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Comparative efficacy and safety of nalbuphine and hydromorphone in painless colonoscopy techniques: a randomized controlled trial

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Abstract

Background Colonoscopy is essential for diagnosing colon lesions but is often associated with discomfort. Painless colonoscopy techniques are being increasingly used to improve the patient experience."However, in the case of painless colonoscopy, anesthesia is performed outside the operating room, which requires more significant peri-examination of hemodynamic changes and adverse postoperative reactions. This requires a more careful selection of narcotic analgesics, and there needs to be optimal analgesic drug guidance in clinical practice. This study compared the efficacy and safety of nalbuphine and hydromorphone in improving patient comfort and maintaining hemodynamic stability during elective colonoscopy.

Methods This prospective, randomized, double-blinded controlled trial included 72 adult patients (aged 18–65) who underwent sedation colonoscopy. The 72 patients were randomly divided into two groups using a computer-generated random sequence. Body mass index 18.5–28.0 kg/m2; American Society of Anesthesiologists (ASA) grade I to II. Then, the nalbuphine group was given 0.13 mg/kg nalbuphine, the hydromorphone group was given 0.016 mg/kg hydromorphone, and during the operation, 10–20 mg/time propofol could be appropriately injected according to the patient's examination and cooperation. All patients were continuously monitored for oxygen saturation, heart rate, and noninvasive mean arterial blood pressure. The colonoscopy time and anesthesia time were recorded. Adverse reactions such as hypotension, decreased oxygen saturation, nausea, and vomiting were recorded. Anesthesiologist satisfaction, gastroenterologist (operator), and patient satisfaction were recorded.

Results Both nalbuphine and hydromorphone effectively maintained hemodynamic stability, with no significant differences in vital signs observed between the groups ($P > 0.05$). However, nalbuphine significantly reduced the incidence of postoperative nausea, vomiting, dizziness, and headache compared to hydromorphone ($P < 0.05$). The reduced side effects of nalbuphine were marked, suggesting a better postoperative comfort profile.

Conclusions While nalbuphine and hydromorphone effectively maintain intraoperative vital signs, nalbuphine offers superior postoperative comfort. This makes nalbuphine a preferable analgesic choice in outpatient colonoscopy

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settings. Further research is warranted to determine the optimal dosages for both drugs and to explore their mechanisms of action in procedural pain management.

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Keywords Efficacy, Safety, Nalbuphine, Hydromorphone, Painless colonoscopy techniques, RCT

Introduction

As colon lesions become more prevalent, colonoscopy screening has become increasingly essential for early diagnosis and intervention [1–4]. The colonoscopy procedure often leads to significant pain due to air insufflation and instrument insertion. [5–8]. Without sedation and analgesia, patients often struggle to tolerate the discomfort and stimulation associated with the procedure [9, 10]. To address these challenges and improve patient comfort, painless colonoscopy techniques, which utilize both sedation and analgesia, have become more widely adopted. These techniques aim to minimize discomfort, improve the patient experience, and potentially increase the uptake of screening.

However, performing anesthesia outside the operating room, as is common in painless colonoscopy, introduces additional considerations, such as the risks of respiratory depression and hemodynamic instability associated with analgesics [11–16]. These risks require careful selection of analgesic agents that can effectively relieve pain while minimizing adverse effects, especially in outpatient settings where rapid recovery and discharge are desired [17–22]

Nalbuphine, a synthetic opioid analgesic with a distinct pharmacological profile, presents an attractive option for pain management in painless colonoscopy [23–25]. As a mixed opioid agonist–antagonist, nalbuphine provides adequate analgesia similar to other opioids, such as morphine and fentanyl, while carrying a lower risk of respiratory depression due to its ceiling effect on this adverse reaction. This makes nalbuphine especially suitable for settings where minimizing respiratory complications is a priority. Furthermore, nalbuphine's potential to cause less nausea, vomiting, and sedation compared to full opioid agonists further supports its use in outpatient procedures, where patient comfort and rapid recovery post-procedure are critical. Hydromorphone was selected as the comparator because it is a widely used opioid for colonoscopy procedures and has a similar pharmacological profile to nalbuphine. Previous studies have demonstrated the effectiveness of hydromorphone for managing procedural pain in gastrointestinal procedures [26, 27].

Given the critical role of colonoscopy in screening for colon lesions and the need to enhance patient comfort and safety, this study aims to explore the impact of nalbuphine on patient comfort and the overall safety profile of painless colonoscopy. By focusing on nalbuphine's analgesic efficacy and its potential to reduce anesthesia-related risks, this research seeks to provide evidence-based support for its use in painless colonoscopy procedures.

Methods

Study design

This prospective, randomized, double-blinded, controlled clinical trial evaluates the effects of hydromorphone versus nalbuphine on efficacy and safety during painless colonoscopy. The study adheres to the principles outlined in the Declaration of Helsinki. It received approval from the Institutional Review Board of Tianjin Jizhou District People's Hospital on October 23, 2023 (approval number IRB2023 - 18), and was registered in the Chinese Clinical Trial Registry on November 9, 2023 (registration number ChiCTR2300077446). Written informed consent was obtained from all participants prior to inclusion in the trial. The study follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized clinical trials, and the trial protocol is available in Supplement 1. The study is scheduled to run from December 2023 to May 2024.

Inclusion and exclusion criteria

The trial includes 72 participants aged 18 to 65 who were classified by the American Society of Anesthesiologists (ASA) as class I to II and scheduled to undergo painless colonoscopy under deep sedation (no tracheal intubation required). Patients were required to be willing to participate in the study and available for telephone follow-up within 4 h post-surgery. Exclusion criteria included: (1) known allergy to hydromorphone or nalbuphine; (2) a long history of opioid analgesia; (3) severe cardiovascular, liver, or kidney disease; and (4) inability to read, write, or understand Chinese.The study would be terminated if there was a significant increase in adverse events or if the safety of the intervention could not be ensured. Termination criteria included: (1) excessive adverse events, (2) failure to meet primary outcome measures after initial data analysis, or (3) a higher than expected dropout rate of more than 15%.

Criteria for discharge from recovery include: (1) a Postanesthesia Recovery Score (PARS) of 29, (2) stable vital

signs, and (3) a minimum of 20 min without signs of significant nausea or dizziness post-procedure.

Randomization and blinding

A computer-generated randomization sequence assigned eligible patients to either the hydromorphone or nalbuphine group in a 1:1 ratio (Fig. 1). To ensure the assignments remained concealed, the results were sealed in sequentially numbered envelopes and provided to a nurse not involved in the study. Participants, anesthesiologists, and outcome evaluators were blinded to group assignment. The experimental drug was placed in an opaque bag to further maintain blinding.

Adverse events

Adverse events were defined as any untoward medical occurrences that were observed during the study period. These were reported by clinical staff immediately to the

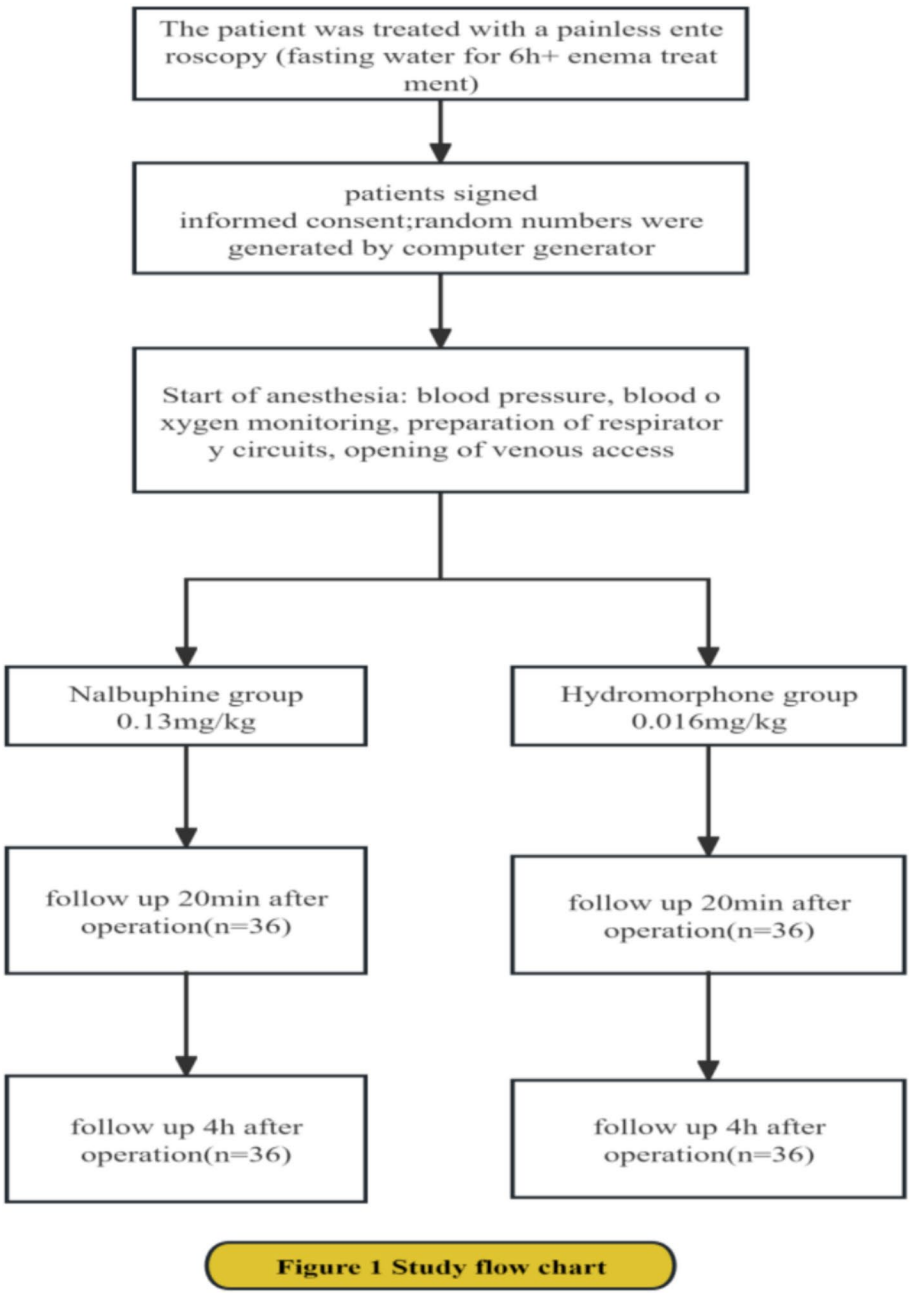

Fig. 1 Study flow chart

principal investigator. Serious adverse events (SAEs), including respiratory depression or cardiovascular instability, were reported within 24 h to the Ethics Committee, who reviewed the event for potential protocol modifications or patient safety actions.

Sample size calculation

Based on preliminary study results, we anticipated that 34.5% of the participants in the hydromorphone group and 2.7% of those in the nalbuphine group would experience postoperative nausea and vomiting. The sample size was calculated with a power of 90% and an alpha of 0.05. Using PASS software (V.20.0.6, NCSS, Kaysville, USA), the calculation yielded 32 participants per group, considering 1:1 randomization. To account for a 15% dropout rate, a total of 36 patients per group were included, bringing the total number of participants to 72.

Painless colonoscopy implementation

The study allowed for the use of propofol if opioid-based sedation alone was insufficient. However, the primary goal was to assess the efficacy of nalbuphine in managing abdominal pain, which often requires stronger analgesia, particularly in gastrointestinal procedures. Supplemental propofol was administered to 12% of patients in the Hydromorphone group and 15% of patients in the Nalbuphine group. The average dose of propofol administered was 0.05 mg/kg, depending on the patient's response to opioid sedation.

All patients fasted and were prepared with an enema prior to the examination. Vital signs were recorded immediately upon entry into the procedure room. Venous access was established, and patients received nasal catheter oxygen (5 L/min) while being continuously monitored for heart rate (via three-lead ECG), SpO_2, and blood pressure (recorded before induction, 2 min after induction, at admission, after reaching the splenic and hepatic flexure, upon arrival at the ileocecal area, and during endoscopic withdrawal).During the procedure, patients were continuously monitored for vital signs (heart rate, SpO_2, MAP), respiratory rate, and level of sedation. Any abnormal readings were immediately addressed by the anesthesia team following protocol. For example, hypoxia was managed by increasing supplemental oxygen and initiating manual ventilation if SpO_2 dropped below 90%.

First aid medications, simple respiratory balloons and masks, endotracheal intubation equipment, anesthesia machines, and other necessary rescue equipment were prepared. Five minutes before the colonoscopy, all patients were administered 0.05 mg/kg of propofol. Participants were then randomly assigned to one of two groups. In the nalbuphine group, patients received 0.13 mg/kg of nalbuphine intravenously 4 min before the colonoscopy. In the hydromorphone group, patients were administered 0.016 mg/kg of hydromorphone intravenously 4 min before the procedure.

In the event of severe adverse reactions (e.g., respiratory distress, bradycardia), emergency equipment was available, including endotracheal intubation tools, a ventilator, and medications such as atropine for bradycardia and ephedrine for hypotension. A trained emergency response team was on standby.

If patients were unable to cooperate during the examination after receiving the analgesic drug, an additional 10–30 mg of propofol was administered. Mild hypoxia was defined as SpO_2 lower than 94% and lasting for less than 30 s. The airway was opened, and mandibular support was applied. If SpO_2 decreased to 90% and lasted longer than 30 s, severe hypoxia was defined. In cases of respiratory distress or when SpO_2 reached 90% with a respiratory rate below six breaths per minute, airway operations (e.g., mandibular push forward to open the airway) were performed immediately, and manual ventilation with a mask and breathing balloon was initiated. Bradycardia was defined as a heart rate below 60 beats per minute, and atropine (0.3/0.5 mg) was administered when heart rate dropped below 50 beats per minute. For hypotension, defined as mean arterial pressure (MAP) below 60 mmHg or a 30% decrease from baseline, 3–5 mg of ephedrine was used. The Ramsay sedation score was recorded by an independent researcher unaware of the group assignment, with ratings as follows: 1—anxiety or irritability; 2—cooperation and sedation; 3—drowsiness but responsive to commands; 4—sleeping but responsive to tactile stimuli; 5—sleeping and unresponsive.

Outcome measures

Primary outcomes

Postoperative nausea and vomiting (PONV) were evaluated using the PONV Intensity Scale. The scale is calculated as: PONV intensity = severity of nausea (1 = mild, 2 = moderate, 3 = severe) × pattern of nausea (1 = varying, 2 = constant) × duration of nausea (in hours). Dizziness, headache, and colic were assessed using a numerical rating scale (0–10). The Visual Analog Scale (VAS) was used to evaluate patients'pain, where a 100 mm line is used, and patients mark the intensity of their pain. Patient satisfaction with anesthesia care (PSAC) was also measured.

Secondary outcomes

Intraoperative vital signs, including mean arterial pressure, SpO_2, and heart rate, were continuously monitored and recorded at predefined time points: before induction, 2 min after induction, at admission, after reaching the splenic and hepatic flexure, upon arrival at the ileocecal

area, and during endoscopic withdrawal. If heart rate slowed, blood pressure dropped, or the somatogenetic reaction was ≥2 points, these parameters were recorded at various time intervals.

Patients were assessed using the Postanesthesia Recovery Score (PARS) at 20 min and 4 h post-awakening. The PARS assesses five criteria: respiration, circulation, consciousness, skin color, and activity level. Each parameter is rated on a scale from 0 to 2, and the total score is used to determine the patient's readiness for discharge from the recovery unit.

Statistical methods

Data analysis will be conducted on an intention-to-treat basis. Continuous variables, such as mean arterial pressure (MAP), heart rate (HR), and SpO_2, will be compared between groups using either Student's t-test or the Mann–Whitney U test, depending on the distribution of the data. Normally distributed data will be analyzed using Student's t-test, while non-normally distributed data will be evaluated using the Mann–Whitney U test. Categorical variables, such as the incidence of nausea or vomiting, will be analyzed using the appropriate chi-square test or Fisher's exact test. Ranked data will be compared using the Mann–Whitney U test. Differences will be considered statistically significant at a p-value of <0.05.

Results

A total of 72 patients were selected from December 2023 to April 2024 at Tianjin Jizhou People's Hospital. No patients were lost to follow-up within 4 h. See Fig. 1 for details. Multiple participants were included in each analysis, with assignments based on the initial group allocation.

There were no significant differences in general demographic data, such as sex, age, BMI, or ASA grade, between the two groups. Basic vital signs, including blood pressure, pulse oxygen saturation (SpO_2), and heart rate, showed no significant differences between the groups (see Table 1). Additionally, no significant differences in SpO_2, MAP, or heart rate were found between the groups at the T1-T7 time points ($p>0.05$). However, both groups showed a significant decrease in heart rate at the T4 time point, when the colonoscope passed the splenic flexure, as demonstrated in Table 2 and Figs. 2, 3, and 4.

The incidence of bradycardia, hypotension, and severe hypoxia did not differ significantly between the two groups ($p>0.05$). See Table 3.

However, the incidence of nausea and dizziness in the nalbuphine group was significantly lower than in the hydromorphone group ($p<0.05$). See Table 4. Gastroenterologists'main concerns were the influence of hypoxic treatment on colonoscopy procedures, the difficulty of patient position changes, and patient body movement during the procedure. Anesthesiologists'dissatisfaction primarily stemmed from severe hypoxia, nausea, and vomiting. Patient satisfaction was significantly higher in the nalbuphine group compared to the hydromorphone group ($p>0.05$). See Table 5.

Table 1 Demographic characteristics

Variables	Hydromorphone group ($n=36$)	Nalbuphine group ($n=36$)	P
Age, Mean ± SD(yr)	49.47 ± 11.85	50.97 ± 10.12	0.093
Male, no	20	15	0.646
BMI, Mean ± SD (kg/m2)	24.84 ± 2.56	25.10 ± 3.27	0.076
Total use of propofol, Mean ± SD (mg)	56.67 ± 29.01	53.89 ± 32.54	0.549
Duration of anesthesia, Mean ± SD (min)	25.53 ± 22.85	20.56 ± 11.60	0.542
Colonoscopy time, Mean ± SD (min)	20.44 ± 22.27	16.64 ± 11.06	0.414
MAP at baseline, Mean ± SD (mmHg)	93.36 ± 17.18	85.25 ± 11.71	0.059
SpO_2 at baseline, Mean ± SD (%)	98.31 ± 1.35	98.67 ± 0.99	0.181
Heart rate at baseline, Mean ± SD (r/min)	83.56 ± 18.04	76.58 ± 11.37	0.297

Discussion

This randomized controlled trial compared the effects of nalbuphine and hydromorphone on hemodynamic stability and postoperative side effects in colonoscopy patients.

Adverse reactions

The observed high incidence of adverse reactions, particularly dizziness (50%) and nausea (44%) in the hydromorphone group, is a notable finding. A review of existing literature reveals that adverse event rates for hydromorphone in similar procedural settings vary widely. For example, a study by Liu et al. (2022) reported a lower incidence of nausea (approximately 30%) in patients undergoing gastrointestinal procedures with hydromorphone sedation [26]. Similarly, another study by Ma et al.(2020) and Chen et al.(2024) observed the dizziness rate of around 35% and 20% in a comparable patient population [27, 28].

The raw data, which is presented later in the manuscript, shows that the rate of adverse events was higher than anticipated. However, we do not view this as a major issue, as it actually reinforces our hypothesis that the initial 1:1 dosing ratio for nalbuphine may have underestimated its analgesic efficacy, particularly in managing

Table 2 Summary of the two sets of vital signs

Vital signs	Group	T1	T2	T3	T4	T5	T6	T7
SpO_2 (%)	hydromorphone	98.28 ± 0.24	98.31 ± 0.26	97.66 ± 0.28	96.94 ± 0.55	97.22 ± 0.40	96.94 ± 0.43	97.50 ± 0.29
	nalbuphine	98.68 ± 0.16	98.38 ± 0.23	97.73 ± 0.33	97.76 ± 0.27	97.92 ± 0.26	97.97 ± 0.24	98.19 ± 0.20
	F	0.009	0.006	0.92	2.57	2.56	0.48	3.03
	P	0.926	0.938	0.342	0.113	0.114	0.493	0.086
HR (beats/min)	hydromorphone	83.34 ± 3.34	82.19 ± 2.00	81.88 ± 2.02	78.00 ± 2.22	79.13 ± 2.11	78.53 ± 1.89	76.84 ± 2.03
	nalbuphine	76.54 ± 1.84	73.27 ± 1.78	75.70 ± 1.66	73.24 ± 1.48	71.54 ± 1.72	71.30 ± 1.55	73.84 ± 1.60
	F	0.41	1.13	0.00	0.78	0.002	0.01	1.21
	P	0.524	0.291	1.00	0.38	0.966	0.92	0.276
MAP (mmHg)	hydromorphone	91.25 ± 2.84	82.69 ± 2.59	75.19 ± 2.48	70.75 ± 2.15	72.50 ± 2.07	72.63 ± 2.05	73.78 ± 1.98
	nalbuphine	85.08 ± 1.91	75.30 ± 1.74	71.03 ± 1.81	69.97 ± 1.89	72.03 ± 1.82	72.62 ± 1.48	73.22 ± 1.56
	F	0.49	0.36	0.86	0.20	0.24	2.46	1.73
	P	0.487	0.549	0.356	0.660	0.626	0.121	0.193

T1, before induction; T2, 2 min after induction; T3, at admission; T4, after reaching the splenic flexure; T5, after reaching the hepatic flexure; T6, upon arrival at the ileocecal area; T7, during endoscopic withdrawal

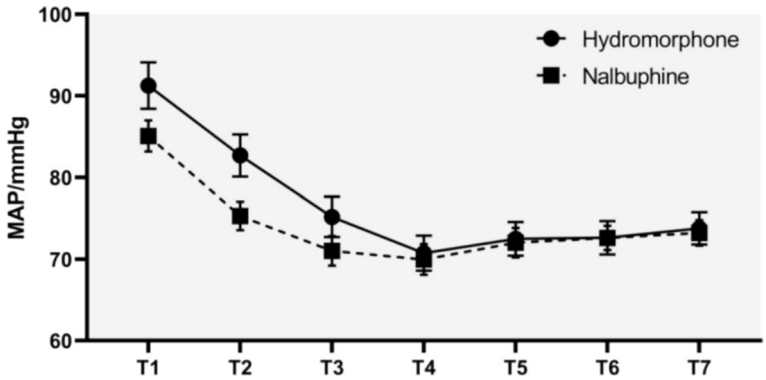

Fig. 2 The MAP change in two groups. ($p > 0.05$) (Note: T1, before induction; T2,2 min after induction; T3, at admission; T4, after reaching the splenic flexure; T5, after reaching the hepatic flexure; T6, upon arrival at the ileocecal area; T7, during endoscopic withdrawal.)

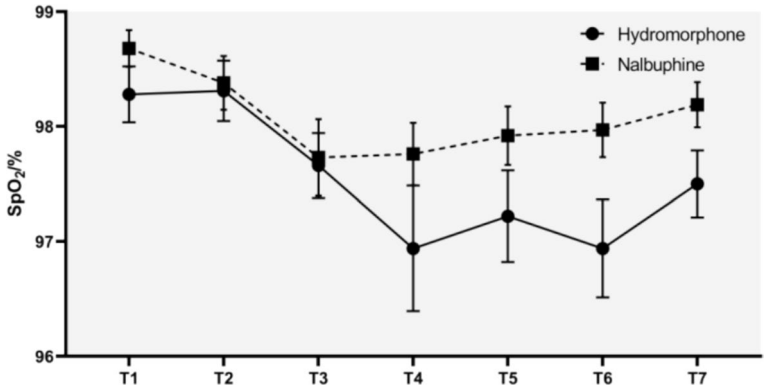

Fig. 3 the SpO_2 change in two groups. ($p > 0.05$) (Note: T1, before induction; T2,2 min after induction; T3, at admission; T4, after reaching the splenic flexure; T5, after reaching the hepatic flexure; T6, upon arrival at the ileocecal area; T7, during endoscopic withdrawal.)

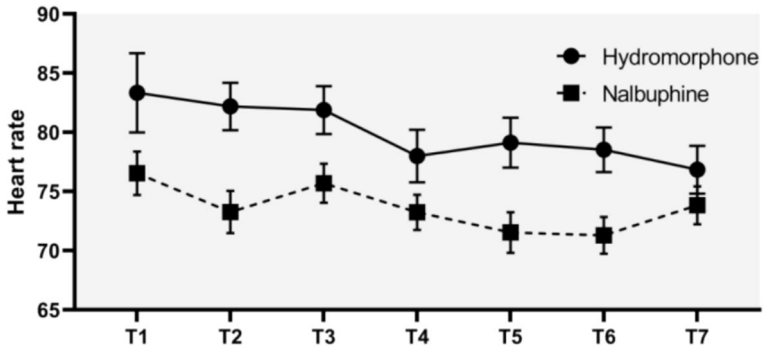

Fig. 4 The heart rate change in two groups. ($p > 0.05$) (Note: T1, before induction; T2,2 min after induction; T3, at admission; T4, after reaching the splenic flexure; T5, after reaching the hepatic flexure; T6, upon arrival at the ileocecal area; T7, during endoscopic withdrawal.)

Table 3 Summary of intraoperative vital sign changes

	Hydromorphone group ($n = 36$)	Nalbuphine group ($n = 36$)	P
Mild hypoxia	6	5	1
Normal SpO_2	31	30	
Hypotension	8	8	1
Normal MAP	28	28	
Bradycardia	0	1	–
Normal HR	36	35	

T1, before induction; T2, 2 min after induction; T3, at admission; T4, after reaching the splenic flexure; T5, after reaching the hepatic flexure; T6, upon arrival at the ileocecal area; T7, during endoscopic withdrawal

Table 4 Summary of adverse reactions in the two groups (20 min after examination)

	Hydromorphone group ($n = 36$)	Nalbuphine group ($n = 36$)	P
Dizziness	18	5	0.002
No dizziness	18	31	
Nausea	16	1	< 0.001
No nausea	20	35	
Abdominal pain	26	32	0.135
No abdominal pain	10	4	

T1, before induction; T2, 2 min after induction; T3, at admission; T4, after reaching the splenic flexure; T5, after reaching the hepatic flexure; T6, upon arrival at the ileocecal area; T7, during endoscopic withdrawal

Table 5 Summary of the degree of satisfaction between the two groups of patients

Satisfaction degree	Hydromorphone group($n = 36$)	Nalbuphine group($n = 36$)	P	Z
3, highly satisfied	11	34	< 0.01	– 5.387
2, moderately satisfied	16	1		
1, somewhat satisfied	6	1		
0, not satisfied	3	0		

visceral pain. This finding suggests that the current dose conversion for hydromorphone may need to be adjusted. Our results indicate that the analgesic potential of nalbuphine has likely been significantly underestimated in previous studies.

Given the high rates of adverse events observed, it is worth considering whether the study protocol should have been modified when these high rates became apparent. Although the study was designed to closely monitor adverse events and report them promptly, the initial protocol did not include a predefined threshold for modifying the dosing regimen based on interim results. In hindsight, a more flexible approach to dose adjustment, perhaps incorporating interim analyses to assess safety profiles, could have been considered. This would allow for real-time adjustments to minimize patient discomfort while maintaining the study's integrity.

The dosing of hydromorphone in our study was based on existing reference data and clinical guidelines, which suggested a dose of 0.016 mg/kg for effective procedural sedation. However, it is important to note that dosing recommendations for hydromorphone can vary significantly in clinical practice. For instance, some studies have used lower doses (e.g., 0.01 mg/kg) for similar procedures, with comparable efficacy but potentially fewer adverse events. The reason why we used this dose was that the dose was determined after converting the equivalent dose of nalbuphine, morphine and hydromorphone. The test results also showed that the hydromorphone group caused more adverse reactions after achieving the expected analgesic effect, which was exactly the reverse confirmation of 1. The safety range of nalbuphine is

wider, 2. The dose conversion of Nalbuphine may not be the 1:1 conversion ratio that we are familiar with.

Hemodynamic stability

A key finding of this study is that both nalbuphine and hydromorphone effectively maintain hemodynamic stability during colonoscopy. This suggests that both drugs can be safely used from a cardiovascular perspective, which is crucial for a broad range of patients undergoing colonoscopy, including those with underlying cardiovascular conditions.

Given the efficacy of nalbuphine and hydromorphone in maintaining intraoperative vital signs, the choice between these analgesics may be influenced by their postoperative side effect profiles. The findings from this study support the selection of nalbuphine over hydromorphone in colonoscopy procedures, particularly for patients who are more prone to or concerned about postoperative nausea and vomiting. This choice could lead to improved patient experiences and better overall outcomes.

The cost-effectiveness of nalbuphine was also considered. Although nalbuphine may have a slightly higher initial cost than hydromorphone, its lower incidence of postoperative complications could reduce overall healthcare costs by decreasing the need for extended recovery times and emergency interventions.

This preference may be related to the fact that nalbuphine is a mixed opioid agonist–antagonist, primarily acting on the κ– 2b receptor, which provides effective analgesia in smooth muscle organs. This action may better inhibit visceral pain while also exerting a specific sedative effect through κ receptors. Studies indicate that visceral analgesia mediated by κ receptor agonists is particularly effective in procedural settings like colonoscopy.

In conclusion, this randomized controlled trial comprehensively assessed the effects of nalbuphine and hydromorphone on hemodynamic parameters and postoperative side effects in colonoscopy patients. Both analgesics effectively maintain patient vital signs within acceptable ranges, and nalbuphine demonstrated a significant advantage in reducing the incidence of postoperative nausea, vomiting, dizziness, and headache compared to hydromorphone. While nalbuphine appears to offer several advantages over hydromorphone in terms of reducing postoperative side effects, further studies with larger sample sizes are necessary before making definitive recommendations for its widespread use in painless colonoscopy.

Future research should focus on optimizing dosing regimens for both nalbuphine and hydromorphone, exploring patient-specific factors that influence drug response, and investigating the mechanisms behind the observed differences in postoperative side effects to better inform clinical practice.

Limitations and future research

The conclusions of this study are based on its design, which specifically targeted a demographic of adults aged 18–65 years undergoing elective colonoscopy. As is typical with clinical research, the generalizability of these findings to other populations, procedural types, or settings should be viewed with caution. Future research could expand upon these results by including a broader range of patient demographics, investigating different types of endoscopic procedures, and examining the long-term effects of analgesic choices on patient recovery and satisfaction. Further studies are needed to explore the mechanisms behind the observed differences in postoperative side effects between nalbuphine and hydromorphone. Such investigations could provide deeper insights into opioid pharmacodynamics and help develop more tailored analgesic regimens for procedural medicine. The study included patients classified as ASA I and II to minimize confounding factors and isolate the effects of nalbuphine on abdominal pain management during colonoscopy. Future research will include patients with ASA III or higher to improve the generalizability of the findings.

Moreover, this study's dosing of hydromorphone, based on existing reference data, may present a limitation. The variability in dosing recommendations found in the literature suggests that the hydromorphone dosage used in this study might have been relatively high, which could help explain the increased incidence of adverse reactions observed. Consequently, future research should aim to determine the optimal hydromorphone dosage for painless colonoscopy, balancing efficacy and safety more effectively.

Future studies should aim to better optimize dosing for hydromorphone in painless colonoscopy. This could involve conducting dose-finding studies to determine the minimal effective dose that provides adequate analgesia while minimizing adverse effects. Additionally, exploring patient-specific factors, such as age, body mass index, and comorbidities, could help tailor dosing regimens more effectively. For example, elderly patients or those with a history of opioid sensitivity may benefit from lower doses. Furthermore, incorporating pharmacokinetic and pharmacodynamic modeling could provide more precise dosing recommendations, ensuring both efficacy and safety.

Conclusion

This randomized controlled trial comprehensively assessed the effects of nalbuphine and hydromorphone on hemodynamic parameters and postoperative side effects in colonoscopy patients. Both analgesics effectively maintain patient vital signs within acceptable ranges and nalbuphine demonstrated a significant advantage in reducing the incidence of postoperative nausea, vomiting, dizziness, and headache compared to hydromorphone. While nalbuphine appears to offer several advantages over hydromorphone in terms of reducing postoperative side effects, further studies with larger sample sizes are necessary before making definitive recommendations for its widespread use in painless colonoscopy.

Abbreviations

HM	Hydromorphone
ASA	American society of anesthesiologists
BMI	Body mass index
VAS	Visual analog scale
MAP	Mean arterial pressure
HR	Heart rate
SD	Standard difference
SpO_2	Peripheral oxygen saturation
RSS	Ramsay sedation score
PONV	Postoperative Nausea and Vomiting
PARS	Postanesthesia recovery score
PSAC	Patient Satisfaction with Anesthesia Care

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-025-03038-6.

Supplementary Material 1.

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Authors' contributions

ZSM analyzed and interpreted the patient data regarding the vital signs and PONV. HCL was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

This study is in line with the principles of the Declaration of Helsinki. The study received approval from the institutional the Institutional Review Board of Tianjin Jizhou District People's Hospital on October 23, 2023, with approval number IRB2023 - 18, and registered in the Chinese Clinical Trial Registry on November 9, 2023, with registration number ChiCTR2300077446.Written informed consent was obtained from all participants before their inclusion in the trial.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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