

PROSPECTIVE STUDY OF OPIOID-SPARING MULTIMODAL ANALGESIA AND EARLY RECOVERY OUTCOMES IN PATIENTS UNDERGOING ELECTIVE ABDOMINAL SURGERY

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ABSTRACT

Background: Effective postoperative pain control is essential for improving patient comfort, facilitating early mobilisation, restoring gastrointestinal function, and promoting timely recovery after abdominal surgery. Excessive perioperative opioid use may contribute to nausea, vomiting, sedation, urinary retention, ileus, respiratory depression, and delayed functional recovery. Opioid-sparing multimodal analgesia combines different analgesic modalities to achieve adequate pain relief while minimizing opioid exposure. The aim is to evaluate opioid-sparing multimodal analgesia and its association with early postoperative recovery outcomes in patients undergoing elective abdominal surgery. **Materials and Methods:** This prospective observational study included 106 adult patients undergoing elective open or laparoscopic abdominal surgery at a tertiary care hospital. All patients received a standardized opioid-sparing multimodal analgesic regimen. Postoperative pain was assessed using the Numerical Rating Scale at PACU arrival and at 2, 6, 12, and 24 hours. Twenty-four-hour opioid consumption, rescue analgesic requirement, time to oral intake, ambulation, return of bowel function, QoR-15 score, hospital stay, and adverse effects were recorded. Data were analysed using IBM SPSS Statistics version 27.0, with $p < 0.05$ considered statistically significant. **Results:** The mean age was 47.63 ± 11.24 years, and 56.60% were males. Mean NRS at rest decreased from 4.42 ± 0.82 at PACU arrival to 1.68 ± 0.71 at 24 hours, while movement-related NRS decreased from 5.91 ± 0.93 to 2.46 ± 0.76 ($p < 0.001$ for both). Mean 24-hour opioid consumption was 5.36 ± 4.28 morphine milligram equivalents, and 37.74% required no rescue analgesia. Mean time to ambulation was 9.61 ± 3.18 hours and bowel function returned at 20.93 ± 6.42 hours. QoR-15 decreased from 132.15 ± 6.91 preoperatively to 124.96 ± 8.87 at 24 hours ($p < 0.001$). Higher opioid consumption correlated with higher pain scores, longer PACU stay, delayed oral intake, ambulation, bowel recovery, and longer hospital stay, while it correlated negatively with QoR-15. Postoperative nausea and vomiting occurred in 12.26%, and no respiratory depression was observed. **Conclusion:** Opioid-sparing multimodal analgesia was associated with effective pain control, relatively low opioid consumption, favorable early recovery parameters, and a low incidence of opioid-related adverse effects in elective abdominal surgery.

INTRODUCTION

Effective postoperative pain management is a fundamental component of perioperative care and has a direct influence on patient comfort, mobilisation, respiratory function, gastrointestinal recovery, sleep, and the overall experience of surgery. Abdominal surgical procedures are particularly relevant because tissue incision, visceral manipulation, inflammation, and postoperative movement can produce substantial nociceptive input during the early recovery period. Inadequately controlled acute postoperative pain may interfere with coughing, deep breathing, mobilisation, and oral intake and may consequently delay functional recovery. Contemporary perioperative practice therefore aims not only to reduce pain intensity but also to facilitate an earlier return to normal physiological and functional activity. This broader approach has encouraged integration of analgesia into structured perioperative pathways rather than considering postoperative pain as an isolated symptom.^[1] Opioids have traditionally played a central role in the management of moderate-to-severe postoperative pain because of their potent analgesic properties and rapid clinical effect. However, increasing recognition of opioid-related adverse effects has led to reconsideration of their routine and unrestricted perioperative use. Nausea and vomiting, sedation, dizziness, pruritus, urinary retention, gastrointestinal dysmotility, respiratory depression, and delayed mobilisation are clinically important concerns, particularly after major abdominal procedures. Opioid tolerance, opioid-induced hyperalgesia, and persistent postoperative opioid use have further strengthened the need for more rational prescribing. Consequently, modern postoperative pain management has progressively shifted towards strategies that provide satisfactory analgesia while limiting opioid exposure to the lowest clinically effective requirement.^[2] Opioid-sparing multimodal analgesia is based on the simultaneous use of two or more analgesic modalities that act through different mechanisms within the pain pathway. Rather than relying predominantly on systemic opioids, multimodal regimens may incorporate paracetamol, non-steroidal anti-inflammatory drugs or selective cyclooxygenase-2 inhibitors, local anaesthetic infiltration, regional nerve blocks, neuraxial techniques, and selected non-opioid adjuncts according to the surgical procedure and individual patient characteristics. Combining complementary mechanisms can address different components of postoperative pain while reducing dependence on any single analgesic drug. This approach is particularly compatible with enhanced recovery pathways, in which adequate analgesia is closely linked with early oral intake, mobilisation, restoration of gastrointestinal function, and timely discharge.^[3] The concept of opioid stewardship has

further refined perioperative analgesic practice. Opioid sparing does not imply complete avoidance of opioids or acceptance of inadequate pain relief. Instead, it emphasizes appropriate patient selection, individualized dosing, regular pain assessment, prioritization of non-opioid modalities, and use of rescue opioids when clinically indicated. The objective is to achieve a balance between effective analgesia and avoidance of unnecessary opioid exposure. Such an approach is especially relevant in heterogeneous abdominal surgical populations because the intensity and duration of postoperative pain may vary considerably according to incision size, open or laparoscopic technique, tissue handling, patient comorbidities, baseline pain sensitivity, and surgical complexity.^[4] Advances in minimally invasive surgery and regional anaesthesia have also changed expectations regarding early postoperative recovery. Laparoscopic procedures generally produce a different pattern of somatic and visceral pain compared with conventional open surgery, while ultrasound-guided abdominal wall blocks and local anaesthetic techniques provide opportunities to reduce systemic analgesic requirements. Pharmacological approaches using scheduled non-opioid medications can be combined with these techniques to provide more comprehensive analgesia. Current multimodal practice therefore requires careful selection of interventions rather than application of a uniform drug regimen to every patient. Consideration of contraindications, renal and hepatic function, bleeding risk, cardiovascular status, age, and other patient-specific factors remains essential when developing an opioid-sparing protocol.^[5] Evaluation of an opioid-sparing strategy should extend beyond pain scores alone. Cumulative opioid consumption, requirement and timing of rescue analgesia, pain during movement, postoperative nausea and vomiting, sedation, and respiratory adverse events are important measures of analgesic effectiveness and safety. Equally important are patient-centred recovery outcomes such as awakening from anaesthesia, duration of post-anaesthesia care, oral intake, ambulation, gastrointestinal recovery, and readiness for discharge. Quality-of-recovery instruments provide an additional multidimensional assessment by incorporating physical comfort, emotional status, independence, pain, and other aspects of postoperative well-being. Prospective evaluation of these outcomes can provide a more complete representation of perioperative recovery than a single measure of pain intensity.^[6]

MATERIALS AND METHODS

This prospective observational study was conducted at a tertiary care hospital to evaluate opioid-sparing multimodal analgesia and its association with early postoperative recovery among adult patients undergoing elective abdominal surgery. A total of

106 patients were included in the study. Patients were managed according to a standardized perioperative analgesic protocol designed to provide adequate pain relief while minimizing opioid exposure. Clinical and recovery-related observations were recorded prospectively from the preoperative period until hospital discharge. Adult patients scheduled for elective abdominal surgical procedures under general anaesthesia were screened during pre-anaesthetic evaluation. Eligible patients who fulfilled the selection criteria and provided written informed consent were enrolled using a consecutive sampling method.

Inclusion and Exclusion Criteria

Patients aged 18–70 years, of either sex, belonging to American Society of Anesthesiologists physical status I–III, and scheduled for elective open or laparoscopic abdominal surgery were included. Patients with known hypersensitivity or contraindication to any component of the multimodal analgesic regimen, chronic opioid use, substance dependence, severe hepatic or renal dysfunction, significant cognitive impairment, uncontrolled psychiatric illness, pregnancy, emergency surgery, or requirement for postoperative mechanical ventilation or intensive care admission were excluded.

Methodology

A detailed preoperative evaluation was performed for all enrolled patients. Demographic and clinical parameters including age, sex, body mass index, ASA physical status, relevant comorbidities, previous surgical history, preoperative medications, type of surgery, anticipated surgical complexity, and baseline haemodynamic parameters were recorded. Baseline pain was assessed using an 11-point Numerical Rating Scale ranging from 0 for no pain to 10 for the worst imaginable pain. Preoperative quality of recovery was assessed using the Quality of Recovery-15 questionnaire wherever applicable.

Opioid-Sparing Multimodal Analgesia Protocol:

All patients received a multimodal analgesic regimen incorporating agents with different mechanisms of action. The protocol included paracetamol, a non-steroidal anti-inflammatory drug or selective COX-2 inhibitor in the absence of contraindications, and local anaesthetic infiltration or an appropriate regional analgesic technique based on the surgical procedure. Additional non-opioid analgesic adjuvants were administered according to institutional protocol and individual clinical requirements. General anaesthesia was standardized as far as clinically possible. Opioids were used only when required for intraoperative supplementation or postoperative rescue analgesia and were administered in the lowest effective dose.

Postoperative Pain and Opioid Assessment:

Postoperative pain intensity was assessed using the Numerical Rating Scale at rest and during movement or coughing. Pain scores were recorded on arrival in the post-anaesthesia care unit and at approximately 2, 6, 12, and 24 hours after surgery.

The time to first rescue analgesia, number of rescue analgesic doses, type of opioid administered, and cumulative opioid consumption during the first 24 postoperative hours were documented. All administered opioids were converted into intravenous morphine milligram equivalents to allow standardized assessment of opioid exposure.

Early Recovery Outcome Parameters: Early postoperative recovery was evaluated using clinically relevant parameters including time to awakening, duration of stay in the post-anaesthesia care unit, time to first oral intake, time to ambulation, return of bowel function, and readiness for discharge. Postoperative Quality of Recovery-15 scores were recorded and compared with baseline values wherever applicable. Total length of hospital stay was also documented.

Adverse Effects and Safety Monitoring: Patients were monitored for opioid-related and postoperative adverse events, including nausea and vomiting, excessive sedation, dizziness, pruritus, respiratory depression, urinary retention, ileus, hypotension, and need for unexpected intensive care support. Sedation was assessed clinically using a standardized sedation scale. Complications related to regional analgesia, local anaesthetic administration, or non-opioid analgesic medications were also recorded.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 27.0. Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range depending on data distribution, while categorical variables were presented as frequencies and percentages. Normality of continuous variables was assessed using the Shapiro–Wilk test. Repeated postoperative measurements were analysed using repeated-measures ANOVA or an appropriate non-parametric equivalent. Categorical variables were compared using the Chi-square test or Fisher's exact test. Pearson or Spearman correlation was used to assess relationships between opioid consumption and selected recovery parameters, as appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

[Table 1] Demographic and Clinical Characteristics of the Study Participants

A total of 106 patients undergoing elective abdominal surgery were included in the study. The mean age of the study population was 47.63 ± 11.24 years, while the mean body mass index was 25.71 ± 3.82 kg/m². Of the 106 patients, 60 (56.60%) were males and 46 (43.40%) were females, showing a slight male predominance in the study population. With respect to preoperative physical status, 29 (27.36%) patients belonged to ASA Physical Status I, 58 (54.72%) belonged to ASA Physical Status II,

and 19 (17.92%) belonged to ASA Physical Status III. Thus, more than half of the participants were classified as ASA II. Regarding the type of surgical procedure, 67 (63.21%) patients underwent laparoscopic abdominal surgery, whereas 39 (36.79%) underwent open abdominal surgery. Among the recorded comorbidities, hypertension was present in 30 (28.30%) patients and diabetes mellitus in 19 (17.92%) patients. Overall, 43 (40.57%) patients had at least one major medical comorbidity. The mean duration of the surgical procedure was 118.62 ± 34.71 minutes.

[Table 2] Postoperative Numerical Rating Scale Pain Scores at Different Time Intervals

Postoperative pain scores were assessed both at rest and during movement or coughing at PACU arrival and at 2, 6, 12, and 24 hours following surgery. At PACU arrival, the mean NRS score at rest was 4.42 ± 0.82 , while the mean NRS score during movement or coughing was higher at 5.91 ± 0.93 . At 2 hours postoperatively, the mean NRS score at rest decreased to 3.51 ± 0.76 , whereas the corresponding score during movement or coughing was 5.02 ± 0.85 . A further reduction was recorded at 6 hours, when the mean NRS score was 2.91 ± 0.74 at rest and 4.13 ± 0.82 during movement or coughing. At 12 hours after surgery, the mean pain score at rest further decreased to 2.31 ± 0.73 , while the mean score during movement or coughing was 3.36 ± 0.78 . By 24 hours, the mean NRS score had declined to 1.68 ± 0.71 at rest and 2.46 ± 0.76 during movement or coughing. Repeated-measures analysis demonstrated a statistically significant change in pain scores across the postoperative time points both at rest and during movement or coughing ($p < 0.001$ for both).

[Table 3] Postoperative Opioid Consumption and Rescue Analgesic Requirements

The mean cumulative opioid consumption during the first 24 postoperative hours was 5.36 ± 4.28 morphine milligram equivalents. Of the 106 patients, 40 (37.74%) did not require any rescue analgesia during the postoperative observation period, while 66 (62.26%) required at least one rescue analgesic dose. Regarding the number of rescue analgesic doses, 43 (40.57%) patients required only one dose, 18 (16.98%) required two doses, and 5 (4.72%) required three or more rescue analgesic doses. Thus, among patients requiring additional analgesia, the largest proportion required only a single rescue dose. Among the 66 patients who required rescue analgesia, the mean time to administration of the first rescue analgesic was 6.81 ± 2.39 hours after surgery.

[Table 4] Early Postoperative Recovery and Safety Outcomes

The mean time required for awakening following anaesthesia was 11.84 ± 2.71 minutes. The average duration of stay in the post-anaesthesia care unit was 82.36 ± 17.92 minutes. The mean time to initiation of the first oral intake was 6.08 ± 2.41 hours, while

the mean time to postoperative ambulation was 9.61 ± 3.18 hours. Return of bowel function occurred after a mean duration of 20.93 ± 6.42 hours. The mean preoperative Quality of Recovery-15 score was 132.15 ± 6.91 . At 24 hours after surgery, the mean QoR-15 score was 124.96 ± 8.87 . The paired comparison between preoperative and 24-hour QoR-15 scores showed a statistically significant difference ($p < 0.001$). The mean duration of hospital stay was 2.88 ± 1.06 days. A total of 86 (81.13%) patients were considered ready for discharge within 72 hours following surgery, whereas the remaining 20 (18.87%) patients were not ready for discharge within this period. Regarding postoperative adverse events, postoperative nausea and vomiting was recorded in 13 (12.26%) patients and was the most frequently observed adverse event. Dizziness occurred in 10 (9.43%) patients, while urinary retention was reported in 7 (6.60%). Excessive sedation was observed in 6 (5.66%) patients, and pruritus occurred in 5 (4.72%). Postoperative ileus was documented in 3 (2.83%) patients. No episode of respiratory depression was recorded among any of the 106 patients during the postoperative observation period.

[Table 5] Association of 24-Hour Opioid Consumption with Pain and Early Recovery Parameters

Pearson correlation analysis was performed to assess the relationship between cumulative 24-hour opioid consumption and postoperative pain and recovery parameters. A positive correlation was observed between opioid consumption and NRS pain score at rest at 24 hours, with a correlation coefficient of $r = 0.393$. This association was statistically significant ($p < 0.001$). Opioid consumption also showed a positive correlation with the NRS score during movement at 24 hours ($r = 0.421$, $p < 0.001$), which was the strongest positive correlation among the parameters evaluated. A statistically significant positive correlation was observed between cumulative opioid consumption and duration of PACU stay ($r = 0.286$, $p = 0.003$). Opioid consumption was also positively correlated with time to first oral intake ($r = 0.314$, $p = 0.001$) and time to postoperative ambulation ($r = 0.277$, $p = 0.004$). Similarly, a significant positive correlation was found between opioid consumption and time to return of bowel function ($r = 0.251$, $p = 0.009$). The relationship between opioid consumption and length of hospital stay was also positive and statistically significant, although relatively weak ($r = 0.213$, $p = 0.028$). In contrast, the QoR-15 score at 24 hours showed a statistically significant negative correlation with cumulative opioid consumption ($r = -0.331$, $p = 0.001$). Thus, increasing opioid consumption was accompanied by decreasing 24-hour QoR-15 scores within the observed study population. All the correlations included in the analysis reached statistical significance at the predefined level of $p < 0.05$.

Table1: Demographic and Clinical Characteristics of the Study Participants (n=106)

Parameter	Result
Age (years), Mean $\pm$ SD	47.63 $\pm$ 11.24
BMI (kg/m ²), Mean $\pm$ SD	25.71 $\pm$ 3.82
Male	60 (56.60%)
Female	46 (43.40%)
ASA Physical Status I	29 (27.36%)
ASA Physical Status II	58 (54.72%)
ASA Physical Status III	19 (17.92%)
Laparoscopic abdominal surgery	67 (63.21%)
Open abdominal surgery	39 (36.79%)
Hypertension	30 (28.30%)
Diabetes mellitus	19 (17.92%)
Any major medical comorbidity	43 (40.57%)
Duration of surgery (minutes), Mean $\pm$ SD	118.62 $\pm$ 34.71

Table 2: Postoperative Numerical Rating Scale Pain Scores at Different Time Intervals (n=106)

Time of Assessment	NRS at Rest, Mean $\pm$ SD	NRS During Movement/Coughing, Mean $\pm$ SD
PACU arrival	4.42 $\pm$ 0.82	5.91 $\pm$ 0.93
2 hours	3.51 $\pm$ 0.76	5.02 $\pm$ 0.85
6 hours	2.91 $\pm$ 0.74	4.13 $\pm$ 0.82
12 hours	2.31 $\pm$ 0.73	3.36 $\pm$ 0.78
24 hours	1.68 $\pm$ 0.71	2.46 $\pm$ 0.76
p-value*	<0.001	<0.001

*Repeated-measures analysis across postoperative time points.

Table 3: Postoperative Opioid Consumption and Rescue Analgesic Requirements (n=106)

Parameter	Result
24-hour opioid consumption (morphine milligram equivalents), Mean $\pm$ SD	5.36 $\pm$ 4.28
No rescue analgesia required	40 (37.74%)
Rescue analgesia required	66 (62.26%)
One rescue analgesic dose	43 (40.57%)
Two rescue analgesic doses	18 (16.98%)
≥ 3 rescue analgesic doses	5 (4.72%)
Time to first rescue analgesia among patients requiring rescue analgesia (n=66), hours, Mean $\pm$ SD	6.81 $\pm$ 2.39

Table 4: Early Postoperative Recovery and Safety Outcomes (n=106)

Parameter	Result	p-value
Time to awakening (minutes), Mean $\pm$ SD	11.84 $\pm$ 2.71	
PACU stay (minutes), Mean $\pm$ SD	82.36 $\pm$ 17.92	
Time to first oral intake (hours), Mean $\pm$ SD	6.08 $\pm$ 2.41	
Time to ambulation (hours), Mean $\pm$ SD	9.61 $\pm$ 3.18	
Return of bowel function (hours), Mean $\pm$ SD	20.93 $\pm$ 6.42	
Preoperative QoR-15 score, Mean $\pm$ SD	132.15 $\pm$ 6.91	
QoR-15 score at 24 hours, Mean $\pm$ SD	124.96 $\pm$ 8.87	<0.001*
Length of hospital stay (days), Mean $\pm$ SD	2.88 $\pm$ 1.06	
Ready for discharge within 72 hours	86 (81.13%)	
Postoperative nausea and vomiting	13 (12.26%)	
Dizziness	10 (9.43%)	
Urinary retention	7 (6.60%)	
Excessive sedation	6 (5.66%)	
Pruritus	5 (4.72%)	
Postoperative ileus	3 (2.83%)	
Respiratory depression	0 (0.00%)	

*Paired comparison between preoperative and 24-hour QoR-15 scores.

Table 5: Association of 24-Hour Opioid Consumption with Pain and Early Recovery Parameters (n=106)

Parameter	Pearson Correlation Coefficient (r)	p-value
NRS at rest at 24 hours	0.393	<0.001
NRS during movement at 24 hours	0.421	<0.001
Duration of PACU stay	0.286	0.003
Time to first oral intake	0.314	0.001
Time to ambulation	0.277	0.004
Return of bowel function	0.251	0.009
QoR-15 score at 24 hours	-0.331	0.001
Length of hospital stay	0.213	0.028

DISCUSSION

The present prospective study included 106 patients undergoing elective abdominal surgery, with a mean age of 47.63 $\pm$ 11.24 years and mean BMI of 25.71

$\pm 3.82 \text{ kg/m}^2$. Males constituted 56.60% of the population, 54.72% of patients were ASA physical status II, and 63.21% underwent laparoscopic procedures. The mean operative duration was 118.62 ± 34.71 minutes. These characteristics were reasonably comparable with those reported by Shukla et al. (2023), who studied 70 patients undergoing total abdominal hysterectomy and reported mean ages of 46.69 ± 8.23 and 46.37 ± 7.82 years in the quadratus lumborum and transversus abdominis plane block groups, respectively. Their corresponding mean BMIs were 24.31 ± 2.11 and $23.94 \pm 2.27 \text{ kg/m}^2$, while operative durations were 104.71 ± 21.11 and 98.43 ± 18.10 minutes. ASA I patients constituted 60.0% and 65.7% of their two groups, respectively. The present population therefore had a similar age and BMI profile, although operative duration was somewhat longer and the current study additionally included ASA III patients, reflecting a broader clinical population.^[7] Postoperative pain demonstrated a consistent decline over the first 24 hours. The mean NRS score at rest decreased from 4.42 ± 0.82 at PACU arrival to 3.51 ± 0.76 at 2 hours, 2.91 ± 0.74 at 6 hours, 2.31 ± 0.73 at 12 hours, and 1.68 ± 0.71 at 24 hours. During movement or coughing, the respective scores declined from 5.91 ± 0.93 to 5.02 ± 0.85 , 4.13 ± 0.82 , 3.36 ± 0.78 , and 2.46 ± 0.76 , with both trends being significant at $p < 0.001$. Zhao et al. (2021) similarly demonstrated progressive pain control after laparoscopic colorectal surgery. Their posterior TAP-block group had resting NRS scores of 1.3 ± 0.5 , 1.7 ± 0.6 , 1.7 ± 0.7 , and 1.7 ± 0.6 at 2, 6, 12, and 24 hours, compared with 3.4 ± 1.1 , 2.7 ± 0.6 , 2.3 ± 0.6 , and 2.1 ± 0.4 in controls. Movement scores at 24 hours were 2.2 ± 0.4 versus 2.7 ± 0.5 . Thus, the 24-hour values in the present study, particularly an NRS of 1.68 at rest and 2.46 during movement, were within a comparable range, although early postoperative movement pain was higher.^[8] The mean cumulative opioid requirement in the present study was 5.36 ± 4.28 morphine milligram equivalents during the first 24 postoperative hours. Forty patients (37.74%) required no rescue analgesia, while 66 (62.26%) required additional analgesia. Only one rescue dose was required by 43 (40.57%) patients, two doses by 18 (16.98%), and three or more doses by only 5 (4.72%). Among those requiring rescue analgesia, the first dose was administered after a mean of 6.81 ± 2.39 hours. Kayhan et al. (2018), in a randomized trial of 80 patients undergoing laparoscopic bariatric surgery, reported substantially greater 24-hour morphine requirements of $23.94 \pm 13.89 \text{ mg}$ with intravenous ibuprofen and $30.23 \pm 13.76 \text{ mg}$ with intravenous acetaminophen; the between-group difference in opioid consumption approached but did not reach significance ($p = 0.055$). They nevertheless found significantly lower pain burden with ibuprofen at rest and during movement. The lower mean opioid requirement in the present study should be

interpreted in the context of differences in surgical procedures, regional analgesic techniques, rescue protocols, and methods used to express opioid equivalents.^[9]

Early postoperative recovery in the present study was characterized by a mean awakening time of 11.84 ± 2.71 minutes and a PACU stay of 82.36 ± 17.92 minutes. Oral intake was initiated at a mean of 6.08 ± 2.41 hours and ambulation at 9.61 ± 3.18 hours. Yeo et al. (2022) investigated opioid-sparing multimodal analgesia against morphine-based patient-controlled analgesia in 97 patients undergoing minimally invasive colorectal cancer surgery. They demonstrated non-inferior pain control with multimodal analgesia, with a mean between-group difference in 24-hour resting NRS of only 0.25 (95% CI -0.61 to 1.11). Median intraoperative remifentanyl use was also lower in their multimodal group than in the PCA group (654 versus 996 μg , $p < 0.001$), and median PACU stay was reduced from 35 to 25 minutes ($p < 0.001$). Although the PACU duration in the present study was longer, the study included a heterogeneous population undergoing both open and laparoscopic abdominal procedures and included ASA I–III patients. The early oral intake and ambulation observed in the current cohort further characterized the postoperative recovery profile following the opioid-sparing approach.^[10]

Quality of recovery represented an important patient-centred outcome in the present study. The mean QoR-15 score decreased from 132.15 ± 6.91 preoperatively to 124.96 ± 8.87 at 24 hours, with the 7.19-point postoperative reduction being statistically significant ($p < 0.001$). Despite this early postoperative decline, the mean 24-hour score remained relatively high on the 0–150 QoR-15 scale. Hao et al. (2023) studied 80 patients undergoing laparoscopic cholecystectomy and reported a significant difference in recovery quality between opioid-based and opioid-free anaesthesia. On postoperative day 1, median QoR-15 scores across the opioid-based and opioid-free groups were 91.00 (90.00–92.00) and 113.00 (108.25–115.00), respectively, and on postoperative day 2 they were 106.00 (104.00–112.00) and 133.00 (130.00–135.00), respectively, with $p < 0.001$. The 24-hour mean QoR-15 of 124.96 ± 8.87 in the present study was numerically higher than the day-1 scores reported in that trial. However, direct numerical comparison requires caution because of differences in surgical magnitude, anaesthetic protocols, baseline recovery scores, and statistical presentation of QoR-15 data.^[11] The safety profile in the present series showed postoperative nausea and vomiting in 13 (12.26%) patients, dizziness in 10 (9.43%), urinary retention in 7 (6.60%), excessive sedation in 6 (5.66%), pruritus in 5 (4.72%), and postoperative ileus in 3 (2.83%). Importantly, no patient developed respiratory depression. Ziemann-Gimmel et al. (2014) evaluated opioid-free total intravenous anaesthesia in 119 bariatric surgical patients and

found PONV in 12 of 60 patients (20.0%) receiving opioid-free TIVA compared with 22 of 59 patients (37.3%) receiving conventional volatile anaesthesia with opioids ($p=0.04$). This represented an absolute risk reduction of 17.3% with opioid-free anaesthesia. The PONV incidence of 12.26% in the present study was numerically lower than the incidence in either group of that randomized study. Differences in baseline PONV risk, type of abdominal surgery, antiemetic prophylaxis, anaesthetic agents, and opioid exposure may explain part of this variation. Nevertheless, the absence of recorded respiratory depression together with relatively low frequencies of sedation and pruritus described the overall safety findings associated with the opioid-sparing regimen in the present cohort.^[12] Return of bowel function occurred at a mean of 20.93 ± 6.42 hours in the present study, while mean hospital stay was 2.88 ± 1.06 days and 86 (81.13%) patients were considered ready for discharge within 72 hours. Only 3 (2.83%) patients developed postoperative ileus. Alvarez et al. (2015) reported similar recovery-oriented benefits after implementing an enhanced recovery pathway in elective laparoscopic colectomy. Their postoperative intravenous morphine consumption decreased from 75 mg to 19 mg ($p=0.0001$), mean return of bowel function improved from postoperative day 2.99 to day 2.33 ($p=0.0001$), and hospital discharge occurred one day earlier, on postoperative day 2.7 compared with day 3.7 in the historical control group ($p=0.0013$). The mean hospital stay of 2.88 days in the present study was therefore close to the 2.7-day stay reported after implementation of their enhanced recovery pathway. The considerably earlier recorded bowel recovery of approximately 20.93 hours in the present cohort may partly reflect differences in the definition of bowel recovery, surgical case mix, extent of bowel manipulation, and the inclusion of non-colorectal abdominal operations.^[13]

The correlation analysis provided additional information regarding the relationship between opioid exposure and recovery. Greater 24-hour opioid consumption correlated significantly with higher NRS scores at rest ($r=0.393$, $p<0.001$) and during movement ($r=0.421$, $p<0.001$), longer PACU stay ($r=0.286$, $p=0.003$), delayed oral intake ($r=0.314$, $p=0.001$), delayed ambulation ($r=0.277$, $p=0.004$), delayed bowel recovery ($r=0.251$, $p=0.009$), and longer hospital stay ($r=0.213$, $p=0.028$). Conversely, opioid consumption correlated negatively with 24-hour QoR-15 ($r=-0.331$, $p=0.001$). Kim et al. (2023) likewise identified an association between postoperative opioid exposure and recovery in 240 patients undergoing radical cystectomy. Their median daily opioid consumption was 57.5 mg morphine equivalents and median hospital stay was 10 days. Multivariable analysis demonstrated that daily morphine-equivalent consumption was independently associated with longer hospitalization

($\beta=0.076$, $p<0.001$), with approximately one additional hospital day for every 13.2-mg increase in daily MME; postoperative ileus itself was associated with an additional 6.64 days of hospitalization ($p=0.004$). These data are directionally consistent with the positive relationship between opioid exposure, delayed bowel recovery, and longer hospitalization observed in the present study, while the current correlations with pain and QoR-15 additionally demonstrate the broader relationship between opioid requirement and early postoperative recovery.^[14]

CONCLUSION

Opioid-sparing multimodal analgesia provided effective postoperative pain control with relatively low opioid requirements in patients undergoing elective abdominal surgery. Pain scores decreased significantly over the first 24 hours, while early oral intake, ambulation, bowel recovery, and discharge readiness were generally favorable. Higher opioid consumption was significantly associated with greater pain intensity and delayed recovery parameters, whereas quality-of-recovery scores showed an inverse association with opioid exposure. The regimen was also associated with a low incidence of opioid-related adverse effects and no observed respiratory depression.

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