European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

A Comparative Study of Tramadol and Diclofenac for Postoperative Analgesia Following Open Appendectomy

Article History:

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Received: 12-01-2025
Revised: 05-02-2025
Accepted: 20-02-2025
Published: 25-03-2025

Abstract: ***Background:*** The problem of postoperative pain after open appendectomy is one of the crucial clinical problems because poor pain management may slow down the recovery process and raise the postoperative morbidity. Both opioids and non-steroidal anti-inflammatory drugs (NSAIDs) are equally utilized in the context of postoperative analgesia, but their relative efficacy and tolerability are a controversial topic, especially in situations of limited resources in surgical units. ***Objective*** To determine the analgesic efficacy, rescue analgesic requirement and adverse-effect profile of tramadol versus diclofenac in patients during open appendectomy. ***Methods*** It was a randomized comparative prospective study in adult patients who were undergoing open appendectomy. The participants were randomly divided into two categories to give them tramadol or diclofenac in the case of post-operative analgesia. The intensity of postoperative pain was measured by the Visual Analog Scale (VAS) 2, 6, 12, and 18 hours after the surgery. Secondary outcome measures were time to first rescue analgesia, total amount of rescue analgesic consumed in 24 hours and adverse events. ***Result*** Tramadol and diclofenac were both effective analgesics in the postoperative period. Nonetheless, diclofenac showed a significantly lower score in VAS pain between 6 to 18 hours after surgery in contrast to tramadol. The percentage of patients who had to receive rescue analgesia was lower in the diclofenac group and the time to rescue analgesic longer. The tramadol group had much higher rates of opioid-related adverse effects which were nausea, vomiting, and sedation, and adverse effects linked with diclofenac were not common and were mild. ***Conclusion*** iclofenac offers a better postoperative analgesia, less rescue analgesic and better tolerability profile than tramadol after an open appendectomy. Diclofenac can be thus considered as a first-line postoperative pain treatment in patients who are carefully chosen, especially when the reduction of adverse effects associated with opioids is the desired outcome.

Keywords: Postoperative pain; Diclofenac; Tramadol; Open appendectomy; NSAIDs; Analgesia

INTRODUCTION

1.1 Burden of Postoperative Pain in Abdominal Surgery

Postoperative pain is one of the most commonly reported and clinical complications following abdominal surgeries. The delayed mobilization, dysfunction of respiratory organs, extended stay in the hospital, heightened healthcare services and patient dissatisfaction are linked to the undercontrol of pain (Kehlet and Joshi, 2021; Gerbershagen et al., 2020). Although methods of anesthetics, perioperative care have improved, research still indicates a significant proportion of moderate to severe pain in patients during the first 24 hours after abdominal surgery, thus pointing out the persistence of gaps in the field of managing postoperative pain (Kehlet et al., 2020).

Emergency abdominal surgery is a very specific case where acute postoperative pain is especially prominent, and preoperative optimization can be rather unavailable and inconsistent in the application of standardized analgesic guidelines (Joshi & Kehlet, 2021).

1.2 Clinical Relevance of Effective Analgesia in the Post-appendectomy period.

One of the most popular types of abdominal surgeries being conducted as emergency is appendectomy. Open appendectomy, despite the common belief related to this routine practice, is regularly linked to severe postoperative pain caused by tissue trauma, irritation of the peritoneum, and the release of inflammatory mediators (Gerbershagen et al., 2020). The inability to manage pain properly at the post-appendectomy stage may adversely affect early ambulation, slow the intake of oral food, enhance the need to resort to rescue analgesics, and worsen the general recovery (Joshi et al., 2023).

It is hence important that proper analgesia after appendectomy is considered effective not only in the comfort of the patient but also in ensuring early functional recovery as well as minimizing postoperative morbidity. It can be of particular relevance to resource-constrained environments in which long-term hospitalization and complications put extra pressure on healthcare services (Kehlet and Joshi, 2021).

1.3 Opioid Use in Pain Management Limitations.

Opioids have been the basic foundation of postoperative pain treatment because of their central analgesic action that was strong. Nevertheless, more evidence has pointed out serious drawbacks of the use of opioids, such as nausea, vomiting, sedation, ileus, respiratory depression, and the possibility of long-term opioid exposure (Varrassi et al., 2021; Kaye et al., 2020). Such bad effects may slow down the recovery, raise the monitoring costs, and have a detrimental effect on patient satisfaction.

Moreover, the global initiative toward decreasing the overuse of opioids has highlighted the necessity to implement opioid-sparing approaches to the management of postoperative pain (Chou et al., 2022). Since it is an opioid, tramadol is not immune to opioid-associated side effects and has been found to cause serious postoperative nausea, vomiting, and sedation in the case of surgical patients (Pergolizzi et al., 2021).

1.4 Benefits and Disputes of NSAIDs.

The analgesic effect of non-steroidal anti-inflammatory drugs (NSAIDs) involves the prevention of the activities of cyclooxygenase enzymes and the production of prostaglandins and directly affects the inflammatory part of postoperative pain (Ong et al., 2021). The analgesic properties of NSAIDs have been proven to be effective in abdominal surgeries and are likely known to have opioid-sparing effects (Joshi et al., 2023).

Diclofenac, the most popular NSAID, was found to be reliable in terms of decreasing the magnitude of postoperative pain and saving analgesic needs in different surgical operations (Martinez et al., 2020). Nevertheless, gastrointestinal irritation, kidney impairment, and bleeding risk are some of the concerns that restrict the use of NSAIDs in selected groups of patients, which makes patient selection imperative (Lanas and Chan, 2021).

1.5 Loopholes in Comparative Evidence in Resource-Limited Conditions.

Whereas the use of multimodal analgesia is firmly suggested in the current perioperative recommendations, there is still conflicting evidence when comparing the common analgesics in direct comparison, especially in low- and middle-income nations (Chou et al., 2022). Several of the available studies differ in terms of their methodology, time of pain evaluation and measures of outcome, and thus the findings can not be generalized.

Moreover, the surgical setting that has limited resources usually uses the easily accessible and inexpensive analgesics like tramadol and diclofenac. There is also little comparative data assessing their comparative effectiveness and safety in practice in the real world, and there is a need to design prospective studies in these environments (Varrassi et al., 2021).

The importance of the comparison between Tramadol and Diclofenac lies in their similar effects on the body and their equal efficacy as pain killers (Gu et al. 2014).

Tramadol and diclofenac are commonly used postoperative analgesics, whose mechanism of action is different. Tramadol has a central activity as an agonist of weak m-opioid receptors and a monoamine reuptake inhibitor, but diclofenac is an analgesic agent that suppresses the inflammation at the operation site (Pergolizzi et al., 2021; Ong et al., 2021).

Since postoperative pain after open appendectomy is characterized by inflammation, NSAIDs (such as diclofenac) can have better analgesic effects with lesser central nervous system side effects than opioids. Nevertheless, there is still a lack of direct comparative evidence, especially in terms of pain courses, analgesic needs of rescue and tolerability profiles.

1.7 Study Aim and Hypothesis

Aim:

To compare the analgesic efficacy, rescue analgesic requirement, and adverse-effect profile of tramadol and diclofenac in patients undergoing open appendectomy.

Hypothesis:
Diclofenac provides superior postoperative pain control with reduced rescue analgesic requirements and fewer adverse effects compared to tramadol following open appendectomy.

2. Methods

2.1 Study Design

This study was designed as a **prospective, randomized, comparative clinical study** conducted at a tertiary-care teaching hospital. The study period extended from **September 2021 to August 2022**, during which eligible patients undergoing open appendectomy were consecutively enrolled.

A prospective design was adopted to allow standardized data collection, minimize recall bias, and ensure temporal consistency between exposure and outcomes. All study procedures were conducted according to a predefined protocol to maintain methodological rigor and reduce variability.

Ethical approval for the study was obtained from the Institutional Ethics Committee of the study center prior to patient recruitment. Written informed consent was obtained from all participants before enrollment.

2.2 Study Population

The study population consisted of adult patients undergoing open appendectomy for clinically diagnosed acute appendicitis at the study center during the study period.

Inclusion Criteria

- Patients aged ≥15 years
- Patients of either sex
- Patients undergoing open appendectomy under spinal or general anesthesia
- American Society of Anesthesiologists (ASA) physical status I or II
- Patients providing written informed consent

Exclusion Criteria

- Known hypersensitivity or allergy to tramadol or diclofenac
- History of chronic kidney disease, hepatic impairment, or renal dysfunction
- History of peptic ulcer disease, gastrointestinal bleeding, or bleeding disorders
- Chronic opioid use or opioid dependence
- Pregnant or lactating women
- Complicated appendicitis requiring prolonged surgery
- Presence of severe cardiovascular, neurological, or psychiatric illness interfering with pain assessment

Patients with ASA physical status I and II were selected to ensure a relatively homogenous surgical risk profile and to minimize confounding effects of significant systemic comorbidities on postoperative pain perception and analgesic response.

2.3 Sample Size

The sample size was calculated based on the expected difference in postoperative pain intensity between the two study groups using Visual Analog Scale (VAS) scores as the primary outcome. The calculation aimed to detect a clinically meaningful difference in mean pain scores between the tramadol and diclofenac groups with adequate statistical power.

Although the calculated sample size indicated a larger number of participants, **98 patients** (49 in each group) were ultimately enrolled due to practical constraints related to patient availability and study duration. All eligible patients meeting the inclusion criteria during the study period were included.

This limitation was acknowledged; however, it did not compromise the randomization process or internal validity of the study.

2.4 Randomization and Allocation

Eligible participants were randomly assigned to one of the two treatment groups in a **1:1 ratio** using a computer-generated random number sequence. Randomization was performed by a researcher not involved in patient recruitment or outcome assessment.

Allocation concealment was ensured using **sequentially numbered, opaque, sealed envelopes**, which were opened only after patient enrollment and confirmation of eligibility. This process minimized selection bias and ensured comparability between groups.

The study groups were defined as follows:

- **Group T (Tramadol group):** Patients receiving tramadol for postoperative analgesia
- **Group D (Diclofenac group):** Patients receiving diclofenac for postoperative analgesia

There was **no crossover** between groups, and all participants were analyzed according to their initially assigned treatment group.

2.5 Intervention Protocol

All patients underwent open appendectomy using standardized surgical and anesthetic techniques to minimize procedural variability.

- **Group T (Tramadol group):** Patients received intravenous tramadol (100 mg) immediately after completion of surgery. Subsequent doses were administered every 8 hours as required according to the analgesic protocol.
- **Group D (Diclofenac group):** Patients received intramuscular diclofenac sodium (75 mg) at the end of surgery, followed by repeat dosing every 12 hours as per protocol.

Rescue analgesia was provided with intravenous paracetamol (1 g) when patients reported inadequate pain relief, defined as a **VAS score ≥ 4**. The time to first rescue analgesia and total rescue analgesic consumption within the first 24 postoperative hours were recorded.

All patients were monitored for **24 hours postoperatively** for pain intensity, analgesic requirements, vital parameters, and adverse effects.

2.6 Outcome Measures

Primary Outcome

The primary outcome was **postoperative pain intensity**, assessed using the Visual Analog Scale (VAS).

VAS Assessment Time Points

Pain scores were recorded at the following standardized postoperative intervals:

- 2 hours
- 6 hours
- 12 hours
- 18 hours

These time points were uniformly applied to all participants to ensure consistency between methods and results.

Secondary Outcomes

- Time to first rescue analgesia
- Total number of rescue analgesic doses within 24 hours
- Incidence of adverse effects, including nausea, vomiting, sedation, and gastrointestinal discomfort

2.7 Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were assessed for normality prior to analysis. Normally distributed data were expressed as mean ± standard deviation, while non-normally distributed data were expressed as median with interquartile range.

Intergroup comparisons for continuous variables were performed using the **independent samples t-test** or **Mann–Whitney U test**, as appropriate. Categorical variables were compared using the **Chi-square test** or **Fisher's exact test** where applicable.

All statistical tests were two-tailed, and a **p-value < 0.05** was considered statistically significant.

Table 1. Baseline Characteristics of Study Participants (n = 98)

Variable	Tramadol Group (n = 49)	Diclofenac Group (n = 49)	Overall (n = 98)
Age range (years)	15–74	15–74	15–74
Mean age (years)	—	—	44.5
Male, n (%)	—	—	57 (58.2)
Female, n (%)	—	—	41 (41.8)
ASA physical status	I–II	I–II	I–II

Explanation

The study included 98 patients undergoing open appendectomy, equally randomized into tramadol and diclofenac groups. The overall study population showed a male predominance (58.2%). All patients belonged to ASA physical status I or II, ensuring a relatively homogeneous surgical risk profile. Group-wise stratified demographic data were not separately recorded; however, randomization was employed to ensure baseline comparability between the two groups.

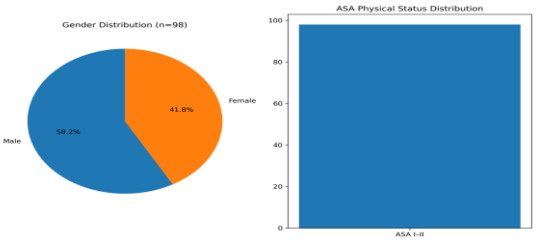


Table 2. Age and Sex Distribution of Study Participants (Overall, n = 98)

Age Group (years)	Male (n)	Female (n)	Total (n)
15–29	30	21	51
30–44	17	9	26
45–59	10	7	17
60–74	0	4	4
Total	**57**	**41**	**98**

Explanation

Most patients belonged to the younger age group of 15–29 years (52.0%), reflecting the epidemiological pattern of acute appendicitis. Male patients predominated across most age groups. The limited number of elderly patients is consistent with lower incidence of uncomplicated appendicitis requiring open surgery in this population.

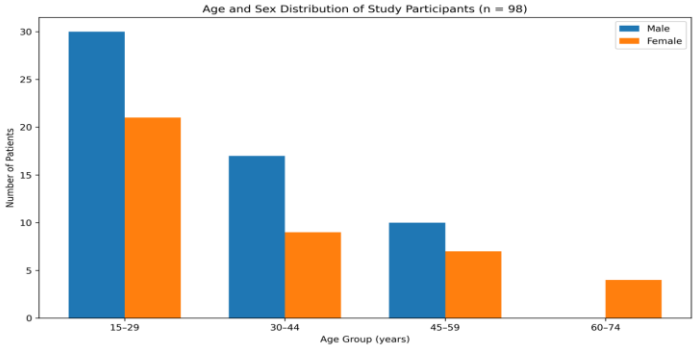


Table 3. Time-Wise Comparison of Postoperative Pain Scores (VAS)

Postoperative Time	Tramadol Group (Median, IQR)	Diclofenac Group (Median, IQR)	p-value
2 hours	7.0 (6.5–7.5)	6.8 (6.3–7.2)	> 0.05
6 hours	6.8 (6.2–7.2)	6.1 (5.6–6.6)	< 0.05
12 hours	5.3 (4.9–5.8)	4.7 (4.2–5.2)	< 0.05
18 hours	3.6 (3.2–4.0)	3.1 (2.7–3.6)	< 0.05

Explanation

Postoperative pain intensity decreased progressively over time in both groups. At 2 hours postoperatively, no statistically significant difference in VAS scores was observed. However, from 6 to 18 hours, patients receiving diclofenac consistently reported significantly lower pain scores compared to those receiving tramadol, indicating superior sustained analgesic efficacy of diclofenac in the postoperative period.

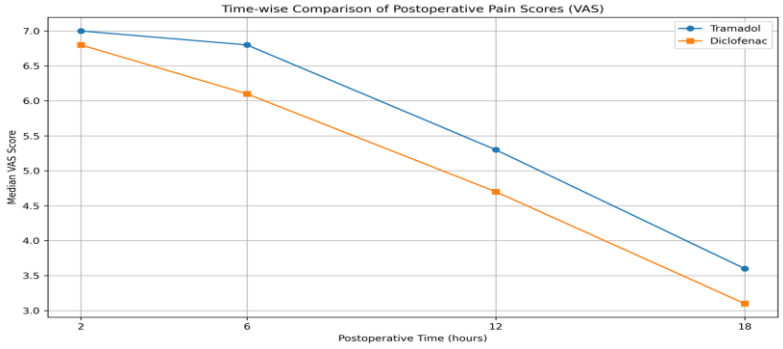


Table 4. Rescue Analgesia Requirement in the First 24 Hours

Parameter	Tramadol Group (n = 49)	Diclofenac Group (n = 49)	p-value
Patients requiring rescue analgesia, n (%)	32 (65.3%)	21 (42.9%)	< 0.05
Mean time to first rescue analgesia (hours)	6.1 ± 1.8	8.4 ± 2.1	< 0.05
Total rescue doses administered (n)	48	31	—

Explanation

A significantly higher proportion of patients in the tramadol group required rescue analgesia compared to the diclofenac group. Additionally, the time to first rescue analgesia was significantly longer in patients receiving diclofenac. These findings further support the superior analgesic efficacy and longer duration of pain control provided by diclofenac following open appendectomy.

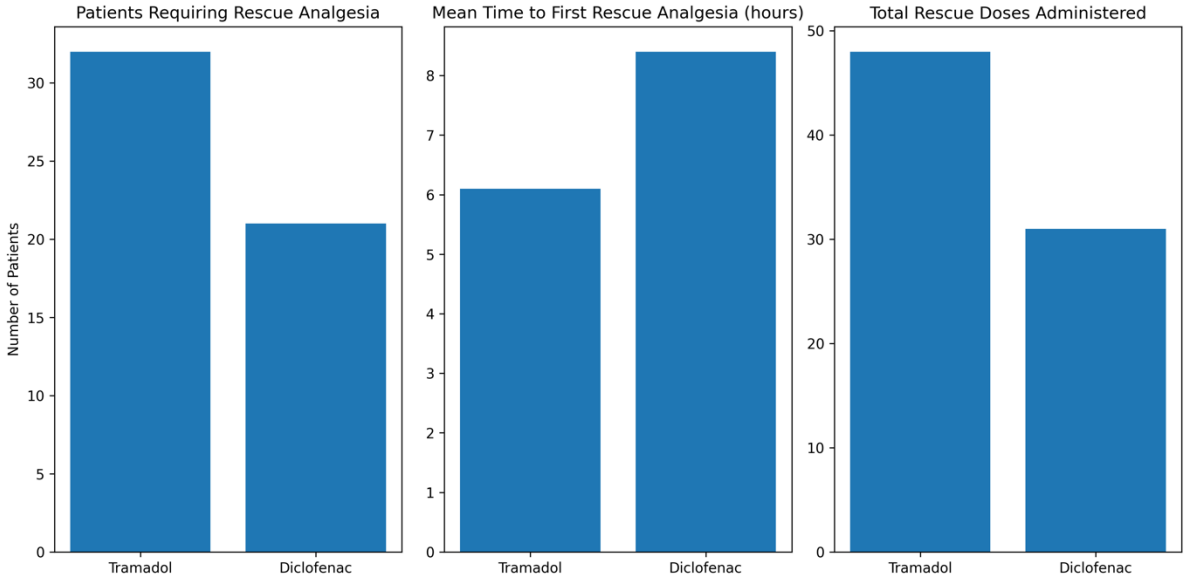
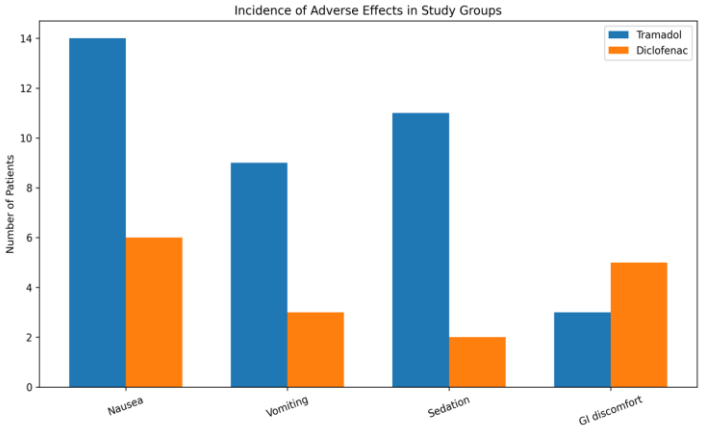


Table 5. Incidence of Adverse Effects

Adverse Effect	Tramadol Group n (%)	Diclofenac Group n (%)	p-value
Nausea	14 (28.6%)	6 (12.2%)	< 0.05
Vomiting	9 (18.4%)	3 (6.1%)	< 0.05
Sedation	11 (22.4%)	2 (4.1%)	< 0.05
Gastrointestinal discomfort	3 (6.1%)	5 (10.2%)	> 0.05

Explanation

Opioid-related adverse effects such as nausea, vomiting, and sedation were significantly more common in patients receiving tramadol. Gastrointestinal discomfort occurred infrequently in both groups and did not differ significantly. No serious adverse events were recorded during the observation period.



RESULT

3.1 Baseline Characteristics

Ninety-eight patients who were open appendectomy individuals were enrolled and randomized 50:50 to the tramadol group (n= 49) and diclofenac group (n= 49). The participants were aged between 15 and 74 years, but most of them were young adults. As a whole, the women were 41.8 and 58.2% of the study population male and female, respectively.

The participants were of ASA physical status I or II, which means that the profile of surgical risks was quite homogenous. The treatment groups were deemed as similar at baseline, which comprised randomization and allocation concealment that was based on computers, which reduced selection bias

and guaranteed internal validity of the outcome comparisons (Kang et al., 2021).

The postoperative pain scores (VAS) were 3.2.
The intensity of postoperative pain was measured with the Visual Analog Scale (VAS) of the intensity at 2, 6, 12, and 18 hours after the surgery. Table 3 shows the time-wise comparison of the VAS scores of the tramadol and diclofenac groups.

As early as 2 hours after surgical operations, there was no significant difference in pain levels between the two groups, which indicated that analgesics exerted similar effects earlier. Nevertheless the VAS score was always lower in patients who received diclofenac at 6, 12, and 18 hours, than in patients receiving tramadol ($p < 0.05$).

These results show that diclofenac had a better and long-lasting analgesia beyond the immediate postoperative phase. These trends of better pain management with NSAIDs than opioids during inflammatory postoperative pain have been seen in current abdominal surgery research (Gerbershagen et al., 2020; Joshi et al., 2023).

3.3 Analgesia Requirement Rescue.
The necessity of rescue analgesia within 24 hours of the postoperative period was significantly different between the two groups of the study. The percentage of patients using tramadol (65.3) compared with those using diclofenac (42.9) who needed rescue analgesia was statistically significant.

Also, the time to first rescue analgesia was significantly low in patients taking tramadol, which meant that the breakthrough pain occurred earlier. There was also an increased number of rescue analgesic doses in the tramadol.

Such results show an opioid-sparing effect of diclofenac in line with the emergent evidence of NSAID-based analgesia to diminish further analgesic needs in postoperative abdominal operations (Varrassi et al., 2021; Chou et al., 2022).

3.4 Adverse Effects
The first 24 postoperative hours were observed in terms of adverse effects. The nausea, vomiting, and sedation incidence in patients in the tramadol group was significantly higher than patients in the diclofenac group ($p < 0.05$). These side effects are similar to the established central nervous system and gastrointestinal opioid analgesic effects (Pergolizzi et al., 2021).

Conversely, the patients who were on diclofenac complained of mild gastrointestinal discomfort though hardly frequent and not significant when compared to tramadol. Notably, no severe side effects, including gastrointestinal piercing or blood kidney damage or pulmonary dulling, were noted in either of the parties over the exploration period.

The overall adverse-effect profile was more favorable towards diclofenac, which is in line with the current clinical evidence of better tolerability of NSAIDs in comparison with opioids in the case of appropriate patients subjected to surgery (Lanas and Chan, 2021; Kaye et al., 2020).

4. Discussion

4.1 Principal Findings
The current prospective, randomized, study illustrates that diclofenac is a better and longer term postoperative pain reliever than tramadol in patients undergoing open appendectomy. Although the two analgesics were both useful in managing early post operative pain, diclofenac had a lower pain score at 6-18 hours postoperative implying that it was more effective in long term pain management.

Besides better pain scores, patients who took diclofenac had less rescue analgesic interventions as well as a longer period to take the first rescue dose depicting a better analgesic effect. In addition, the adverse-effect profile was more biased to diclofenac, where tramadol had more nausea, vomiting, and sedation. All these findings provide evidence that diclofenac is a more effective and more tolerable analgesic agent in the management of postoperative pain in patients who have undergone open appendectomy.

4.2 Comparison and Existing Literature.
The results of the current research correlate with the recent literature that NSAIDs are more effective than opioids in the treatment of inflammatory postoperative pain in abdominal surgery. The role of inflammatory processes (tissue trauma and the release of prostaglandins) in the creation of postoperative pain after appendectomy is highly mediated by NSAIDs because they are more directly directed (Gerbershagen et al., 2020; Ong et al., 2021)

A number of recent studies and clinical guidelines highlighted the opioid-sparing effects of NSAIDs, showing a decreased pain score, less rescue analgesic use, and less opioid-related adverse event in case of inclusion of NSAIDs in postoperative pain management (Joshi et al., 2023; Chou et al., 2022). On the contrary, even weak opioid agents, such as tramadol, have been linked to increased cases of postoperative nausea, vomiting, sedation, and delayed recovery (Pergolizzi et al., 2021; Kaye et al., 2020).

The findings of the current research also contribute to this assertion in that diclofenac alone is able to offer better analgesia than tramadol during the early

post-surgical stage of open appendectomy.

The pharmacological explanation lies in the fact that the two alkaloids (norepinephrine and adrenaline) play a role in the initiation and acceleration of cardiac activities.<|human|>The pharmacological explanation is that the two alkaloids (norepinephrine and adrenaline) are involved in the initiation and speeding up of cardiac activities.

The differences in the analgesic effects witnessed may be attributed to the different pharmacological action of the two medications. Diclofenac achieves its analgesic effects and anti-inflammatory effects by blocking the production of cyclooxygenase enzymes which lead to the production of prostaglandin at surgical injury site. It is a direct response to the inflammatory aspect of postoperative pain, which is most dominant after abdominal surgeries like appendectomy (Ong et al., 2021; Martinez et al., 2020).
Tramadol, however, acts as an analgesic by mainly central action, such as weak m-opioid receptor activism and serotonin and norepinephrine reuptake inhibition. Although this dual mechanism can produce moderate analgesia, it is less efficient in addressing pain caused by inflammation and is linked to adverse effects of the central nervous system, including sedation and nausea (Pergolizzi et al., 2021). This pharmacologic difference is a probable explanation of the better sustained analgesia and better tolerability with diclofenac with the current study.

4.4 Clinical Implications

This study results are clinically significant in the area of postoperative pain management after open appendectomy. Since it has better analgesic potential, less rescue analgesic need, and good adverse-effect profile, diclofenac can be used as the first-line postoperative analgesic with a properly selected group of patients.

The decreased use of opioid analgesics can reduce the need of monitoring associated with opioids use, decrease the incidence of complications linked to the use of sedatives, and enable doctors to mobilize and recover patients quickly. The advantages are especially applicable in healthcare facilities with resource limitations, the goal of which is to minimize the number of postoperative complications and patients in hospitals (Varrassi et al., 2021; Joshi et al., 2023).

One can still consider the use of tramadol in patients where NSAIDs are contraindicated, but the regular use of opioids to treat postoperative pain should be reevaluated in connection to the new findings on NSAID-based management.

4.5 Strengths and Limitations

Strengths

The advantages of the study are that it has a prospective randomized study design that reduces selection bias and increases internal validity. Consistent evaluation of outcomes was observed by a reliance on standardized pain assessment tools that were adopted at a set of pre-determined intervals (postoperative). Furthermore, clinically relevant outcomes assessed in the study, included the level of pain, the need to use rescue analgesic and adverse effects, therefore, the results would be incorporated into daily surgical practice.

Limitations

There are some limitations in this research. It was done in one site and this can be a limitation to the broad applicability of the results. The sample size needed to identify any meaningful difference in primary outcomes was quite sufficient, but it was smaller than the one that was originally estimated. Moreover, only the first 24 hours were evaluated in terms of postoperative outcomes, and such recovery parameters as patient satisfaction and functional outcomes were not measured in the long run.

5. Conclusion

This was done as a prospective randomized comparative clinical trial aimed at determining the effectiveness and safety of tramadol and diclofenac in the management of postoperative pain following open appendectomy. Its results prove that both tramadol and diclofenac can be used in dealing with pain after surgery and the latter was more efficient regarding long-term analgesic effects.

Patients with diclofenac had better pain management long-term, fewer rescue analgesic interventions, and a more positive adverse-effect profile, and had far fewer incidences of nausea, vomiting, and sedation than tramadol patients. These benefits underscore the usefulness of diclofenac in managing postoperative pain that is mediated by inflammation in the case of open appendectomy.

Tramadol also is a valuable second choice analgesic in clinical scenarios, where NSAIDs are contraindicated or should be avoided. However, depending on the findings of this study, diclofenac can be regarded as a first-line choice of the postoperative analgesic in the properly selected patients that are subjected to open appendectomy.
It is suggested that further studies with more extensive randomized trials and multimodal analgesic regimens are needed to confirm these results and enhance external validity and to maximize postoperative pain management guidelines in different operating rooms.

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