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ORIGINAL ARTICLE

Prospective Evaluation of Postoperative Pain Control Strategies in Pediatric Appendectomy Patients

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ABSTRACT:

Background: Appendicitis remains one of the most common surgical emergencies in children, and postoperative pain following appendectomy can significantly influence recovery, emotional well-being, and overall hospital experience. Despite advances in pediatric analgesia, variability persists in the selection and effectiveness of postoperative pain control strategies. Identifying the most effective regimen is essential to optimize comfort, minimize complications, and support early return to normal activities in pediatric patients. **Aim:** The aim of this study was to prospectively evaluate and compare the effectiveness of different postoperative pain control strategies—including acetaminophen, NSAIDs, opioids, and multimodal therapy—in children undergoing appendectomy at a tertiary care hospital. **Materials and Methods:** This prospective observational study included 48 pediatric patients aged 5–15 years who underwent open or laparoscopic appendectomy. Pain control strategies were selected based on clinical judgment and standardized dosing protocols. Postoperative pain was assessed using validated age-appropriate scales, including the Wong-Baker FACES Scale and the Visual Analog Scale (VAS), and scores were recorded at 0, 2, 6, 12, and 24 hours postoperatively. Additional parameters included type of surgery, intraoperative analgesia, time to first analgesic request, adverse effects, and recovery indicators such as return to oral intake. Data were analyzed using descriptive and comparative statistics, with $p < 0.05$ considered significant. **Results:** The majority of patients were males (62.50%) with a mean age of 10.8 ± 2.9 years. Multimodal therapy resulted in the lowest mean VAS scores across all time intervals, with a 24-hour score of 1.96 ± 0.68 compared to acetaminophen (3.42 ± 0.88), NSAIDs (3.08 ± 0.74), and opioids (2.64 ± 0.92), showing a highly significant difference ($p = 0.001$). More than half (54.17%) requested analgesia between 2–6 hours postoperatively, and 66.67% experienced no adverse effects. Return to oral intake was achieved within 6–12 hours in most cases. **Conclusion:** Multimodal analgesia proved to be the most effective strategy for postoperative pain control in pediatric appendectomy patients, providing superior pain relief, fewer rescue doses, and minimal adverse effects compared with single-agent regimens. Integrating multimodal approaches into postoperative protocols may enhance recovery and overall patient comfort.

Keywords: Pediatric appendectomy, postoperative pain, multimodal analgesia, analgesic strategies, pain assessment.

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INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies in childhood and remains a major cause of abdominal pain requiring operative intervention. Large epidemiological datasets estimate that approximately 250,000 cases of appendicitis occur annually in the United States, with the highest incidence in the 10–19-year age group and a consistent male predominance.[1] Subsequent population-based analyses have shown that, although overall trends in appendicitis have evolved over recent decades, the burden of disease in children and adolescents continues to be substantial, with appendicitis remaining a leading indication for emergency abdominal surgery.[2] In many low- and middle-income settings, appendicitis in school-aged children and adolescents similarly constitutes a significant proportion of pediatric surgical admissions, contributing to considerable use of hospital resources, perioperative morbidity, and health-care costs.Clinical presentation and disease course in pediatric appendicitis vary with age, and younger children often present diagnostic and therapeutic challenges. While appendicitis is relatively uncommon in preschool children, when it does occur in those under five years of age it is associated with higher rates of delayed diagnosis, perforation, and postoperative complications compared with older children.[3] Non-specific symptoms, difficulty in localizing pain, and overlap with common childhood illnesses such as gastroenteritis or mesenteric adenitis can obscure the diagnosis. Even among older children, classical features may be absent, and several clinical prediction rules have been proposed to assist in risk stratification. However, systematic reviews of these tools suggest that no single rule achieves consistently high diagnostic performance across settings, underscoring the continued importance of careful clinical assessment and timely surgical management in suspected pediatric appendicitis.[4]Although timely appendectomy effectively removes the source of

infection, the surgical experience itself can be a major source of acute pain and distress in children. Unrelieved postoperative pain may trigger adverse physiological responses, including tachycardia, hypertension, impaired pulmonary function, and delayed mobilization, as well as psychological consequences such as anxiety, sleep disturbance, and fear of future medical procedures. Over the past two decades, advances in pediatric pain science and the development of age-appropriate pain assessment tools have led to more structured approaches to perioperative analgesia.[5] Yet, despite these improvements, substantial evidence indicates that children continue to experience moderate to severe pain after routine surgical procedures, suggesting that available knowledge is not consistently translated into bedside practice.[6,7]Modern concepts of pediatric postoperative pain management emphasize multimodal analgesia and individualized care. Combining acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, and, where feasible, regional anesthesia allows targeting of different components of the pain pathway, improving analgesic efficacy while minimizing dose-dependent adverse effects of any single agent.[5] Comprehensive reviews of pediatric postoperative pain management highlight that inadequately treated acute pain in children may have long-lasting effects on pain processing, behavior, and health-related quality of life, and that prevention and early control of pain are preferable to attempting to "rescue" children once pain becomes severe.[6] These reviews also stress the need for routine use of validated pain scales, regular reassessment, and proactive adjustment of analgesic regimens according to pain scores and functional recovery.

MATERIAL AND METHODS

This study was designed as a prospective observational evaluation conducted at a tertiary care hospital. The primary objective was to compare the effectiveness of different postoperative pain control strategies in children undergoing appendectomy. All methodological steps were planned in advance to ensure uniformity in patient enrollment, pain assessment, and postoperative monitoring.A total of 48 pediatric patients were included in the study. All participants were children aged 5–15 years who presented with clinical and radiological features consistent with acute appendicitis and subsequently underwent open or laparoscopic appendectomy. Consecutive patients meeting the eligibility criteria were enrolled following informed consent from parents or legal guardians.

Inclusion Criteria

Children aged 5–15 years who underwent emergency or elective appendectomy for uncomplicated or complicated appendicitis were considered eligible. Only those who were hemodynamically stable preoperatively and able to self-report or respond to validated pediatric pain scales were included. Patients whose guardians provided written consent were enrolled.

Exclusion Criteria

Patients with known chronic pain disorders, developmental delays impairing pain assessment, documented allergies to analgesic medications used in the study, or those requiring postoperative ventilatory support were excluded. Children with perforated appendicitis who required intensive care monitoring or those receiving preoperative opioid analgesia beyond standard care were also excluded.

Methodology

A non-probability consecutive sampling technique was applied. All eligible children presenting to the pediatric surgery department during the enrollment period were approached for participation, ensuring a representative sample of appendectomy cases commonly encountered in tertiary care settings.Both open and laparoscopic appendectomies were performed according to surgeon preference and institutional protocol. Standardized perioperative care was applied, including preoperative hydration, prophylactic antibiotics, and intraoperative monitoring. The type of surgery, operative findings, duration of surgery, and intraoperative analgesics were recorded for each patient.

Patients were allocated to postoperative analgesic strategies based on surgeon decision and clinical need. Strategies included intravenous acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), opioid analgesics, or multimodal combinations. Dosage, frequency, and route of administration were standardized according to weight-based pediatric guidelines. Rescue analgesia requirements were documented to assess adequacy of pain control.

Postoperative pain was evaluated using age-appropriate and validated scales, including the Wong-Baker FACES Pain Rating Scale and the Visual Analog Scale (VAS). Pain scores were recorded at fixed intervals: immediately upon recovery, at 2 hours, 6 hours, 12 hours, and 24 hours postoperatively. Additional parameters such as time to first analgesic requirement, total analgesic consumption within 24 hours, and patient comfort levels were recorded. Behavioral indicators—including crying, irritability, sleep disturbance, and reduced mobility—were also documented to support objective assessment.

All patients were observed in the surgical ward with continuous monitoring of vital signs, including heart rate, respiratory rate, blood pressure, and oxygen saturation. Adverse effects related to analgesic medications—such as nausea, vomiting, dizziness, pruritus, or sedation—were systematically recorded. Time to ambulation, return to oral intake, and length

of hospital stay were evaluated as secondary clinical outcomes.

Prestructured forms were used to collect demographic data, clinical presentation, operative details, analgesic regimens, pain scores, and postoperative recovery parameters. Data were obtained directly from patient charts, nursing records, and structured interviews with patients and caregivers. All information was checked for completeness and accuracy at the time of entry.

Statistical Analysis

Collected data were entered into a statistical software program for analysis. Descriptive statistics were applied to summarize demographic variables, pain scores, and analgesic requirements. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparative analysis of pain control strategies was performed using appropriate statistical tests, with p-values <0.05 considered statistically significant.

RESULTS

Table 1: Demographic Characteristics of the Study Population

The study included a total of 48 pediatric patients, and the age distribution showed that the majority of children (41.67%) belonged to the 9–12 year age group, whereas equal proportions (29.17%) were observed in both the 5–8 year and 13–15 year categories. The mean age of the patients was 10.8 ± 2.9 years, reflecting that most participants were school-aged children. A higher representation of males was noted in the study population, with 62.50% males compared to 37.50% females, indicating a male predominance commonly observed in pediatric appendicitis. Regarding the type of appendicitis, two-thirds (66.67%) of the cases presented with uncomplicated appendicitis, while 33.33% had complicated appendicitis.

Table 2: Surgical and Operative Variables

Open appendectomy was performed in 58.33% of patients, whereas laparoscopic appendectomy accounted for 41.67%. The comparison between the two surgical approaches showed no statistically significant difference (p = 0.21), indicating that the choice of surgical technique was based largely on surgeon preference or clinical need rather than patient characteristics. The mean duration of surgery was 47.6 ± 12.4 minutes, which falls within acceptable operative times for pediatric appendectomy. In terms of intraoperative analgesic use, acetaminophen was the most commonly administered analgesic (37.50%), followed by NSAIDs (29.17%) and opioids (20.83%). A smaller proportion (12.50%) received multimodal analgesia. A statistically significant difference (p = 0.04) was observed among the different types of intraoperative analgesic strategies, suggesting a non-random pattern of analgesic use, possibly influenced by surgeon preference or severity of clinical presentation.

Table 3: Distribution of Postoperative Pain Control Strategies

Four different postoperative pain control strategies were employed, with acetaminophen-only therapy used in 33.33% of patients and NSAIDs in 25.00%. Opioids and multimodal analgesia were used in 20.83% of patients each. The mean visual analog scale (VAS) pain scores at 24 hours varied significantly across the groups. Patients receiving multimodal therapy demonstrated the lowest mean pain score (1.96 ± 0.68), indicating superior analgesic effectiveness. Opioid therapy also provided better pain relief (mean VAS: 2.64 ± 0.92) compared to acetaminophen and NSAIDs alone. The highest pain scores were reported in the acetaminophen-only group (3.42 ± 0.88). The overall comparison of pain control strategies revealed a highly significant difference (p = 0.001), confirming that multimodal therapy was the most effective regimen for postoperative pain control in pediatric appendectomy patients.

Table 4: Postoperative Outcomes and Recovery Parameters

The time to first analgesic request varied significantly among patients (p = 0.03). More than half (54.17%) requested additional pain medication between 2–6 hours postoperatively, while 29.17% could tolerate more than 6 hours without additional analgesia. A smaller percentage (16.67%) required analgesia within the first 2 hours, indicating early breakthrough pain in some children. Adverse effects were observed in a subset of patients, with nausea/vomiting reported in 20.83% and dizziness in 8.33%, while pruritus was noted in 4.17%. However, the majority (66.67%) experienced no adverse effects, which was statistically significant (p = 0.02). Regarding return to oral intake, most patients (54.17%) resumed oral feeding within 6–12 hours postoperatively, while 25.00% achieved this milestone within the first 6 hours. Only 20.83% took more than 12 hours to resume oral intake. However, the difference across categories was not statistically significant (p = 0.12), suggesting comparable recovery patterns regardless of analgesic strategy.

Table 5: Comparison of Pain Scores Over Time Between Analgesic Groups

Pain scores decreased progressively over the 24-hour postoperative period in all groups, but significant differences were observed between the analgesic strategies throughout all time intervals. Immediately after surgery, multimodal therapy resulted in the lowest mean pain score (4.76 ± 1.05), compared to higher scores in the opioids (5.24 ± 1.18), NSAIDs (5.86 ± 1.02), and acetaminophen (6.12 ± 1.14) groups. These differences were statistically significant (p = 0.04). At 2 hours postoperatively, multimodal

therapy continued to offer superior pain control (3.46 ± 0.74), with opioids performing better than NSAIDs and acetaminophen. This trend persisted at 6 hours, 12 hours, and 24 hours, with multimodal therapy consistently yielding the lowest pain scores at each measurement. The p-values at these intervals (0.01, 0.002, 0.001, and 0.001 respectively) demonstrate that the differences between groups were consistently significant.

Table 1: Demographic Characteristics of the Study Population (n = 48)

Variable	Category	Frequency (n)	Percentage (%)
Age Groups (years)	5–8 years	14	29.17%
	9–12 years	20	41.67%
	13–15 years	14	29.17%
Mean Age ± SD	—	10.8 ± 2.9 years	—
Gender	Male	30	62.50%
	Female	18	37.50%
Type of Appendicitis	Uncomplicated	32	66.67%
	Complicated	16	33.33%

Table 2: Surgical and Operative Variables

Variable	Category	Frequency (n)	Percentage (%)	p-value
Type of Surgery	Open Appendectomy	28	58.33%	
	Laparoscopic Appendectomy	20	41.67%	**0.21** (NS)
Mean Duration of Surgery	—	47.6 ± 12.4 minutes	—	
Intraoperative Analgesia	Acetaminophen	18	37.50%	
	NSAIDs	14	29.17%	
	Opioids	10	20.83%	
	Multimodal	6	12.50%	**0.04** (Significant)

Table 3: Distribution of Postoperative Pain Control Strategies

Analgesic Strategy	Frequency (n)	Percentage (%)	Mean Pain Score at 24 hrs (VAS)	p-value
Acetaminophen Only	16	33.33%	3.42 ± 0.88	
NSAIDs Only	12	25.00%	3.08 ± 0.74	
Opioids Only	10	20.83%	2.64 ± 0.92	
Multimodal Therapy	10	20.83%	1.96 ± 0.68	**0.001** (Highly Significant)

Table 4: Postoperative Outcomes and Recovery Parameters

Outcome Parameter	Category	Frequency (n)	Percentage (%)	p-value
Time to First Analgesic Request	< 2 hours	8	16.67%	
	2–6 hours	26	54.17%	
	> 6 hours	14	29.17%	**0.03** (Significant)
Adverse Effects	Nausea/Vomiting	10	20.83%	
	Dizziness	4	8.33%	
	Pruritus	2	4.17%	
	None	32	66.67%	**0.02** (Significant)
Return to Oral Intake	< 6 hours	12	25.00%	
	6–12 hours	26	54.17%	
	> 12 hours	10	20.83%	**0.12** (NS)

Table 5: Comparison of Pain Scores Over Time Between Analgesic Groups

Time Interval	Acetaminophen (Mean ± SD)	NSAIDs (Mean ± SD)	Opioids (Mean ± SD)	Multimodal (Mean ± SD)	p-value
Immediate (0 hrs)	6.12 ± 1.14	5.86 ± 1.02	5.24 ± 1.18	4.76 ± 1.05	**0.04**
2 hours	5.18 ± 1.02	4.82 ± 0.96	4.12 ± 0.88	3.46 ± 0.74	**0.01**

6 hours	4.32 ± 0.96	3.94 ± 0.88	3.16 ± 0.92	2.42 ± 0.84	**0.002**
12 hours	3.92 ± 0.88	3.46 ± 0.76	2.86 ± 0.82	2.08 ± 0.72	**0.001**
24 hours	3.42 ± 0.88	3.08 ± 0.74	2.64 ± 0.92	1.96 ± 0.68	**0.001**

DISCUSSION

In the present prospective study of 48 pediatric appendectomy patients, the mean age was 10.8 ± 2.9 years, with most children (41.67%) in the 9–12 year group and a clear male predominance (62.50%). This age and sex pattern is in line with the epidemiological observations of Acheson and Banerjee (2010), who reported that acute appendicitis is the most common surgical emergency in children, occurring predominantly in school-aged and early adolescent boys.[8] Our proportion of uncomplicated appendicitis (66.67%) and complicated appendicitis (33.33%) also fits within the range described by Acheson and Banerjee (2010), who emphasised that a substantial fraction of children still present with perforation or advanced disease when diagnosis or referral is delayed.[8]In our series, one-third of patients (33.33%) had complicated appendicitis, whereas two-thirds had uncomplicated disease, which closely mirrors the burden of severe disease highlighted by Elikashvili and Spina (2012) in their evidence-based review of acute appendicitis in childhood.[9] They noted that, despite advances in imaging and clinical scoring, a sizeable proportion of paediatric patients—often around one-third—still present with perforation or significant complications, particularly when symptoms are nonspecific or diagnosis is delayed.Regarding surgical approach, open appendectomy was performed in 58.33% of our patients, while laparoscopic appendectomy accounted for 41.67%, with a mean operative time of 47.6 ± 12.4 minutes. Aarabi et al. (2011) reported, in their population-based New England cohort, that laparoscopic appendectomy use increased steadily over time and became the predominant approach, contributing to reduced length of stay and decreased negative appendectomy rates.[10] Intraoperatively, acetaminophen was the most frequently used analgesic (37.50%), followed by NSAIDs (29.17%), opioids (20.83%), and multimodal regimens (12.50%), with a statistically significant difference between these patterns (p = 0.04). Willey et al. (2005) conducted a prospective randomised trial in children following appendicectomy in which all patients received paracetamol and diclofenac, either rectally or orally, and reported good overall pain control with this combined non-opioid regimen and limited need for additional opioids.[11] Compared with the standardised multimodal protocol used by Willey et al. (2005), our data show more heterogeneous intraoperative practice and relatively lower uptake of multimodal strategies (12.50%), which may partly explain why more than half of our patients required further analgesia within 2–6 hours postoperatively and a subset (16.67%) needed rescue analgesia within the first 2 hours. The key finding of this study is the superior performance of multimodal postoperative analgesia. At 24 hours, the mean VAS score in the multimodal group was 1.96 ± 0.68, compared with 2.64 ± 0.92 in the opioid-only group, 3.08 ± 0.74 in the NSAID-only group, and 3.42 ± 0.88 in the acetaminophen-only group (p = 0.001). This consistent gradient—favouring multimodal therapy from the immediate postoperative period through 2, 6, 12 and 24 hours—closely supports the concept advanced by Yaster (2010), who argued that combining opioids with non-opioid agents (NSAIDs, paracetamol, local anaesthetics and adjuvants) allows lower doses of each drug while achieving better overall pain control in children.[12] The observation that opioid-only regimens in our study provided better pain relief (VAS 2.64 ± 0.92 at 24 hours) than acetaminophen alone (3.42 ± 0.88) or NSAIDs alone (3.08 ± 0.74), yet were still inferior to multimodal therapy (1.96 ± 0.68), is consistent with the systematic review by Wong et al. (2013).^13 Wong et al. (2013) analysed paediatric trials and showed that adding paracetamol or NSAIDs to opioid regimens reduced perioperative opioid consumption and maintained or improved pain scores, often producing clinically important opioid-sparing effects.[13] Postoperative outcomes in the present study further support the value and safety of structured multimodal analgesia. More than half of the children (54.17%) requested their first additional analgesic dose between 2–6 hours after surgery, and 29.17% remained comfortable for more than 6 hours; only 16.67% required rescue analgesia within 2 hours. Adverse effects were generally mild—nausea/vomiting occurred in 20.83%, dizziness in 8.33%, pruritus in 4.17%—and two-thirds of patients (66.67%) had no recorded adverse effects. Hui and Wilson-Smith (2013) reviewed systemic analgesics in children and concluded that a multimodal approach, combined with age-appropriate pain scoring and regular reassessment, can provide effective analgesia with acceptable rates of side-effects such as nausea and sedation when dosing is carefully adjusted to age and weight.[14] Pain in this study was assessed using the Wong-Baker FACES Pain Rating Scale and the visual analogue scale at multiple time points, and scores declined progressively in all groups over 24 hours, with the steepest decline in the multimodal group. Wong and Baker (1988) originally demonstrated that self-report tools based on facial expressions and simple numerical ratings are reliable and valid for children, enabling consistent quantification of pain intensity in the postoperative period.[15] The clear separation of mean scores between our analgesic groups—particularly the approximately 1–2 point advantage of multimodal therapy over acetaminophen or NSAIDs alone at each assessmenttherefore represents a

clinically meaningful difference on validated scales, not just a statistically significant finding.

CONCLUSION

This prospective study demonstrates that multimodal analgesia provides superior and more sustained postoperative pain control in pediatric appendectomy patients compared with single-agent regimens. Children receiving multimodal therapy consistently achieved the lowest pain scores across all postoperative intervals and required fewer rescue analgesics. Recovery profiles were favorable, with minimal adverse effects and comparable functional outcomes across groups. These findings support the routine incorporation of multimodal strategies into postoperative pain management protocols for pediatric appendectomy to optimize comfort, safety, and early recovery.

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