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Original Article

Comparison of Conventional and Opioid Free Anesthesia in Laparoscopic Surgeries

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ABSTRACT

Background: Opioids have long been a cornerstone of perioperative analgesia, but their use is associated with significant side effects, including respiratory depression, nausea, vomiting, delayed recovery, and potential for dependency. This study aimed to compare the efficacy, safety, and recovery outcomes of opioid-based analgesia (OA) versus opioid-free analgesia (OFA) in laparoscopic surgeries.
Methods: In this prospective comparative study, 80 patients undergoing elective laparoscopic nephrectomy under general anesthesia, were randomized into two equal groups: Group OA (n=40) received standard opioid-based analgesia, while Group OFA (n=40) received opioid-free multimodal analgesia. Intraoperative parameters (mean arterial pressure, heart rate, oxygen saturation, fluid administration), sedation scores, postoperative pain scores (VAS), total tramadol consumption, rescue analgesic doses, and incidence of side effects were assessed.
Results: Intraoperative hemodynamic parameters were comparable in both the groups. Group OFA showed significantly lower sedation scores at the Post Anesthesia Care Unit (PACU) (2.0 ± 0.4 vs. 2.5 ± 0.5; p=0.01). Postoperative pain scores were consistently lower in Group OFA at all time intervals up to 48 hours ($p<0.001$). Total tramadol consumption was significantly reduced in the OFA group (150 ± 50 mg vs. 300 ± 50 mg; $p<0.004$), with fewer rescue analgesia doses required (1.5 ± 0.5 vs. 3 ± 0.5; $p<0.0001$). The incidence of nausea and vomiting was significantly lower in the OFA group (7.5% vs. 25%; p=0.02).
Conclusion: Opioid-free analgesia offers superior postoperative outcomes with reduced sedation, lower pain scores, decreased opioid requirement, and fewer side effects compared to traditional opioid-based protocols. These findings support the incorporation of OFA as a viable and effective strategy for perioperative pain management, enhancing recovery and patient safety.

Keywords*: Opioid-Free Analgesia (OFA), Opioid-Based Analgesia (OA), Postoperative Pain, Tramadol Consumption.*

INTRODUCTION

Laparoscopic surgeries have gained widespread popularity in modern surgical practice owing to their advantages, such as smaller incisions, reduced blood loss, decreased postoperative pain, shorter hospital stays, and faster return to daily activities. However, optimal intraoperative and postoperative pain management continues to remain critical for patient recovery and satisfaction [1]. Traditionally, opioids have played a central role in anesthesia protocols for managing intraoperative hemodynamic responses and postoperative pain. Their use, however, is accompanied by several well-known adverse effects such as nausea, vomiting, sedation, respiratory depression, pruritus, urinary retention, ileus, opioid-induced hyperalgesia, and the potential for tolerance and dependence [2–4].

Driven by the global opioid crisis and the Enhanced Recovery After Surgery (ERAS) protocols there is increasing interest in opioid sparing approaches.[5]. Opioid-Free Anesthesia (OFA) has emerged as a promising strategy that utilizes a combination of non-opioid agents including α2-adrenergic agonists (e.g., dexmedetomidine), local anesthetics, NSAIDs, magnesium sulfate, and regional nerve blocks to achieve satisfactory analgesia and hemodynamic stability without the opioid related drawbacks [6,7].

Among the non-opioid agents used, dexmedetomidine plays a pivotal role. It is a selective α2-adrenoceptor agonist with sedative, analgesic, anxiolytic, and sympatholytic properties, which provides stable hemodynamics and minimal respiratory depression—making it suitable for use in OFA regimens [8]. Additionally, dexmedetomidine has shown opioid-sparing effects and contributes to better quality of recovery scores and reduced postoperative nausea and vomiting (PONV) [9,10].

Furthermore, the integration of regional anesthesia techniques, such as the Quadratus Lumborum Block (QLB), adds another layer of benefit by targeting both somatic and visceral pain pathways. QLB, by blocking the thoracolumbar nerves and facilitating the spread of local anesthetic to the paravertebral and thoracic sympathetic chains, has demonstrated effectiveness in providing long-lasting postoperative analgesia for abdominal and retroperitoneal surgeries [11,12]. This may lead to reduced need for rescue analgesics, earlier mobilization, and improved patient satisfaction.

In contrast, opioid-based anesthesia (OA)—while effective—carries a higher burden of opioid-related side effects that can impede early postoperative recovery, increase hospital stay, and diminish patient comfort. Several recent clinical trials and meta-analyses have supported the safety, feasibility, and efficacy of OFA in various surgical settings including bariatric, gynecologic, urologic, and laparoscopic procedures [13,14]. However, despite these promising outcomes, the widespread adoption of OFA protocols is still limited due to variability in institutional practices, lack of standardized protocols, and concerns regarding the adequacy of analgesia.

In this context, our study was designed to compare the efficacy and safety of conventional opioid-based anesthesia and opioid-free anesthesia in patients undergoing laparoscopic nephrectomy. The primary objectives were to assess differences in intraoperative hemodynamic stability (mean arterial pressure, heart rate). The secondary objectives were to assess postoperative parameters such as pain scores, sedation levels, need for rescue analgesia, and side effects like PONV. By evaluating these parameters, this study aims to contribute to the growing body of evidence supporting OFA as a viable and effective alternative to conventional opioid-based anesthesia, especially in surgeries with significant visceral pain components such as laparoscopic nephrectomy.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, single-blind study was conducted on adult patients undergoing retroperitoneal laparoscopic nephrectomy under general anesthesia at a tertiary care center. The study included 80 patients of either sex with an American Society of Anesthesiologists (ASA) physical status classification of I or II. Institutional Ethical Committee approval was obtained before the commencement of the study (Ref: Guts/4th EC/Approved/54/2022). Written informed consent was obtained from all participants.

Inclusion Criteria

- Patients aged between 18 and 65 years
- ASA physical status I and II

Exclusion Criteria

- Known allergy to local anesthetic agents (amide group)
- History of drug addiction
- Obesity (BMI > 30 kg/m²)
- Local site infection
- History of chronic pain (>6 months)
- Anatomical abnormalities
- Congenital coagulopathy
- Psychiatric illness

Patient Allocation

Following preoperative assessment, the enrolled 80 patients were randomly assigned into two equal groups (n=40 each):

- Group OA (Opioid Anesthesia)
- Group OFA (Opioid-Free Anesthesia)

Randomization was performed using a computer-generated randomization table.
*The study was conducted at IKDRC-ITS Civil Hospital, Ahmedabad.

Preoperative Preparation
All patients were fasted overnight and received standard premedication, including:

- Inj. Ondansetron 0.15 mg/kg IV
- Inj. Glycopyrrolate 0.004 mg/kg IV

Standard monitoring equipment, including ECG, non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and Bi-spectral Index (BIS) was applied upon arrival in the operating room. Intravenous access was secured, and baseline parameters (heart rate, NIBP, SpO_2, temperature, and urine output) were recorded.

Anesthetic Management
All patients were preoxygenated with 100% oxygen. Induction of anesthesia was performed using:

- Inj. Thiopental sodium 7 mg/kg IV
- Inj. Atracurium besylate 0.5 mg/kg IV bolus, followed by maintenance infusion at 0.1 mg/kg

Group OA (Opioid Anesthesia)

- Inj. Fentanyl 2 µg/kg IV as a bolus pre-induction
- Continuous infusion of fentanyl at 0.2–0.5 µg/kg/hr was maintained intraoperatively

Group OFA (Opioid-Free Anesthesia)

- Inj. Dexmedetomidine 1 µg/kg loading dose over 10 minutes
- Continuous infusion of dexmedetomidine at 0.2–0.7 µg/kg/hr intraoperatively
- Ultrasound-guided posterior Quadratus Lumborum Block (QLB) was administered using a high-frequency linear probe positioned over the triangle of Petit. After identifying the "thumb sign/human eye sign/baby sign", 20 mL of 0.25% levobupivacaine was injected between the quadratus lumborum muscle and thoracolumbar fascia to achieve a sensory blockade from T6 to L2 dermatomes.

Maintenance of Anesthesia
In both groups, anesthesia was maintained using a mixture of oxygen, air, and sevoflurane (≤1 MAC). Infusions of fentanyl or dexmedetomidine were titrated to maintain BIS values between 40–60. Infusions were stopped immediately after deflation of the pneumoperitoneum.

Extubation
Neuromuscular blockade was reversed using:

- Inj. Neostigmine 0.05 mg/kg IV
- Inj. Glycopyrrolate 0.01 mg/kg IV

Patients were extubated and transferred to the post-anesthesia care unit (PACU).

Intraoperative Monitoring

- Hemodynamic parameters (heart rate, blood pressure, SpO_2) were recorded at baseline, post-intubation, incision, pneumoperitoneum creation, change of position, and pre/post-extubation.
- BIS was continuously monitored to guide anesthetic depth.
- Total sevoflurane consumption was recorded.

Sedation level was assessed post-extubation using the Modified Ramsay Sedation Score.

Postoperative Monitoring

1. Pain Assessment:
   Visual Analog Scale (VAS) was used to assess postoperative pain at regular intervals. If VAS ≥ 4, rescue analgesia was administered.
2. Rescue Analgesia:
   - Inj. Tramadol 1 mg/kg IV bolus followed by infusion 1 mg/kg over 30 minutes not exceeding the maximum dose of 400 mg in 24 hours.
   - Inj. Ondansetron 0.15 mg/kg IV was administered before tramadol
3. Outcome Measures:
   - Number of tramadol rescue doses in 24 hours
   - Total dose of tramadol administered within 24 hours

- Incidence of opioid-related side effects (nausea, vomiting, pruritus, respiratory depression) was documented

4. Statistical Analysis:
   - The data was collected with predesigned proforma and entered in Microsoft Excel 2010.
   - The data was analyzed with Epi info version 7.1.4.0. Comparisons of continuous data between two groups were analyzed within dependent T-test. Comparisons of categorical data were analyzed with Chi-square P-value less than .05 was considered significant.

RESULTS AND OBSERVATIONS:

Table 1: Demographic and Baseline Characteristics of the Study Groups

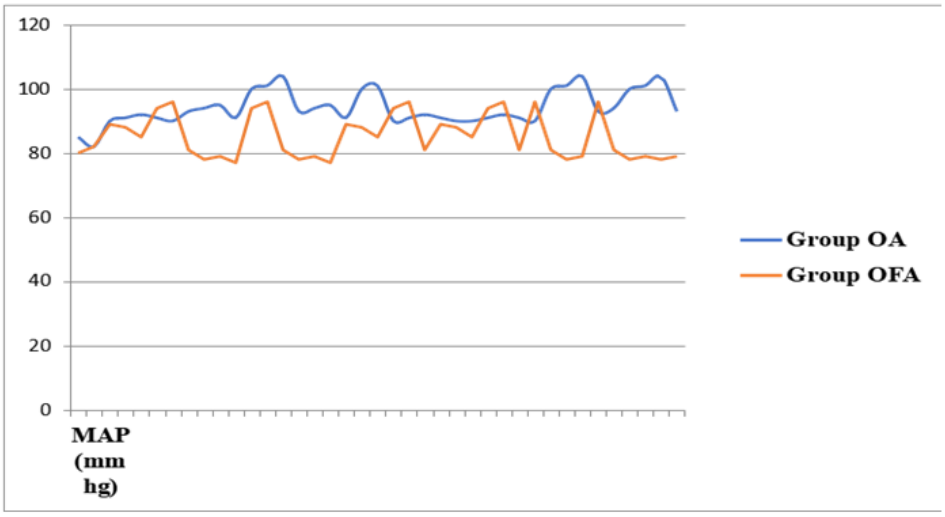
Characteristic	Group OA (Opioid) (n = 40)	Group OFA (Opioid-Free) (n = 40)	p-value
Age (years)	51.8 ± 12.0	50.5 ± 11.5	0.56
Gender (M/F)	22 / 18	23 / 17	0.82
BMI (kg/m²)	27.3 ± 3.5	27.7 ± 3.1	0.69
ASA Classification (I / II)	16 / 24	18 / 22	0.74
Smoking Status (Current/Former/Never)	12 / 10 / 18	11 / 9 / 20	0.84
Hypertension (Yes / No)	20 / 20	22 / 18	0.68
Diabetes Mellitus (Yes / No)	10 / 30	9 / 31	0.81
Duration of Disease (years)	5.3 ± 2.1	5.0 ± 2.2	0.61
Previous Surgeries (Yes / No)	15 / 25	14 / 26	0.82
Education Level (High School / College / Graduate)	18 / 12 / 10	19 / 11 / 10	0.92
Employment Status (Employed / Unemployed / Retired)	20 / 10 / 10	21 / 9 / 10	0.88

Table 2: Intraoperative Data of Study Groups

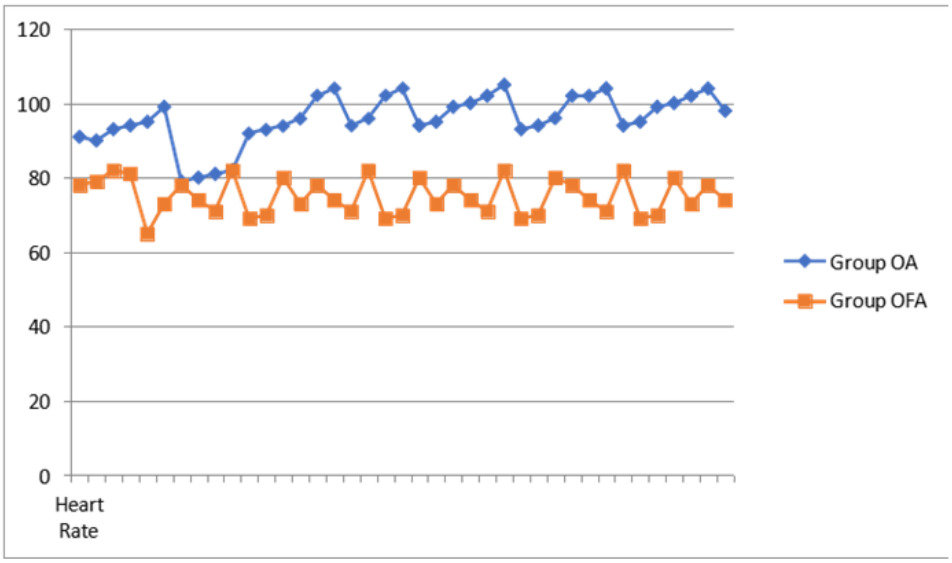
Parameter	Group OA (n = 40)	Group OFA (n = 40)	p-value
Duration of Surgery (minutes)	120.5 ± 25.3	118.7 ± 24.8	0.81
Total Intraoperative Fentanyl (µg)	200 ± 50	0	<0.001
Total Intraoperative Dexmedetomidine (µg)	0	100 ± 20	<0.001
Hemodynamic Instability (Hypo/Hypertensive Episodes)	3 / 5	2 / 4	0.79
Intraoperative Blood Loss (ml)	150 ± 30	140 ± 35	0.45
Crystalloid Fluid Administered (ml)	1500 ± 300	1400 ± 250	0.32
Colloid Fluid Administered (ml)	500 ± 100	450 ± 90	0.28

Table 3: Detailed Intraoperative Metrics

Metric	Group OA (n = 40)	Group OFA (n = 40)	p-value
Mean Arterial Pressure (MAP) (mmHg)	95 ± 12	87 ± 10	0.41
Heart Rate (beats/min)	98 ± 10	72 ± 9	0.29
Oxygen Saturation (SpO_2, %)	98 ± 1	98 ± 1	0.85
Total Fluid Administration (mL)	1200 ± 300	1150 ± 250	0.48



Graph 1



Graph 2

Graphs 1 and 2 show a decrease in MAP and heart rate in Group OFA compared to Group OA, which was not statistically significant. But variations in hemodynamic parameters during pneumoperitoneum were similar in both groups

Table 4: Sedation Score at Post-Anesthesia Care Unit (PACU)

Parameter	Group OA (n = 40)	Group OFA (n = 40)	p-value
Sedation Score (at PACU)	2.5 ± 0.5	2.0 ± 0.4	0.01

Table 5: Postoperative Pain Scores (VAS) Over Time

Time Point	Group OA (n = 40)	Group OFA (n = 40)	p-value
PACU Admission	4.5 ± 1.2	2.3 ± 0.8	<0.001
2 hours	3.8 ± 1.1	2.1 ± 0.7	<0.001
6 hours	3.2 ± 0.9	1.8 ± 0.6	<0.001
12 hours	2.9 ± 0.8	1.5 ± 0.5	<0.001
24 hours	2.5 ± 0.8	1.2 ± 0.4	<0.001
48 hours	2.0 ± 0.7	1.0 ± 0.3	<0.001

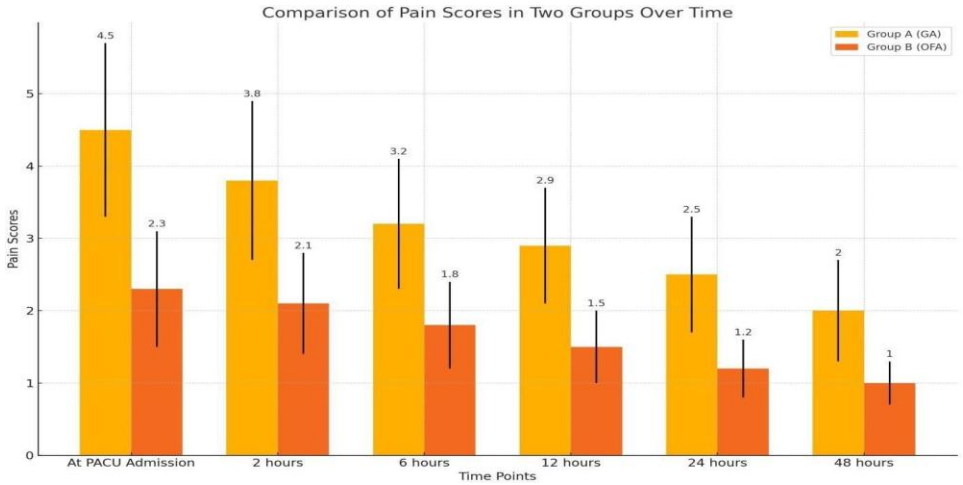


Table 6: Postoperative Rescue Tramadol Consumption

Parameter	Group OA (n = 40)	Group OFA (n = 40)	p-value
Total Tramadol Consumption (mg)	300 ± 50	150 ± 50	<0.004
Number of Rescue Analgesia Doses	3.0 ± 0.5	1.5 ± 0.5	<0.0001

Table 7: Postoperative Side Effects

Side Effect	Group OA (n = 40)	Group OFA (n = 40)	p-value
Nausea and Vomiting (n, %)	10 (25%)	3 (7.5%)	0.02

Total intraoperative sevoflurane consumption was recorded in both groups; however, it was not statistically significant.

DISCUSSION

This study provides a comprehensive comparison between opioid-based analgesia (OA) and opioid-free analgesia (OFA) in patients undergoing surgery, focusing on intraoperative hemodynamics, sedation, postoperative pain, analgesic requirements, and side effects. The results indicate a favorable profile for OFA, reinforcing the growing evidence supporting opioid-free protocols in modern anesthetic practice.

Hemodynamic Parameters

Our study demonstrated no statistically significant differences in intraoperative mean arterial pressure (MAP), heart rate, or oxygen saturation between the two groups. These findings are consistent with previous research, which found that OFA using agents such as dexmedetomidine, ketamine, and lidocaine maintains stable hemodynamics comparable to opioid-based anesthesia [1,2]. Although heart rate was lower in the OFA group, this did not reach statistical significance, likely due to the sympatholytic effects of dexmedetomidine [3].

Sedation and Recovery

The significantly lower sedation scores observed in the OFA group suggest a more rapid and clearer recovery phase. This result aligns with the pharmacodynamic profile of opioids, which are known to prolong sedation in the immediate postoperative period [4]. The use of dexmedetomidine in OFA protocols promotes cooperative sedation without significant respiratory depression or prolonged drowsiness, thereby improving early recovery [5].

Postoperative Pain and Tramadol Requirement

Postoperative VAS pain scores were consistently lower at all time points in the OFA group. These results are in agreement with multiple studies that highlight the multimodal analgesic effect of non-opioid agents such as ketamine and lidocaine in controlling postoperative pain [6,7]. OFA has been shown to reduce central sensitization, leading to improved pain control and reduced opioid consumption postoperatively [8].

The lower total tramadol consumption and fewer rescue analgesia doses in the OFA group provide further evidence of its superior analgesic efficacy. Our findings are consistent with studies by Beloeil et al. and Bakan et al., both of which observed reduced opioid use and improved pain control in OFA groups [9,10].

Postoperative Side Effects

A significant reduction in nausea and vomiting was noted in the OFA group, a finding in line with previous literature. Opioids are well-established emetogenic agents due to their action on the chemoreceptor trigger zone and gastrointestinal motility [11]. Reducing opioid exposure leads to a lower incidence of postoperative nausea and vomiting

(PONV), improving patient satisfaction and recovery outcomes [12].

Implications

The results of this study suggest that OFA is a safe and effective alternative to traditional opioid-based analgesia. Its benefits include better postoperative pain control, reduced need for rescue analgesics, fewer side effects, and improved early recovery. This aligns with the goals of Enhanced Recovery After Surgery (ERAS) protocols, which emphasize multimodal, opioid-sparing strategies [13].

CONCLUSION

This comparative study between opioid-based analgesia (OA) and opioid-free analgesia (OFA) in patients undergoing surgery demonstrates significant clinical advantages of opioid-free protocols. Patients in the OFA group exhibited notably lower sedation scores, reduced postoperative pain intensity at all assessed time intervals, and significantly less postoperative rescue tramadol consumption. Additionally, the incidence of opioid-related side effects such as nausea and vomiting was markedly lower in the OFA group.

While intraoperative parameters remained comparable, the overall postoperative recovery profile strongly favored OFA. The reduction in postoperative opioid use not only minimized adverse effects but also potentially enhanced patient satisfaction and recovery outcomes.

These findings support the growing body of evidence advocating for opioid-free anesthesia techniques as a safer and more effective alternative to traditional opioid-based analgesia in perioperative pain management. However, larger multi-center trials and long-term follow-up are warranted to further validate the generalizability and sustainability of these outcomes across diverse surgical populations.

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