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Original Research Article

Comparative Study of Low-Flow Vs HFA in Laparoscopic GI Surgeries and Its Effect on Postoperative Pain

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Abstract

Background: Laparoscopic gastrointestinal (GI) surgeries, though minimally invasive, often lead to significant postoperative pain that can affect patient recovery and satisfaction. Anesthetic technique, particularly the gas flow rate used during general anesthesia, may influence pain outcomes. Low Flow Anesthesia (LFA) has been hypothesized to offer better intraoperative physiological stability, potentially reducing postoperative discomfort. However, limited data are available from Indian tertiary care centers, especially in Eastern India.

Method: This prospective observational study at Nalanda Medical College and Hospital in Patna included 100 elective laparoscopic gastroscopic patients from April 2024 to March 2025. Participants were in Group L (n=50) and Group H (n=50) for low-flow and high-flow anaesthesia. VAS was used to quantify patients' discomfort at 2, 6, 12, and 24-hours following surgery. It was important to document rescue analgesic use and operation data. SPSS v25 analysis used p-values below 0.05.

Results: Of the 100 participants, both LFA and HFA groups (n=50 each) had comparable baseline characteristics. VAS pain scores were significantly lower in the LFA group at 6 and 12 hours postoperatively (p = 0.01, p = 0.002). Fewer LFA patients required rescue analgesics (14 vs. 26; p = 0.03), and total paracetamol usage was lower (1.2 g vs. 1.8 g; p = 0.02). Intraoperative vitals and end-tidal CO_2 remained stable in both groups. LFA offered superior postoperative pain control.

Conclusion: LFA appears to be a superior technique in laparoscopic GI surgeries with respect to postoperative pain control and reduced analgesic requirement. Its cost-effectiveness and environmental benefits further enhance its clinical relevance. Larger, multi-center trials are recommended to validate these findings and support wider implementation in perioperative care protocols.

Keywords: Analgesia, Anesthesia, High-Flow, Laparoscopic, Low-Flow, Postoperative Pain, Surgery.

Introduction

Background: Role of Anesthesia in Laparoscopic GI Surgeries: Laparoscopic gastrointestinal (GI) operations have transformed surgery by offering less invasive alternatives to open abdominal and gastrointestinal surgery [1]. They have fewer complications, faster recovery, shorter hospital stays, as well as better cosmetic results than open operations.

Even though laparoscopy is minimally invasive, patients may experience visceral, shoulder tip, and incisional pain after surgery. Intraoperative haemodynamic stability, postoperative recovery, and pain management depend on the anaesthetic technique [2]. General anaesthesia is needed for laparoscopic gastrointestinal procedures to ensure appropriate sedation, analgesia, muscular relaxation, and ventilation during pneumoperito neum [3]. The type and rate of FGF (fresh gas flow) during anaesthesia delivery may affect postoperative outcomes like pain. FGF is the rate of oxygen and volatile anaesthetic supply to the patient during surgery [4]. Based on flow rate, anaesthesia is divided into HFA and LFA.

HFA typically involves FGFs of more than 2 L/min, commonly in the range of 4–6 L/min. It is favoured for its ability to rapidly adjust anesthetic depth and maintain a clear airway circuit with minimal rebreathing of expired gases [5]. On the other hand, LFA, often defined as FGF less than or equal to 1 L/min, has gained popularity due to its cost-effectiveness, environmental benefits (due to reduced volatile anesthetic use), and physiological benefits.

Understanding Low-Flow vs HFA: LFA involves rebreathing most exhaled gases (excluding carbon dioxide) after soda lime removes it from the anaesthesia circuit for control and resource efficiency [6]. It reduces inhalational agent use and ambient pollutants while protecting airway heat and humidity. Lower-flow anaesthesia warms and humidifies, which may help patients recover more comfortably and protect mucosa. Due to these benefits, postoperative discomfort may be minor.

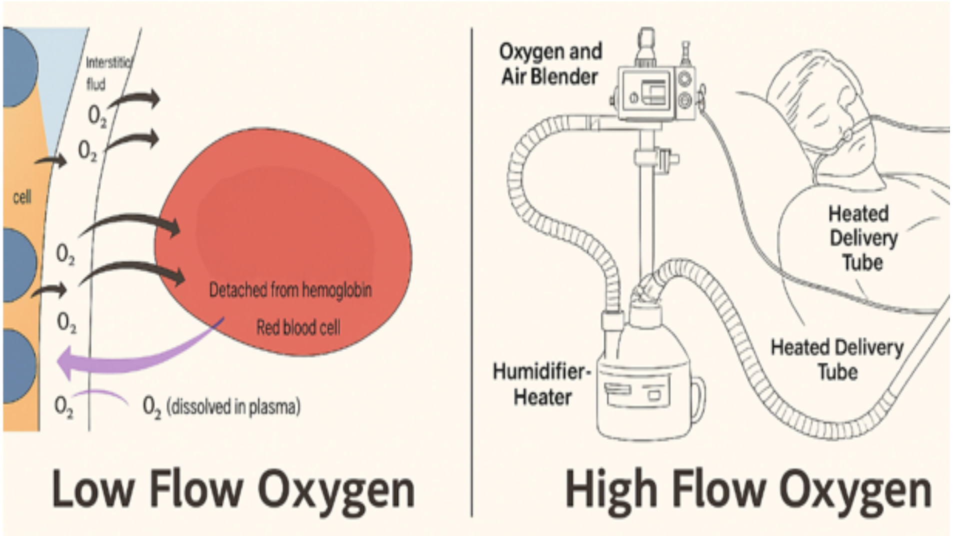

Figure 1: Difference between LFA vs HFA (Source: [7])

HFA flushes the circuit with large amounts of fresh gases to quickly regulate anaesthetic concentration and reduce rebreathing [8]. This approach provides quick and flexible adjustment of anaesthesia depth, but it may cause more heat and humidity to escape the airway, drying mucosal surfaces, causing a sore throat, or making recovery more painful. The increased usage of volatile anaesthetics raises procedure costs and environmental effect.

FGF rates' effects on patient outcomes like postoperative pain have not been well studied, especially in resource-constrained or high-volume healthcare systems like India's [9]. Even though both LFA and HFA are clinically known and used, their effects on postoperative recovery patterns need further study.

Postoperative Pain:

A Critical Outcome in Laparoscopic Surgeries: Pain is a major issue after laparoscopic gastrointestinal surgery in the first few days [10]. These operations can cause postoperative pain due to organ manipulation, carbon dioxide insufflation (which irritates the peritoneum and diaphragm), and port site sores. Effective pain treatment improves patient satisfaction, allows early ambulation, reduces postoperative complications including deep vein thrombosis and atelectasis, and shortens hospital stays [11].

Despite the availability of minimally invasive treatments and multimodal analgesia for postoperative pain management, few research has examined how anaesthetic flow rate affects pain perception and analgesic use. This study examines how FGF rate affects postoperative pain in elective laparoscopic gastrointestinal surgeries to fill that knowledge gap.

International studies that have compared LFA and HFA lack data from Indian tertiary medical facilities like NMCH, Patna. Public hospitals in India have a different patient demography, healthcare system, and anaesthetic technique than Western hospitals. Public hospital patients are mostly low-income; thus, they rarely have access to advanced postoperative pain management. In many instances, optimising intraoperative anaesthesia methods can improve postoperative results without increasing complexity or cost.

Moreover, Indian anesthesia guidelines are increasingly recognizing the need for resource-conscious techniques, especially in view of cost, availability of volatile agents, and environmental impact. In this context, LFA offers a promising approach that could improve not just economic efficiency but also clinical outcomes such as pain control, provided it is proven to be safe and effective. Despite its theoretical advantages, low-flow techniques remain underutilized in many parts of India due to lack of familiarity, training, or robust clinical data from within the Indian healthcare ecosystem. Hence, a focused study comparing LFA and HFA in laparoscopic GI surgeries at a tertiary care teaching hospital like NMCH can provide meaningful, real-world evidence to inform anesthesia practice across similar institutions in India.

Objectives

1. To assess and compare the intensity of postoperative pain at 2, 6, 12, and 24 hours post-surgery using the VAS.
2. To analyse the need for rescue analgesia in both groups.
3. To observe any significant intraoperative or early postoperative complications related to the type of anesthetic flow.

Materials and Methods

Study Design and study Duration: This prospective comparative observational study was undertaken at the Department of Anaesthesiology and Surgery at NMCH, Patna, and Bihar, a tertiary care teaching hospital serving a large urban and rural population. The research was carried out over a 12-month period, from April 2024 to March 2025.

Sample Size and Group Allocation: The study included 100 adults receiving elective laparoscopic GI procedures under general anaesthesia. Participants were split into two equal groups:

- Group L (LFA): 50 patients received LFA with a FGF rate of less than 1 L/min.
- Group H (HFA): 50 patients received HFA with a flow rate of 3–6 L/min.

Inclusion Criteria

- Aged between 18–60 years.
- Classified as American Society of Anesthesiologists (ASA) Physical Status I or II.
- Undergoing elective laparoscopic GI surgeries (e.g., laparoscopic cholecystectomy, appendectomy, diagnostic laparoscopy).

Exclusion Criteria

- Emergency surgical indications.
- History of chronic pain syndromes or long-term analgesic/opioid use.
- Known psychiatric illness or opioid addiction.
- ASA physical status III or higher.
- Intraoperative conversion to open surgery.

Randomization Method: Participants were assigned to either group using simple random sampling with sealed envelope technique. An anaesthesiologist not involved in intraoperative care or data collection allocated preoperatively to hide allocation.

Anesthesia Protocol: All patients underwent standard preoperative assessment and fasting protocols. Routine monitoring in the operation room included ECG, non-invasive blood pressure, SpO_2, end-tidal CO_2, and temperature.

- Premedication: Midazolam 0.02 mg/kg IV and Fentanyl 2 µg/kg IV.
- Induction: Propofol 2–2.5 mg/kg IV and Atracurium 0.5 mg/kg IV for muscle relaxation.
- Maintenance: Sevoflurane (1–2%) in O_2/N_2O mixture; Isoflurane used in select cases based on availability.
    - Group L: LFA (<1 L/min) after an initial wash-in at 4 L/min for 10 minutes.
    - Group H: HFA (3–6 L/min) maintained throughout the procedure.
- Reversal: Neostigmine 0.05 mg/kg and Glycopyrrolate 0.01 mg/kg IV.

Continuous monitoring of intraoperative parameters was carried out, including mean arterial pressure, heart rate, end-tidal CO_2, and oxygen saturation.

Pain Assessment Protocol: Postoperative pain was assessed using the VAS at predefined intervals:

- 6 hours, 2 hours, 12 hours, and 24 hours after surgery.
- The VAS scale ranged from 0 (no pain) to 10 (worst imaginable pain). All assessments were carried out by trained nursing staff blinded to the anesthesia group.

Rescue analgesia (IV Paracetamol 1g) was provided if VAS ≥ 4. The number and timing of rescue doses were recorded.

Ethical Considerations: The NMCH, Patna Institutional Ethics Committee (IEC) gave their stamp of approval to the study's protocol before it ever began. Each participant was given a thorough description of the study's objectives, procedures, and scope before their written informed consent was obtained.

Statistical Analysis: Data obtained during the study were compiled and processed using SPSS software. Continuous variables, such as VAS scores, were reported as mean ± standard deviation and observed using the Student's t-test.

The Chi-square test was used to analyse categorical data, such as gender and the necessity of rescue analgesia, which were shown as percentages. A p-value less than 0.05 was deemed statistically significant.

Results

Demographic Profile: The research involved a hundred patients; fifty were assigned to the LFG (Group L) and fifty to the HFG (Group H) groups. Regarding demographic variables including gender, age distribution, and ASA physical status, there were no statistically significant differences between the two groups.

Table 1: Patients' Demographic Profile

Parameter	Group L (n=50)	Group H (n=50)	p-value
Age (years, mean ± SD)	38.4 ± 10.2	37.8 ± 11.1	0.72
Sex (M/F)	28/22	27/23	0.84
ASA I/II	30/20	32/18	0.66

Age, sex, and ASA grade were not significantly different between the two sets of data ($p > 0.05$).

Baseline Characteristics: BMI, type of GI procedure, and duration of surgery were documented for all patients. The distribution was again comparable between groups.

Table 2: Baseline Characteristics and Surgical Profile

Parameter	Group L (n=50)	Group H (n=50)	p-value
BMI (kg/m², mean ± SD)	24.6 ± 3.1	24.9 ± 3.4	0.64
Type of Procedure			
Laparoscopic Cholecystectomy	34	36	0.68
Appendectomy	10	8	
Diagnostic Laparoscopy	6	6	
Duration of Surgery (min)	85.3 ± 15.4	86.7 ± 14.8	0.58

Pain Score Comparison (VAS Scores): Pain was measured using the VAS at 2, 6, 12, and 24 hours postoperatively. The LFG consistently reported lower VAS scores at all intervals, with statistically significant differences observed at 6 and 12 hours.

Table 3: Mean VAS Scores at Different Time Points

Time Post-op	Group L (mean ± SD)	Group H (mean ± SD)	p-value
2 hours	3.6 ± 1.1	4.0 ± 1.2	0.07
6 hours	3.2 ± 1.0	4.1 ± 1.3	0.01
12 hours	2.8 ± 1.1	3.7 ± 1.2	0.002
24 hours	1.9 ± 0.9	2.2 ± 1.0	0.12

Rescue Analgesic Requirement: The requirement for rescue analgesia (IV Paracetamol) was significantly lower in Group L. Not only did fewer patients require additional analgesics, but the total dosage over 24 hours was also reduced.

Table 4: Rescue Analgesic Usage

Parameter	Group L	Group H	p-value
Patients requiring rescue analgesia (n)	14	26	0.03
Mean number of doses per patient	1.1 ± 0.3	1.6 ± 0.4	0.01
Total paracetamol dose (g/24h)	1.2 ± 0.4	1.8 ± 0.6	0.02

Intraoperative Parameters: Intraoperative monitoring revealed no significant differences in hemodynamic parameters or end-tidal CO_2 levels between the two groups. Hemodynamic stability was maintained in both groups. End-tidal CO_2 was within the normal range throughout surgeries, with no group-specific deviations.

Discussion

This research was designed to compare the effects of HFA and LFA techniques on postoperative pain in patients undergoing laparoscopic GI surgeries. The outcomes of the study clearly indicate that patients in the LFA group (Group L) experienced lower postoperative pain levels compared to those in the HFG (Group H), particularly at the 6 and 12-hour postoperative time points. This difference was statistically significant and was further corroborated by the reduced need for rescue analgesia in Group L.

While the early postoperative pain scores (at 2 hours) and later scores (at 24 hours) did not show significant differences, the intermediate time points which are often the most uncomfortable for patients reflected a noticeable benefit in the LFG. Additionally, the frequency and total dosage of rescue analgesics were significantly lower in Group L, suggesting not only reduced pain but also greater comfort and potentially faster recovery.

These findings align with the hypothesis that LFA, by maintaining a more stable internal environment during surgery, could lead to decreased tissue irritation, improved mucosal hydration, and thus lower pain perception postoperatively.

Physiological Rationale: LFA reduces postoperative pain due to several physiological processes. The humidity and temperature of the inhaled gas mixture are maintained via low-flow systems, which use new gas at less than 1 L/min. HFA employs 3–6 L/min and allows the patient to breathe colder, drier gases. These differences may seem insignificant, but they can dry up the mucosa, increase evaporative losses, and potentially cause an inflammatory response that increases nociception during surgery.

LFA reduces the effects of oxygen and carbon dioxide level oscillations on pain sensitivity and stress response due to better alveolar gas exchange and more stable haemodynamic parameters. LFA dampens neurohumoral fluctuations to reduce central and peripheral pain pathway activation. Low-flow systems employ less volatile anaesthetics, reducing environmental exposure and possibly metabolite building, which can promote postoperative nerve end sensitisation. The more physiologically harmonious environment created by these processes may explain the lower VAS scores and analgesic demands in this study.

Comparison with Previous Studies: This study confirms previous international and Indian studies on LFA's clinical effects. A randomized controlled trial by [12] in Germany reported that LFA was associated with better postoperative recovery profiles, including lower pain scores and reduced opioid use.

Similarly, an Indian study by [13], conducted at a tertiary care center in Delhi, found that patients receiving LFA during laparoscopic cholecystectomy required significantly less postoperative analgesia than those in the HFG.

A few studies such as the one conducted by [14,15] in South Korea reported no significant difference in postoperative pain between the two groups. However, those studies often included patients undergoing non-abdominal surgeries or used inconsistent pain assessment intervals, which might have influenced their findings.

The present study used a homogeneous population for laparoscopic GI procedures, a standardised anaesthesia technique, and VAS measurements at regular intervals to improve internal validity.

Limitations

While the findings of this study are promising, several limitations must be acknowledged. A larger, multi-centric study might provide more robust data and help generalize the findings across different surgical specialties and patient populations. Another limitation lies in the relatively short follow-up period. Pain was assessed only up to 24 hours postoperatively. Long-term effects such as the development of chronic post-surgical pain, return to daily activities, or satisfaction scores were not evaluated. Furthermore, patient-reported outcomes like nausea, vomiting, or general well-being were not included, which could have added depth to the recovery profile analysis.

Conclusion

The present study concludes that LFA is associated with significantly lower postoperative pain levels and reduced need for rescue analgesia compared to HFA in patients undergoing laparoscopic gastrointestinal surgeries. These data imply that low-flow approaches may improve postoperative patient comfort and recovery. The physiological benefits of LFA, such as greater humidity and temperature preservation, may reduce nociceptive stimulation during surgery. Given its cost-effectiveness and environmental advantages, LFA presents a clinically valuable alternative for elective laparoscopic procedures, especially in resource-constrained settings like tertiary care hospitals. To establish stronger evidence and broader applicability, larger multi-center randomized controlled trials are recommended. Such studies should explore not only pain outcomes but also long-term recovery parameters, patient satisfaction, and perioperative complications to comprehensively evaluate the clinical utility of LFA in routine surgical practice.

Reference

1. E. Gin, D. Lowen, M. Tacey, and R. Hodgson, “Reduced laparoscopic intra-abdominal pressure during laparoscopic cholecystectomy and its effect on post-operative pain: a double-blinded randomised control trial,” J. Gastrointest. Surg., vol. 25, no. 11, pp. 2806–2813, 2021.
2. E. Ünal et al., “The effect of low-flow versus HFA on postoperative cognitive functions in geriatric patients undergoing TUR-P surgery,” Turk Geriatri Dergisi, vol. 27, no. 1, 2024.
3. M. Öterkuş et al., “The effect of low flow anesthesia on hemodynamic and peripheral oxygenation parameters in obesity surgery,” Saudi Med. J., vol. 42, no. 3, pp. 264, 2021.
4. A. Badughaish et al., “The impact of FGF sevoflurane anesthesia on perioperative hypothermia in adult patients undergoing elective open or laparoscopic digestive surgery: A prospective randomized controlled trial,” Open J. Anesthesiol., vol. 12, no. 1, pp. 34–48, 2021.
5. R. Venkatraman, T. G. Chitrambalam, and A. Preethi, “Comparison of different carbon dioxide insufflation rates on hemodynamic changes in laparoscopic surgeries: A randomized controlled trial,” Cureus, vol. 15, no. 1, 2023.
6. Z. Alrasheed and A. Al-Dabbagh, “The effect of carbon dioxide volume insufflation on postoperative pain in elective laparoscopic cholecystectomy: An observational study,” Pak. J. Med. Health Sci., vol. 14, no. 3, pp. 1530–1535, 2020.

7. A. Agarwal, S. Sant, A. Panwar, and S. Singh, "Post-operative lung functions after low-flow versus HFA: A randomized, double blind comparative study," Int. J. Acad. Med. Pharm., vol. 5, no. 4, pp. 674–680, 2023.
8. A. Mermer and B. Kozanhan, "Comparison of the effects of low-flow and normal-flow anesthesia on intracranial pressure, cerebral oxygenation and bispectral index in laparoscopic cholecystectomy operation," Eur. Rev. Med. Pharmacol. Sci., vol. 27, no. 18, 2023.
9. T. B. Tanrıverdi et al., "Comparison of the effects of low-flow and normal-flow desflurane anaesthesia on inflammatory parameters in patients undergoing laparoscopic cholecystectomy," Turk. J. Anaesthesiol. Reanimat., vol. 49, no. 1, pp. 18–24, 2020.
10. A. Onur et al., "The effect of minimal and high flow anesthesia on optic nerve sheath diameter in laparotomic gynecological surgery," J. Surg. Med., vol. 7, no. 4, pp. 276–279, 2023.
11. S. Kutlusoy, E. Koca, and A. Aydın, "Reliability of LFA procedures in patients undergoing laparoscopic cholecystectomy: Their effects on our costs and ecological balance," Niger. J. Clin. Pract., vol. 25, no. 11, pp. 1911–1917, 2022.
12. H. T. Söner et al., "Comparison of the effects of low flow desflurane and high flow desflurane on oxidative stress and DNA damage in anesthesia applications," Acad. J. Health Sci. Med. Balear., vol. 39, no. 1, pp. 96–102, 2024.
13. T. K. Prasad, N. Gnanasekar, K. S. Priyadharsini, and R. S. Chacko, "Randomized double-blind trial comparing effects of low-flow vs HFA on postoperative lung functions using respirometer," J. Anaesthesiol. Clin. Pharmacol., vol. 36, no. 4, pp. 535–540, 2020.
14. K. N. Banavathu and F. Ghazala, "Low flow anesthesia while using desflurane vs isoflurane: A prospective randomized clinical comparison study," [unpublished/incomplete citation].
15. B. K. Uğur, "Comparison of ventricular repolarization parameters including Tp-e, Tp-e/QTc, JTc and JTd during low-flow and high-flow desflurane anesthesia in gynecologic laparoscopic surgery," Dicle Med. J., vol. 47, no. 4, pp. 836–845, 2020.