despite its proven efficacy, evidence comparing multimodal and opioid-based analgesic regimens specifically within the context of general surgery remains relatively limited, particularly in developing healthcare settings where practice patterns and resource availability vary [11].

Given this background, the present study was undertaken to evaluate the comparative efficacy and safety of multimodal analgesia versus conventional opioid-based analgesia in patients undergoing general surgical procedures. The study aims to assess postoperative pain intensity, total opioid consumption, incidence of analgesia-related side effects, and parameters of functional recovery such as ambulation and duration of hospital stay. The findings from this research are expected to provide clinically relevant insights that can support the wider adoption of multimodal analgesic strategies in routine general surgical practice, improving both patient outcomes and the quality of perioperative care.

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of General Surgery at Canadian specialist hospital during January 2023 to January 2025 to evaluate the clinical effectiveness and safety of multimodal analgesia compared with opioid-based analgesia in postoperative pain management. The research protocol was approved by the Institutional Ethics Committee before recruitment, and all participants provided written informed consent prior to inclusion. The study adhered to the principles outlined in the Declaration of Helsinki [12].

Study Design And Participants

The investigation adopted a hospital-based, prospective, parallel-group design. Adult patients aged between 18 and 65 years, classified under ASA physical status I–II, and scheduled for elective general surgical procedures (such as hernia repair, cholecystectomy, appendectomy, or exploratory laparotomy) under general or spinal anesthesia were considered eligible. Patients with chronic opioid use, known drug hypersensitivity to any of the study medications, hepatic or renal impairment, psychiatric disorders, pregnancy, or lactation were excluded. Patients unwilling to participate or those lost to follow-up were also omitted from final analysis.

Sample Size And Group Allocation

The sample size was calculated using previous studies that reported differences in mean Visual Analogue Scale (VAS) pain scores between multimodal and opioid-based regimens [13]. Assuming a mean difference of 1.0 unit on the VAS, a standard deviation of 1.5, $\alpha = 0.05$, and power = 80 %, a minimum of 45 patients per group was required. To compensate for possible dropouts, the study enrolled 100 patients,

equally distributed into two groups of 50 each:

- Group A (Multimodal Analgesia, MMA): Received a combination of non-opioid analgesics and adjuvants.
- Group B (Opioid-Based Analgesia, OBA): Managed primarily with opioids according to institutional postoperative pain protocols.

Random allocation was ensured through sealed opaque envelopes prepared by an independent staff member not involved in patient care.

Analgesic Regimens

In Group A, patients received intravenous paracetamol 1 g every 8 hours and ketorolac 30 mg every 8 hours as scheduled medications. Local infiltration with 0.25 % bupivacaine at the surgical incision site was performed at wound closure wherever feasible. Intravenous tramadol 50 mg served as rescue analgesia whenever the VAS score reached or exceeded 4.

In Group B, patients were managed with intravenous tramadol 100 mg every 8 hours or morphine 0.1 mg/kg as per postoperative need. Non-opioid analgesics such as paracetamol were allowed only for breakthrough pain. All patients received standard antiemetic prophylaxis with ondansetron 4 mg IV every 12 hours. Vital parameters were continuously monitored, and adverse events such as nausea, vomiting, dizziness, constipation, sedation, or respiratory depression were documented meticulously.

Pain And Recovery Assessment

Pain intensity was evaluated using a 10-point VAS, where 0 denoted no pain and 10 the worst imaginable pain. Assessments were made at 2, 6, 12, and 24 hours after surgery by trained nursing personnel blinded to the analgesic regimen [14]. The total number of rescue analgesic doses and cumulative opioid consumption during the first 24 hours were recorded.

Functional recovery parameters included time to first ambulation, duration of hospital stay, and overall patient satisfaction, which was graded on a 5-point Likert scale (1 = very dissatisfied, 5 = very satisfied). Postoperative nausea and vomiting (PONV) were scored using a standardized ordinal scale (0 = none, 1 = mild, 2 = moderate, 3 = severe).

Data Collection And Statistical Analysis

All perioperative data-including demographic characteristics, operative duration, type of anesthesia, pain scores, and complications—were recorded in pre-structured case report forms. Data were entered in Microsoft Excel 2019 and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequency (percentage). Intergroup comparisons for continuous data were made using the Student's t-test or Mann–Whitney U-test, depending on data distribution. Categorical data were analyzed using the Chi-square test or Fisher's exact test where appropriate. Statistical significance was defined at $p < 0.05$.

Ethical Considerations

Ethical clearance was obtained prior to data collection. Participants' confidentiality was maintained throughout the study by anonymizing patient identifiers. No financial inducement or external funding was involved, and patients retained the right to withdraw at any stage without compromising their standard medical treatment.

RESULTS

Demographic and Baseline Characteristics

A total of 100 patients who underwent elective general surgical procedures were enrolled in the study and successfully completed the 24-hour postoperative observation period. Participants were evenly divided into Group A (Multimodal Analgesia, n = 50) and Group B (Opioid-Based Analgesia, n = 50). The demographic characteristics of both groups were comparable, ensuring baseline homogeneity for meaningful comparison of postoperative outcomes.

The mean age of participants in Group A was 42.6 ± 11.3 years, whereas in Group B it was 44.1 ± 12.8 years, with no significant difference ($t = 0.61$, $p = 0.54$). The gender distribution showed a predominance of males in both groups (64 % in Group A and 58 % in Group B; $\chi^2 = 0.37$, $p = 0.54$). The mean body mass index (BMI) was similar (24.8 ± 2.6 kg/m² in Group A vs 25.2 ± 2.4 kg/m² in Group B; $p = 0.43$). Likewise, the distribution of ASA physical status I and II did not differ significantly ($\chi^2 = 0.17$, $p = 0.67$). The mean duration of surgery and the type of anesthesia were comparable, excluding the possibility that surgical complexity or anesthetic modality influenced postoperative pain perception.

No statistically significant intergroup differences were observed ($p > 0.05$), confirming that the two cohorts were demographically comparable.

Table 1: Demographic And Surgical Characteristics Of Study Participants

Parameter	Group A (MMA) Mean ± SD / n (%)	Group B (OBA) Mean ± SD / n (%)	Statistical Test	p-value
Age (years)	42.6 ± 11.3	44.1 ± 12.8	$t = 0.61$	0.54
Gender (M/F)	32 / 18	29 / 21	$\chi^2 = 0.37$	0.54
BMI (kg/m²)	24.8 ± 2.6	25.2 ± 2.4	$t = 0.79$	0.43
ASA I/II	31 / 19	33 / 17	$\chi^2 = 0.17$	0.67
Duration of Surgery (min)	87.4 ± 20.2	89.1 ± 21.8	$t = 0.40$	0.69

Postoperative Pain Intensity

Pain intensity was assessed using the VAS at 2, 6, 12, and 24 hours after surgery. As shown in Table 2, the multimodal analgesia group exhibited consistently lower mean VAS scores at all postoperative intervals.

Immediately after surgery (2 hours), pain levels were comparable between the groups (4.2 ± 1.0 vs 4.5 ± 0.9, $p = 0.16$). However, at 6 hours postoperatively, the mean VAS score in Group A decreased to 3.1 ± 0.8, whereas it remained 4.2 ± 1.0 in Group B ($t = 5.26$, $p < 0.001$). At 12 hours, pain further reduced in the multimodal group (2.5 ± 0.7) compared with the opioid group (3.8 ± 1.1, $p < 0.001$). By 24 hours, Group A patients experienced almost complete pain relief (1.6 ± 0.5), whereas Group B still reported moderate discomfort (2.9 ± 0.8, $p < 0.001$). These findings indicate that multimodal analgesia provided superior and sustained analgesic efficacy over time.

Table 2: Mean Postoperative VAS Pain Scores at Different Time Intervals

Time Interval	Group A (MMA) Mean ± SD	Group B (OBA) Mean ± SD	t-value	p-value
2 h	4.2 ± 1.0	4.5 ± 0.9	1.40	0.16
6 h	3.1 ± 0.8	4.2 ± 1.0	5.26	<0.001*
12 h	2.5 ± 0.7	3.8 ± 1.1	6.53	<0.001*
24 h	1.6 ± 0.5	2.9 ± 0.8	9.22	<0.001*

*Significant at $p < 0.05$.

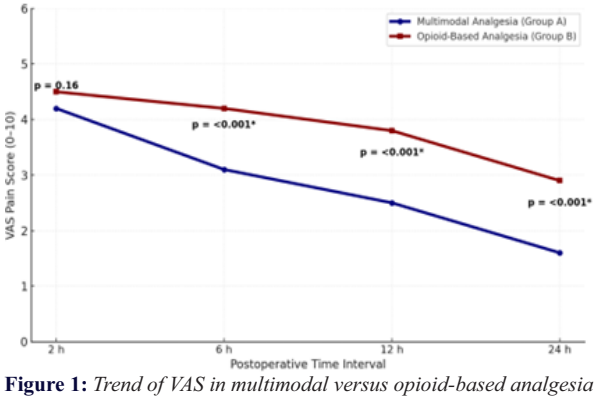

Figure 1: *Trend of VAS in multimodal versus opioid-based analgesia groups.*

Opioid Requirement And Rescue Analgesic Use

Cumulative 24-hour opioid consumption, expressed in morphine-equivalent milligrams, was significantly reduced in Group A (52.4 ± 18.3 mg) compared with Group B (108.7 ± 24.6 mg). This represents an approximate 52 % reduction in opioid requirement, which was statistically highly significant ($t = 14.03$, $p < 0.001$).

Moreover, the frequency of rescue analgesia was markedly lower in the multimodal group, with only 7 patients (14 %) requiring an

additional dose compared to 21 patients (42 %) in the opioid group (χ^2 = 9.76, p = 0.002). This reduction in supplemental analgesic need underscores the superior efficacy of multimodal pain control.

Table 3: Comparison Of Opioid Consumption And Rescue Analgesic Requirement

Parameter	Group A (MMA)	Group B (OBA)	Statistical Test	p-value
Total Opioid Consumption (mg)	52.4 ± 18.3	108.7 ± 24.6	t = 14.03	<0.001*
Patients Requiring Rescue Analgesia n (%)	7 (14 %)	21 (42 %)	χ^2 = 9.76	0.002*

*Significant at $p < 0.05$.

Adverse Effects

Adverse events were monitored for 24 hours postoperatively. The overall incidence of side effects was substantially lower in the multimodal group compared with the opioid group (Table 4). The occurrence of PONV was 12 % in Group A versus 34 % in Group B (χ^2 = 6.26, p = 0.012). Sedation was noted in 4 % of Group A and 18 % of Group B (p = 0.03). Although constipation was more frequent in the opioid group (18 % vs 6 %), the difference did not reach statistical significance (p = 0.08). No serious respiratory depression or allergic reactions were reported in either group.

Table 4: Incidence Of Adverse Effects

Adverse Effect	Group A (MMA) n (%)	Group B (OBA) n (%)	χ^2	p-value
Nausea / Vomiting	6 (12 %)	17 (34 %)	6.26	0.012*
Constipation	3 (6 %)	9 (18 %)	3.06	0.08
Sedation	2 (4 %)	9 (18 %)	4.70	0.03*

*Significant at $p < 0.05$.

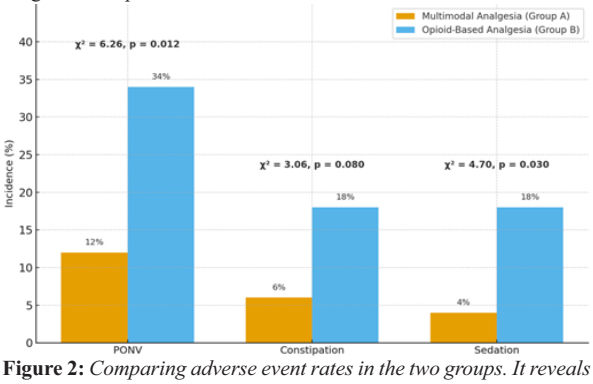

Figure 2: *Comparing adverse event rates in the two groups. It reveals higher rates of PONV and sedation in the opioid-based analgesia group, while the multimodal group maintained a lower complication profile.*

Recovery And Patient Satisfaction

The inclusion of multiple non-opioid agents and local anesthetic infiltration in the multimodal regimen translated into faster postoperative recovery. The mean time to ambulation was 9.8 ± 2.6 hours in Group A compared with 13.4 ± 3.1 hours in Group B (t = 6.22, $p < 0.001$). The average hospital stay was significantly shorter in the multimodal group (3.1 ± 0.9 days) than in the opioid-based group (4.6 ± 1.2 days, $p < 0.001$).

Patient satisfaction scores, rated on a five-point Likert scale, were higher in Group A (4.6 ± 0.5) versus Group B (3.8 ± 0.6, $p < 0.001$). These findings collectively suggest that multimodal analgesia not only enhanced analgesic quality but also accelerated postoperative recovery and improved the overall patient experience.

Table 5: Comparison Of Recovery Parameters And Patient Satisfaction

Parameter	Group A (MMA) Mean ± SD	Group B (OBA) Mean ± SD	t-value	p-value
Time to Ambulation (hours)	9.8 ± 2.6	13.4 ± 3.1	6.22	<0.001*
Hospital Stay (days)	3.1 ± 0.9	4.6 ± 1.2	6.53	<0.001*
Patient Satisfaction (1–5 Likert)	4.6 ± 0.5	3.8 ± 0.6	7.38	<0.001*

*Significant at $p < 0.05$.

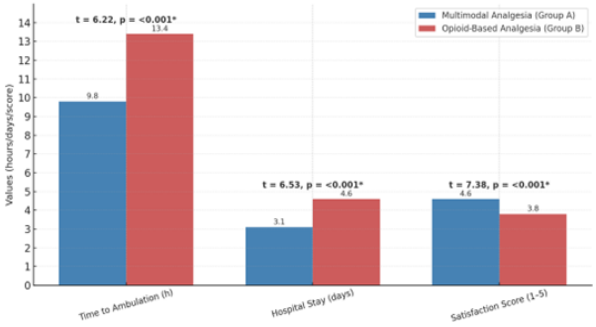

Figure 3: *Recovery outcomes (time to ambulation, hospital stay, and satisfaction).*

DISCUSSION

Postoperative pain is a predictable yet often underestimated physiological response that can significantly impair surgical recovery when inadequately managed. It triggers neuroendocrine stress, activates the sympathetic nervous system, and can culminate in delayed wound healing, pulmonary complications, and prolonged hospital stay [15]. In the present investigation, the multimodal analgesic strategy demonstrated clear superiority over conventional opioid-based regimens across multiple clinical parameters, including pain control, opioid sparing, adverse event reduction, and recovery outcomes.

Patients who received MMA consistently reported lower VAS scores at every postoperative assessment beyond the second hour, with statistical significance observed from 6 hours onward ($p < 0.001$). This pattern highlights that while both regimens initially provided comparable analgesia, the multimodal approach offered prolonged and sustained pain relief. These findings reinforce the fundamental principle that targeting different nodes in the pain pathway yields more effective analgesia than focusing solely on central μ-opioid receptor activity.

The reduction in total opioid consumption by nearly half (≈52%) among MMA recipients not only validates the opioid-sparing potential of combination therapy but also underscores its clinical safety and efficiency. The favorable outcomes seen in this study mirror the evolving paradigm of perioperative pain control, where multimodal and patient-centered strategies are increasingly replacing opioid-centric models [16,17].

The biological justification for multimodal analgesia lies in the complex nature of pain transmission, which involves peripheral nociceptor activation, spinal modulation, and supraspinal perception. Each pharmacological agent used in the multimodal regimen acts at a distinct level of this pathway, producing additive or synergistic analgesic effects [18].

Acetaminophen acts primarily within the central nervous system by inhibiting the cyclooxygenase (COX) pathway in the brain and increasing pain thresholds via serotonergic modulation. Ketorolac, a nonsteroidal anti-inflammatory drug (NSAID), attenuates peripheral sensitization by blocking prostaglandin synthesis at the site of tissue injury. When combined with local infiltration of bupivacaine, which stabilizes neuronal membranes by blocking voltage-gated sodium channels, this triad effectively reduces both peripheral and central sensitization [19]. The result is broader analgesic coverage, reduced need for opioids, and diminished side effect burden.

In contrast, opioids primarily modulate pain through μ-receptor activation in the central nervous system, which, while highly potent, is accompanied by undesirable adverse reactions. Excessive activation of these receptors depresses respiratory drive, delays gastrointestinal motility, and induces nausea, vomiting, and sedation. This pharmacodynamic limitation explains the higher rates of PONV and sedation observed in the opioid-based group in this study, consistent with prior observations by Oderda et al. (2003) [21].

The outcomes of this study are in harmony with a growing body of

literature advocating multimodal strategies for perioperative pain control. Kehlet and Dahl (1993) [6] were among the earliest to propose the concept of "balanced analgesia," highlighting that the simultaneous use of non-opioid agents not only reduces total opioid consumption but also enhances functional recovery. Wick et al. (2017) [3] later demonstrated that integrating paracetamol, NSAIDs, and regional techniques substantially improved postoperative outcomes across various surgical specialties.

A comparable trend was reported by Lee and colleagues (2023) [18], who evaluated general surgery patients and found significantly lower VAS scores and opioid consumption among those receiving multimodal therapy. Similarly, Chou (20160 [19] emphasized that the success of modern perioperative pain management depends on combining systemic, regional, and psychological modalities. These findings converge with our study, confirming that multimodal analgesia provides not only superior pain relief but also promotes faster rehabilitation and improved patient satisfaction.

A notable observation from this study is the pronounced improvement in postoperative recovery indicators. Patients in the multimodal group ambulated earlier (mean 9.8 ± 2.6 hours vs 13.4 ± 3.1 hours) and had shorter hospital stays (3.1 ± 0.9 vs 4.6 ± 1.2 days, $p < 0.001$). These outcomes are aligned with the principles of the Enhanced Recovery After Surgery (ERAS) framework, which emphasizes multimodal, opioid-sparing analgesia as a cornerstone of accelerated surgical recovery [21, 22].

Joliat et al. (2018) [23] described that early mobilization, facilitated by effective pain control, minimizes thromboembolic risk, improves pulmonary function, and shortens the convalescence period. Furthermore, multimodal analgesia has been shown to preserve cognitive clarity, allowing patients to participate actively in physiotherapy and early feeding programs, thereby enhancing overall recovery trajectories [24].

The improvement in patient satisfaction observed in our study (mean score 4.6 ± 0.5 vs 3.8 ± 0.6, $p < 0.001$) reflects not only better pain control but also reduced incidence of distressing symptoms such as nausea and sedation. Satisfaction is a multidimensional outcome influenced by comfort, emotional stability, and confidence in care, and hence serves as an important indicator of holistic postoperative recovery [25].

The present findings hold considerable relevance in both clinical and systemic contexts. The opioid crisis, which has emerged as a global concern, underscores the urgent need for opioid-sparing perioperative strategies. By halving the requirement for opioids without compromising analgesic efficacy, multimodal protocols present a sustainable and safer alternative. The regimen used in this study-comprising paracetamol, ketorolac, and local bupivacaine-is inexpensive, easily available, and feasible for implementation even in resource-constrained healthcare settings, including public hospitals.

Furthermore, by reducing the incidence of adverse effects and shortening hospital stay, multimodal analgesia can lower treatment costs and enhance bed turnover, thereby improving institutional efficiency. From a patient-centered perspective, it enhances comfort, reduces anxiety about postoperative pain, and fosters trust in surgical care systems.

Limitations And Future Scope

Although the study demonstrates robust clinical benefits, certain limitations warrant mention. The analysis was limited to the first 24 postoperative hours; extending observation to 72 hours or the first postoperative week could provide deeper insights into long-term pain trajectories. Moreover, pain perception is inherently subjective and influenced by psychological and cultural factors, which may introduce variability. Future research could incorporate objective biomarkers of stress response-such as serum cortisol, catecholamines, or inflammatory cytokines-to complement subjective pain scores.

Additionally, exploring advanced regional techniques such as transversus abdominis plane (TAP) blocks, erector spinae plane blocks, or continuous wound infiltration catheters as adjuncts within multimodal regimens could yield even greater analgesic and recovery benefits. Integration of pharmacogenomic profiling might further individualize analgesic strategies by predicting drug metabolism and response variability.

CONCLUSION

The present study provides robust evidence that multimodal analgesia offers a safer and more effective alternative to traditional opioid-based regimens for postoperative pain management in general surgical patients. By combining non-opioid agents acting through complementary mechanisms, this approach achieves superior analgesia with significantly lower opioid consumption and reduced incidence of adverse effects such as nausea, vomiting, and sedation.

Patients receiving multimodal therapy experienced earlier ambulation, shorter hospital stays, and higher satisfaction levels, highlighting its pivotal role in promoting functional recovery and aligning with the principles of Enhanced Recovery After Surgery (ERAS). These findings reinforce the growing consensus that pain management should move beyond reliance on opioids and adopt an integrated, evidence-based framework tailored to both physiological and patient-centered outcomes.

Given its simplicity, affordability, and clinical efficacy, the multimodal approach evaluated in this study can be feasibly implemented even in resource-limited settings, providing tangible benefits for both patients and healthcare systems. Future research should explore long-term outcomes, diverse surgical populations, and the addition of advanced regional techniques to further refine multimodal analgesic protocols.

Conflict Of Interest

The authors declare no conflict of interest related to the conduct, analysis, or publication of this research. The study was carried out solely for academic and scientific purposes without any influence from external organizations or pharmaceutical entities.

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