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Impact of Low Opioid Anesthesia on Postoperative Recovery Quality in Patients undergoing Laparoscopic Colorectal Resection- A Randomized Controlled Trial

Conghui Hao
The Affiliated Lianyungang Hospital of Xuzhou Medical University, The First People's Hospital of Lianyungang

Yunyan Wang
Lianyungang Clinical College of Nanjing Medical University, The First People's Hospital of Lianyungang

Xiaobao Zhang
The Affiliated Lianyungang Hospital of Xuzhou Medical University, The First People's Hospital of Lianyungang

Pin Zhu
The Affiliated Lianyungang Hospital of Xuzhou Medical University, The First People's Hospital of Lianyungang

Yong Wu
The Affiliated Lianyungang Hospital of Xuzhou Medical University, The First People's Hospital of Lianyungang

Jiying Feng
The Affiliated Lianyungang Hospital of Xuzhou Medical University, The First People's Hospital of Lianyungang

Hengfei Luan
luanhengfei1027@163.com

Lianyungang Clinical College of Nanjing Medical University, The First People's Hospital of Lianyungang

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Abstract

Purpose: Opioid analgesics may affect the quality of postoperative recovery and delay discharge due to their significant adverse effects, such as hyperalgesia, postoperative nausea and vomiting (PONV), shivering, and respiratory depression. Our objective was to explore the effect of a multimodal anesthesia approach with low opioid use on the quality of postoperative recovery in patients undergoing laparoscopic colorectal resection, and to formulate an optimal anesthesia management strategy for enhancing postoperative recovery quality.

Patients and methods: 56 adult patients undergoing laparoscopic colorectal resection were randomly allocated to the low opioid anesthesia group (Group LOA) or the opioid-based anesthesia group (Group OA). The primary outcome was the quality of postoperative recovery using the QoR-15 scale on postoperative day 2 (POD 2). The secondary outcomes included the QoR-15 scale on postoperative day 7 (POD 7), pain visual analogue scores (VAS) assessed at 2, 4, 8, 24, and 48 hours after surgery, sufentanil consumption 24 hours after surgery, perioperative hemodynamic data and incidence of perioperative adverse reactions.

Results: The QoR-15 score in group LOA was higher than that in group OA on POD2 and POD7 107.8(110.0,111.3) vs. (89.0(87.0,91.0); 131.5(130.0,135.0) vs. 109.0(107.0,110.3), P<0.001). The Visual Analogue Scale (VAS) scores in group LOA were lower than that in group OA at 2, 4, 8 and 24 hours post-operation (1(1-2) vs. 2(2-3); 2(1-2) vs. 3(2-3); 2(2-3) vs. 3(2-3); 2(1-2) vs. 2(2-3), P□0.05). There was difference in sufentanil consumption 24 hours after surgery between the two groups (77.5(75.8, 80.0), 65.0(63.0, 66.0) P□0.05). The mean arterial pressure (MAP) in group LOA were higher than that in group OA at the time of before intubation (T1), and 1 min before skin incision (T3) (84.3±3.1 vs. 77.4±5.4 ; 83.0±2.5 vs. 80.3±3.6, P<0.05). There were differences in respiratory depression, nausea and vomiting between the two groups(6(23.1) vs. 1(3.8); 8(30.8) vs. 2(7.7); 6(23.1) vs. 1(3.8), P□0.05).

Conclusion: Low opioid anesthesia improved the quality of postoperative recovery in patients undergoing laparoscopic colorectal resection with better pain relief, more stable perioperative hemodynamic data and less adverse effects.

Clinical Trial Registry: ChiCTR2400081940□Date: March 15th, 2024

1. INTRODUCTION

Colorectal cancer (CRC) remains the third most commonly diagnosed cancer globally and accounts for approximately 10% of all tumor-related deaths.[1] Laparoscopic colorectal resection, while minimally invasive, still involves significant surgical trauma due to complex dissection within a well-innervated anatomical region.[2] This can lead to considerable physiological stress, delayed recovery, and increased postoperative complications.[3] Enhancing recovery following such procedures remains a key clinical priority.

As we all know, opioids play a pivotal role in general anesthesia due to their potent analgesic properties, the ability to suppress the surgical stress response and mitigate trauma-related physiological disturbances during surgery.[4] Although opioids are fundamental to general anesthesia for their potent analgesic and stress-reducing effects, their use is associated with well-documented adverse outcomes such as postoperative nausea and vomiting (PONV), respiratory depression, gastrointestinal dysfunction, and potential long-term use.[5] These complications may hinder the early postoperative recovery, which is crucial for the prognosis of patients and is not beneficial for patient recovery.[6–8]

Notably, evidence from randomized controlled trials supporting low-opioid anesthesia in laparoscopic colorectal surgery remains limited. To address this gap, we designed a study comparing a structured low-opioid anesthesia protocol with conventional opioid-based anesthesia.[9–12] We hypothesize that utilizing a low-opioid anesthesia technique – which combines multimodal agents (e.g., esketamine, dexmedetomidine, NSAIDs, and regional techniques) to reduce opioid use – would result in improved postoperative recovery, superior analgesia, more stable hemodynamics, and fewer adverse effects compared to traditional opioid-based anesthesia in patients undergoing laparoscopic colorectal surgery.

2. METHODS

2.1. Patients and Study Design

This prospective, randomized, single-blinded clinical study was conducted from November 2023 to May 2025, at the First People's Hospital of Lianyungang, China. We included patients hospitalised for patients between 1 May 2024 and 1 February 2025. The registration date of this study is March 15, 2024. The study complied with the Declaration of Helsinki and was approved by the Medical Ethics Committee of the First People's Hospital of Lianyungang (KY- 20230920002-01). The study was registered on ClinicalTrials.gov (ChiCTR2400081940). 56 adult patients with ASA physical status I or II, aged 40–70 years, scheduled for laparoscopic colorectal resection were enrolled. Exclusion criteria were as follows: a. A history of allergy or contraindication to ropivacaine, esketamine, or nonsteroidal anti-inflammatory drugs (NSAIDs) (e.g., significant risk of elevated blood pressure and intracranial pressure, poorly controlled or untreated hypertension, untreated or undertreated hyperthyroidism, gastrointestinal bleeding); b. Presence of mental illness and other chronic pain conditions or other conditions that may confound the analgesic response; c. Inability to read and write Chinese leading to communication barriers; d. Patients with severe cardiac and respiratory diseases; e. Patients with significant skin damage and infection in the ultrasound scan area; f. Reluctance to utilize intravenous pain relief pumps and refusal to participate. This study was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

2.2 Study Randomization

Patient allocation in this randomized controlled trial was determined by a computer-generated sequence with 1:1 allocation. To ensure concealment, the assignments were placed in sequentially numbered,

opaque, sealed envelopes. These were opened by the anesthesiologist only after the patient entered the operating room, thereby disclosing the group assignment (LOA or OA). A research nurse, otherwise uninvolved in the study, was responsible for preparing all medications. Blinding was maintained for the patients, surgeons, nursing staff, postoperative outcome assessors, and the statistician. Due to the distinct drug administration regimens, the attending anesthesiologist was the only individual not blinded to the allocation.

2.3 Study Endpoints

The primary endpoint of this trial was defined as the quality of recovery on postoperative day 2, assessed using the 15-item Quality of Recovery (QoR-15) questionnaire. This comprehensive, patient-reported instrument evaluates five key recovery domains: physical comfort (5 items), emotional state (4 items), physical independence (2 items), psychological support (2 items), and pain (2 items). Each item is rated on a numerical scale from 0 to 10, with 0 representing a poor recovery and 10 representing an excellent recovery for that aspect. The cumulative scores from all items yield a total QoR-15 score, which ranges from 0 (poorest quality of recovery) to 150 (best quality of recovery).

The secondary outcomes included as follows: the pain visual analogue scores (VAS) were recorded at 2, 4, 8, 24, and 48 hours post-surgery. Additionally, The mean arterial pressure of the patients were recorded at baseline (T0), before intubation (T1), after intubation (T2), 1 min before skin incision (T3), 1 min after skin incision (T4), and at the end of the operation (T5). The incidence of perioperative adverse reactions including bradycardia, nausea and vomiting, dizziness, increased oral discharge, and respiratory depression was documented. Furthermore, the utilization of sufentanil within the first 24 hours after surgery as well as the effective pressing times were assessed. Finally, variables such as length of hospital stay, time in PACU, first exhaust time were also recorded (Time in PACU: defined as the time from PACU admission until meeting discharge criteria -Aldrete score ≥ 9; First exhaust time: defined as the first passage of gas postoperatively, reported by the patient or nursing records; Length of hospital stay: calculated from the day of surgery to the day of discharge.)

2.4 Anesthetic Management Protocol

All patients scheduled for elective laparoscopic colorectal resection were identified and visited according to standard protocols, based on predefined inclusion and exclusion criteria.Standard intraoperative monitoring was initiated upon arrival in the operating room, encompassing electrocardiogram (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and body temperature. In addition to these standard measures, the depth of anesthesia was monitored throughout the procedure using bispectral index (BIS) monitoring.

Pre-oxygenation was administered for 3 minutes before anesthesia induction. Group LOA received a pre-anesthesia dose of dexmedetomidine at a constant rate of 0.6 μg/kg, which was administered 10 minutes prior to induction. During the induction period, group LOA was given remazolam (0.2mg/kg), propofol (1-2mg/kg), atracurium cisenesulfonate (0.2mg/kg), sufentanil (0.2ug/kg), and esketamine (0.2mg/kg). Group OA was given remazolam (0.2mg/kg), propofol (1-2mg/kg), atracurium

cisenesulfonate (0.2mg/kg) and sufentanil(0.4ug/kg). Anesthetic maintenance period: Group LOA received propofol at a dosage of 4-6mg/kg/h, dexmedetomidine at a dosage of 0.1-0.2ug/kg/h, and esketamine at a dosage of 0.2-0.3mg/kg/h. Group OA received propofol at a dosage of 4-6mg/kg/h and remifentanil at a dosage of 0.1-0.3ug/kg/min. Both groups were administered sevoflurane inhalation anesthesia with concentrations ranging from 1% to 3%.

In adult patients undergoing general anesthesia with endotracheal intubation, implement intraoperative mechanical ventilation using Pressure Control Volume Guaranteed (PCV-VG) mode. Set initial tidal volume to 6–8 mL/kg predicted body weight and respiratory rate to 12–20 breaths/min. Adjust sevoflurane concentration in an oxygen/air mixture (FiO_2 0.6, total gas flow 2 L/min) to maintain BIS values between 40 and 60, targeting a MAC range of 0.8–1.4. Continuously monitor $PetCO_2$ and maintain it within 35–40 mmHg, while ensuring peak airway pressure remains below 30 cm H_2O. Regularly assess ventilatory and hemodynamic parameters every 5 minutes and adjust settings accordingly to ensure physiological stability throughout surgery.

After surgery, the surgeon used 0.375% ropivacaine for local infiltration anesthesia in each endoscopic incision. In the two group, participants received transversus abdominis plane (TAP) block (20 ml 0.375% ropivacaine for each side). In addition, both groups of patients received patient-controlled intravenous analgesia (PCIA). In group LOA, the analgesic pump formula consisted of sufentanil 1ug/kg + esketamine 1.0mg/kg + troisetron 10mg (diluted with normal saline to a total volume of 100ml). The background infusion rate was set at 2ml/h, each compression delivered 2ml, and there was a locking time of 10 minutes. In group OA, the analgesic pump formula included Sufentanil 2ug/kg + troisetron 10mg (diluted with normal saline to a total volume of 100ml). The background infusion rate was also set at 2ml/h, each compression delivered 2ml, and there was a locking time of 10 minutes. Following surgery, suspend PCIA infusion if the patient's VAS score<1 and exhibits respiratory depression, confusion, blood pressure instability, or other conditions that hinder continued use of the analgesic pump.

Hypotension, defined as a systolic blood pressure reduction of more than 20% from the preoperative baseline or a systolic blood pressure below 90 mmHg, was managed with intravenous norepinephrine at a dose of 4–8 μg during the period from anesthesia induction to discharge from the post-anesthesia care unit (PACU). Bradycardia, defined as a heart rate reduction exceeding 20% from the preoperative baseline or a heart rate below 50 beats per minute (bpm), was treated with 0.5 mg of intravenous atropine.

2.5 Data Analysis

QoR-15 was chosen as the primary outcome on POD 2 after surgery. Previous literature reports [28] indicate that the QoR-15 score of 70.6 ± 13.4 is typical for patients undergoing colorectal surgery on the second day post-operation, and an average difference of at least 12 points is considered clinically significant. The bilateral significance and efficacy were set at 0.05 and 80%, respectively, and G-power software was utilized to calculate a required sample size of 22 patients per group. Accounting for an

estimated dropout rate of approximately 15%, we plan to enroll a total of 56 patients. Dataset analysis was conducted using SPSS Statistics (Version 25.0). The distribution of continuous and ordinal variables was studied using the Shapiro–Wilk test. Continuous variables with a normal distribution are presented as mean ± SD and analyzed with the independent samples t-test, while skewed data are presented as median (IQR) and analyzed with the Mann-Whitney U test. Categorical variables are presented as n (%) and analyzed with Pearson's chi-square test. A two-tailed p-value < 0.05 was deemed statistically significant.

3. RESULTS

3.1. Recruitment Process

The details of the study cohort conduction are shown in Figure 1. 56 adult patients underwent laparoscopic colorectal resection at our hospital. Of these, 4 patients were excluded; 3 because of not meeting inclusion criteria, 1 because of declining to participate. Among 52 patients included in this analysis, 26 received intraoperative OA anesthesia method and 26 received intraoperative LOA anesthesia method (Figure 1).

3.2. Demographic and Clinical Characteristics

No difference in age, gender, BMI, American Society of Anesthesiologists (ASA), anesthesia duration and operation duration, time in PACU, length of stay, the first exhaust time and effective pressing times were identified between the two groups. There was difference in sufentanil consumption 24 hours after surgery between the two group (P□0.05). There were significant difference in use of sufentanil 24 hours after surgery (77.5(75.8, 80.0) vs. 65.0(63.0, 66.0) P□0.05) (Table 1).

Table 1 Patient characteristics and perioperative data.

Characteristic	Group OA(n=26)	Group LOA(n=26)	P value
Demographic Features			
Age (yr)	61.5±6.3	60.5±7.2	0.259
Gender, n (%)			
Male	12(46.2)	14(53.8)	
Female	14(53.8)	12(46.2)	0.579
BMI (kg/m^2)	21.5±1.1	21.8±1.0	0.332
ASA physical status, n (%)			
□	15(57.7)	16(61.5)	
□	11(42.3)	10(38.5)	0.777
Perioperative data			
Anesthesia duration (min)	126.0±3.9	124.8±3.2	0.363
Operation duration (min)	99.7±4.9	98.0±5.6	0.774
Time in PACU (min)	35.1±1.3	34.3±1.9	0.087
length of hospital stay (d)	6.5±0.9	6.0±0.7	0.108
Use of sufentanil 24 hours after surgery	65.0(63.0, 66.0)	77.5(75.8, 80.0)	□0.001*
Effective pressing times	2.8±0.7	2.4±0.5	0.697
First exhaust time(days)	2.9±0.4	2.0±0.4	0.964

Notes: *p□0.05. Data are expressed as mean±SD, median (interquartile range) or number (percentage).

Abbreviations: LOA: Low dose Opioid-based anesthesia; OA:Opioid anesthesia; BMI: Body Mass Index; ASA: American Society of Anesthesiologists; PACU: Post-anesthesia care unit.

3.3 Visual Analogue Scale (VAS) Assessment

Postoperative pain intensity, as assessed by the Visual Analogue Scale (VAS), was significantly lower in the LOA group than in the OA group at 2, 4, 8, and 24 hours after surgery (all P < 0.05)(Table 2).

Table 2 VAS scores.

VAS	Group LOA(n=26)	Group OA(n=26)	P
2h	1(1-2)	2(2-3)	<0.001
4h	2(1-2)	3(2-3)	<0.001
8h	2(2-3)	3(2-3)	0.019
24h	2(1-2)	2(2-3)	<0.001
48h	1(1-1)	1(1-2)	0.081

Notes: *p□0.05. Data are expressed as median (interquartile range).

Abbreviations: LOA: Low dose Opioid-based anesthesia; OA:Opioid anesthesia□VAS: Visual Analogue Scores.

3.4 Perioperative Adverse Reactions

Patients in the LOA group also experienced a significantly lower incidence of nausea, vomiting, and respiratory depression compared to those in the OA group (all P < 0.05). In contrast, no statistically significant differences were observed between the two groups in terms of lightheadedness or increased oral secretion (Table 3).

Table 3 Perioperative adverse reactions.

Perioperative adverse reactions n (%)	Group OA(n=26)	Group LOA(n=26)	
Nausea	8(30.8)	2(7.7)	0.035*
Vomiting	6(23.1)	1(3.8)	0.042*
Feeling lightheaded or dizzy	4(15.4)	1(3.8)	0.158
Increased oral discharge	1(3.8)	5(20.0)	0.073
Respiratory depression	6(23.1)	1(3.8)	0.042*

Notes: *p□0.05. Data are expressed as number (percentage).

Abbreviations: LOA: Low dose Opioid-based anesthesia; OA:Opioid anesthesia□VAS: Visual Analogue Scores.

3.5 The QoR-15 Score

The QoR-15 score was markedly better in the LOA group than in the OA group on POD2 and POD7 (107.8(110.0,111.3) vs. (89.0(87.0,91.0); 131.5(130.0,135.0) vs. 109.0(107.0,110.3), P<0.001). These differences of 18.8 and 22.5 points are clinically meaningful, as they greatly surpass the MCID of 8.0 for the QoR-15 scale. Group OA demonstrated notably lower scores on POD2 and POD7 for postoperative pain, physical comfort, physical independence, psychological support and emotional state dimensions compared to group LOA (13.0(12.0,14.0) vs. 16.0(15.0,16.0), 16.0(15.0,16.0) vs. 18.0(17.8,18.3), and P< 0.001; 21.0(20.0,22.0) vs. 28.5(28.0,30.3), 28.0(28.0,29.0) vs. 38.0(37.8,40.0) and P < 0.001; 14.0(13.0,14.0) vs. 15.0(14.0,15.3), 17.0(16.8,18.0) vs. 20.0(19.0,20.0) and P□0.001; 15.0(15.0,16.3) vs. 18.0(17.0,18.0), 17.0(16.0,17.0) vs. 19.0(18.0,20.0) and P□0.001; 26.0(26.0,27.00) vs. 32.0(31.0,33.0), 30.0(30.0,33.0) vs. 37.0(36.0,38.0) and P□0.001) (Figure 2).

3.6 Mean Arterial Pressure (MAP)

The mean arterial pressure (MAP) in group LOA was higher than that in group OA at the time of before intubation (T1) and 1 min before skin incision (T3) (84.3±3.1 vs. 77.4±5.4; 83.0±2.5 vs. 80.3±3.6, P<0.05). (Figure 3).

4. DISCUSSION

In this single-center randomized controlled trial involving patients undergoing Laparoscopic Colorectal Resection, we observed that a low-dose opioid anesthesia was associated with improved early recovery.

Our results suggest that the low-opioid anesthesia (LOA) regimen was associated with an improved early recovery profile compared to conventional opioid-based anesthesia. Specifically, the LOA group demonstrated a statistically significant and clinically meaningful increase in the global QoR-15 score on POD 2, with the mean between-group difference exceeding the established Minimal Clinically Important Difference (MCID) of 8.0 for this scale[15-17]. Improvements were observed across all subcomponents. The enhanced recovery metrics in the LOA group may be attributed to the multimodal pharmacological approach. Dexmedetomidine, a component of the LOA regimen, induces a natural sleep-like sedation through its α2-adrenergic agonist properties, which could potentially mitigate postoperative stress responses[18]. Furthermore, the inclusion of esketamine might be particularly relevant for psychological outcomes. Its rapid-acting antidepressant properties, as evidenced in other clinical contexts[19], may offer a plausible explanation for the observed benefits in emotional state metrics. Collectively, these findings suggest that low-opioid anesthesia strategies may confer benefits that extend beyond analgesia optimization, potentially positively influencing early postoperative neuropsychological recovery. However, the confirmations of these effects and their long-term implications require validation in larger, multi-center studies[20]. Our study aligns with the research conducted by Bekker et al., which assessed the postoperative recovery quality in spinal surgery patients. The findings from the postoperative recovery quality scale administered three days prior to surgery indicated that the emotional state, psychological support, and overall scores of the experimental group were significantly higher than those of the control group [21].

Our results showed that the pain dimension score evaluated by the QoR-15 was higher in group LOA. Our study also found that group LOA exhibited significantly lower peak VAS scores during the first 4h, 24h, 48h after surgery, compared with group OA. Meanwhile, group LOA exhibited significant reductions in the consumption of sufentanil 24 hours after surgery. Wang et al. reported that esketamine significantly decreased the proportion of patients reporting moderate to severe pain at rest. This decrease was reflected in the differences noted in the pain dimension score evaluated by the QoR-15[22]. This may be related to hyperalgesia caused by continuous intraoperative infusion of remifentanil in group OA. Currently, the mechanism of hyperalgesia is not clear, which may be related to neuronal sensitization caused by the enhancement of central glutamatergic system activity involving NMDA receptors. Therefore, the use of NMDA receptor antagonists such as esketamine may have an advantage in reducing hyperalgesia[23]. Another explanation could be related to the stimulation of alpha-2 receptors in the brain and spinal cord by alpha-2 agonists (dexmedetomidine) which inhibit neuronal firing leading to analgesia: pain transmission is suppressed by hyperpolarization of interneurons and reduction of the release of pronociceptive transmitters such as substance glutamate[24]. In addition, this may also be due to the TAP block used in the LOA group, which prolonged the postoperative analgesia time.

Postoperative nausea and vomiting(PONV) and respiratory depression are the main adverse effects of opioids. In our exploratory analysis of adverse effects, the LOA group, which consumed less sufentanil, showed a lower observed incidence of PONV and respiratory depression. Meanwhile, it has been reported that esketamine can significantly reduce respiratory depression, reduce the incidence of hypoxemia, and significantly reduce intraoperative CO2 accumulation, which is similar to the previous study of Malo-Manso et al[25]. Wang J et al.showed that the sympathomimetic effect of esketamine, which not only had no respiratory depressant effect but also accelerated the respiratory rate, weakening the respiratory depressant effect of propofol[26]. In a clinical study of patients undergoing thoracoscopic pneumonectomy, LOA with esketamine in combination with dexmedetomidine significantly reduced the incidence of PONV within 48 hours after surgery compared with opioid anesthesia[27]. Ibrahim et al. also reported that patients in the low opioid anesthesia regimen group were able to eat and drink earlier, experienced less nausea or vomiting, and potentially spent about 18 percent less time in the hospital, as expected by the ERAS concept[28].

Anthesia-induced hypotension, commonly observed during the induction of opioid-based anesthesia, poses a significant risk for myocardial injury due to reduced myocardial blood perfusion and oxygen supply[29]. Compared with the MAP of group LOA, the MAP of group OA at T1 and T3 decreased significantly. Group LOA showed more stable hemodynamics group OA. This may be partially attributed to the inhibitory effects of dexmedetomidine on neuronal discharge, as well as its sedative, analgesic, and anti-sympathetic properties, which contribute to hemodynamic stabilization while providing a protective effect on blood pressure and cardiac function[30]. A second explanation may pertain to the mild sympathetic excitation induced by esketamine, along with its distinctive analgesic and sedative properties, which contributed to a reduction in the dosage of other anesthetic agents and enhanced the stability of respiration and circulation[31,32].

This study has several limitations. First, as a single-center investigation, the findings may be influenced by selection bias, which could affect the generalizability of the results. Second, the assessment of recovery quality was limited to postoperative days 2 and 7 (POD2 and POD7) using the QoR-15 scale, leaving the longer-term recovery trajectory unexplored. Third, the experimental design employed only one fixed-dose combination of esketamine and dexmedetomidine for induction, which precludes subgroup analysis of potential differential effects. Moreover, although multiple secondary outcomes were evaluated, no adjustment for multiple comparisons was performed, which increases the risk of Type I error when interpreting these results.Finally, due to the distinct pharmacodynamic profiles of the study medications, anesthesiologists could not be blinded to the group assignment, potentially introducing performance bias during the intraoperative and immediate postoperative phases.

5. CONCLUSIONS

In conclusion, this study demonstrated that compared with opioid anesthesia, Low opioid anesthesia improved the quality of postoperative recovery with better pain relief, more stable perioperative hemodynamic data and less adverse effects in patients undergoing laparoscopic colorectal resection.

Declarations

Authors' contributions

Hengfei Luan have given substantial contributions to the conception or the design of the manuscript, Jiying Feng, Pin Zhu and Yong Wu to patient recruitment, Conghui Hao and Xiaobao Zhang to manuscript writing, Yunyan Wang to acquisition, analysis and interpretation of the data. All authors have participated to drafting the manuscript, Hengfei Luan revised it critically. All authors read and approved the final version of the manuscript. All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

Acknowledgments

All the authors contributed to the conduct of this work by research. All authors read and approved the final manuscript.

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Availability of data and materials

No datasets were generated or analysed during the current study.

Ethics approval and consent to participate

Ethical approval for this study was provided by the Medical Ethics Committee of the First People's Hospital of Lianyungang on November 16, 2023. Written informed consent was obtained from all study participants. All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments .

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Figures

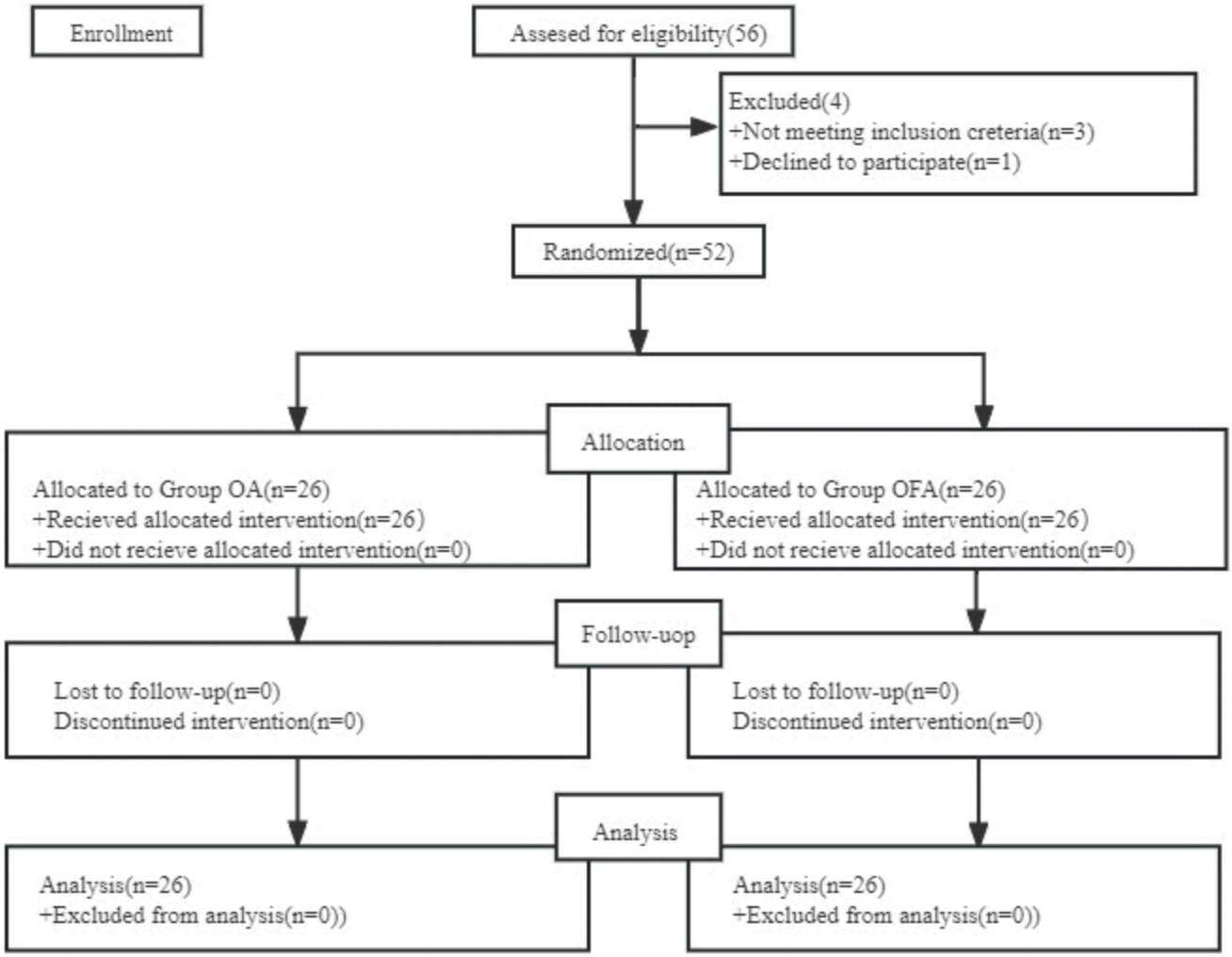


Figure 1

Flow diagram of the study patients.

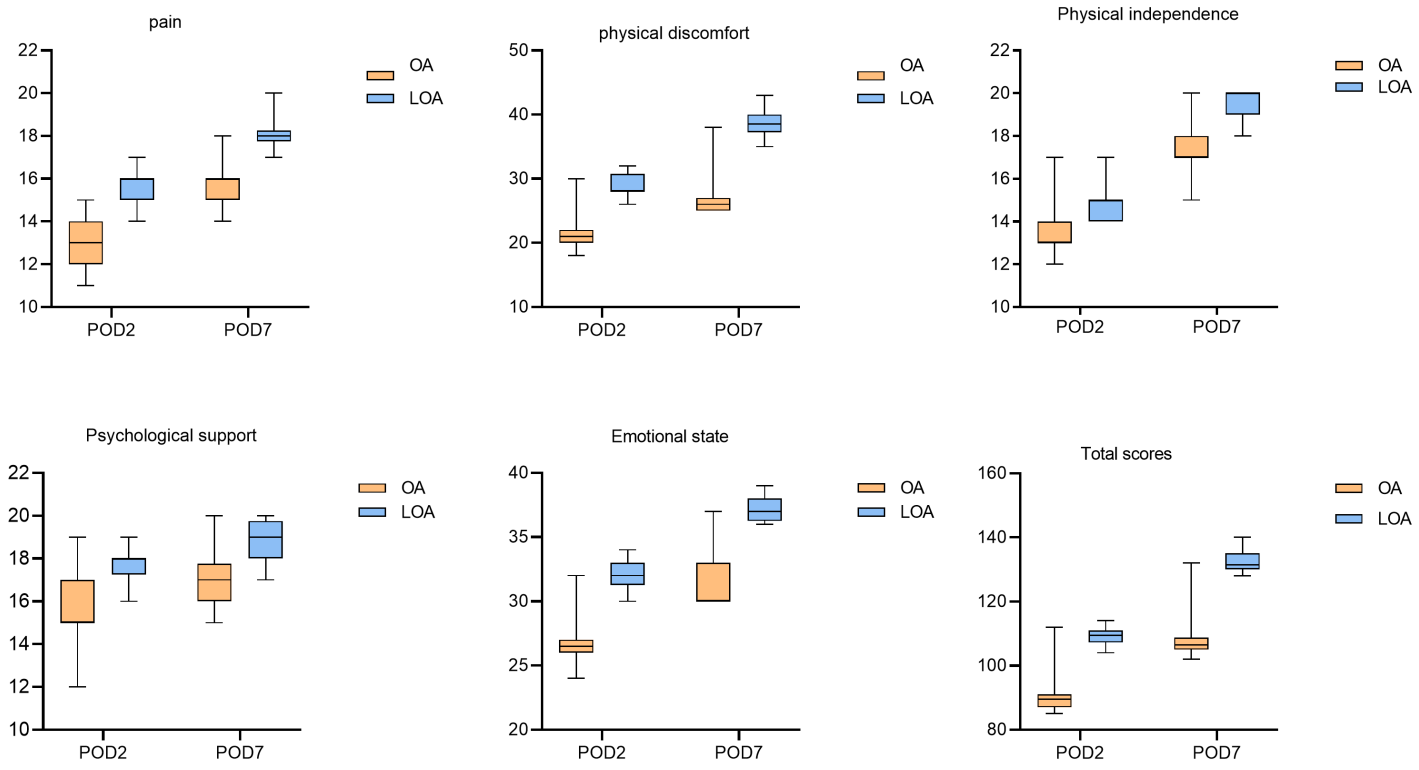


Figure 2

There was a significant change in the global scores, physical comfort, physical dependence, psychological support, pain, and emotional state on POD2 and POD7 ($P < 0.05$). Non normal distribution measurements were expressed as medians and interquartile ranges. $P< 0.05$ was considered to be statistically significant.

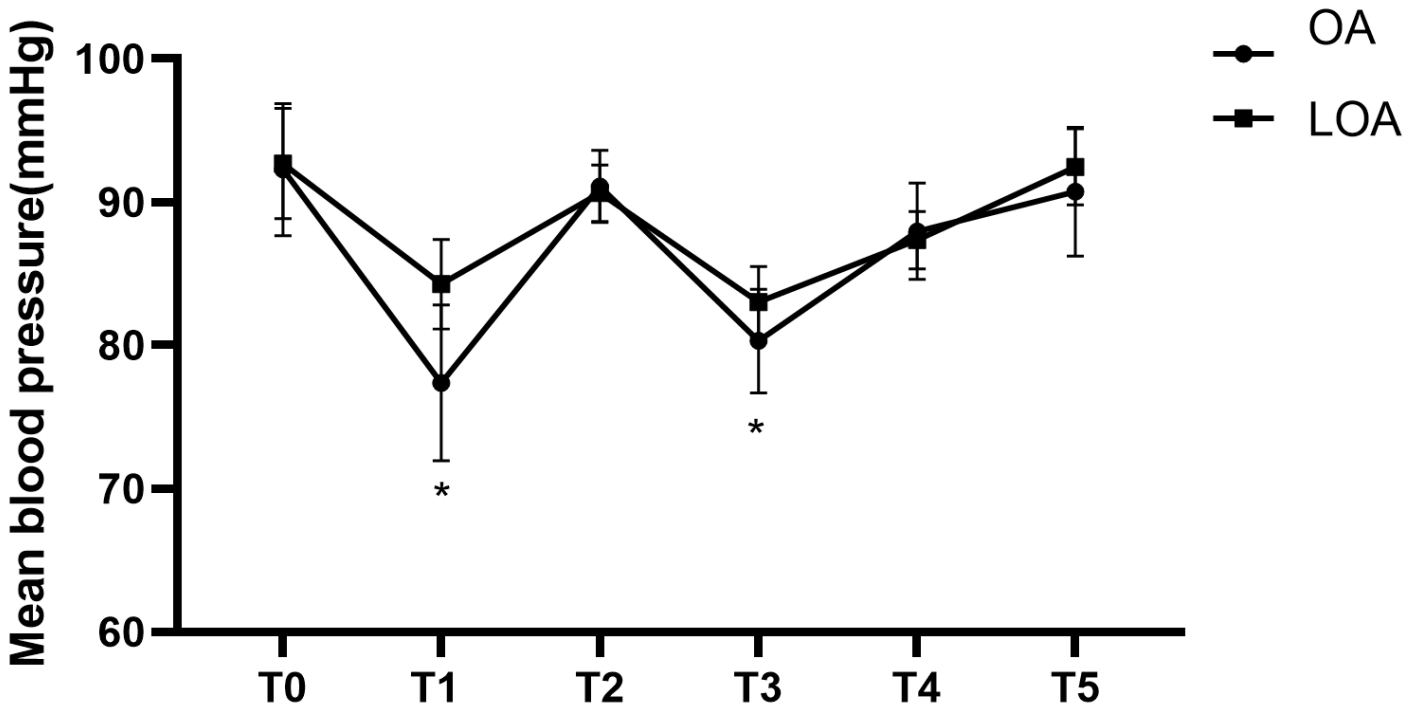


Figure 3

Perioperative Mean blood pressure(MAP)at baseline (T0), before intubation (T1), after intubation (T2), 1 min before skin incision (T3), 1 min after skin incision (T4), and at the end of the operation (T5); *P<0.05.