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MULTIMODAL ANALGESIA OF PAIN MANAGEMENT IN PEDIATRIC APPENDECTOMY

[*1]Dr. Zakariya Sami Mustafa Zakariya

[1]M.B.Ch.B./F.I.C.M.S. (Anesthesia and Intensive Care Unit).

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***Corresponding Author: Dr. Zakariya Sami Mustafa Zakariya**

M.B.Ch.B./F.I.C.M.S. (Anesthesia and Intensive Care Unit).

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ABSTRACT

Background: Acute appendicitis is one of the most common surgical emergencies in children, and appendectomy is still the definitive therapy. Effective pain management during the perioperative and postoperative periods is an essential component of pediatric surgical management, since uncontrolled pain can result in serious physiological, psychological, and clinical consequences. **Objectives:** Is to evaluate the efficacy of multimodal analgesia in the perioperative and postoperative management of pain in children undergoing appendectomy at Mosul city, Ibn Al-Atheer Teaching Hospital, Republic of Iraq, with a focus on pain scores, opioid requirements and adverse effect. **Methods:** This is a hospital-based prospective observational study. It was conducted between the 1st of July of year 2025 to the 10th of November of year 2025 at Mosul city, Ibn Al-Atheer Teaching Hospital, Republic of Iraq. Regarding the analgesic protocol, all of the patients received Fentanyl in a dose of 1 mcg/kg but can be increased into 2-3 mcg/kg during operation according to relief of pain that's measured by heart rate like pulse oximetry and clinical observations. In addition to paracetamol 15 mg/kg during operation then after that every 6 hours at everyday of postoperative period according to pain sensation, diclofenac whenever needed at recovery in a dose of 1 mg/kg. As well as lignocaine 2% plain kind as a skin infiltration technique, before skin incision (for example grid iron incision) and after wound suturing at the end of operation. Ketamine 0.25-0.5 mg/kg was given during immediate postoperative recovery stage in the presence of mild-severe pain respectively. Postoperative pain assessment was done by anaesthetist in the surgical ward depending on visual analogue scale as well as patient general condition such as sleeping, moving in the ward, sitting in the bed and started eating or not yet. The primary outcomes were to evaluate postoperative pain score at time of immediate recovery and at 2, 4, and 8 hours after operation, whereas the secondary outcomes were to assess the patients' side effect of drugs, such as hallucination and secondary outcome. **Results:** The study includes 63 pediatric age patients; of them 27 patients were male and 36 patients were females. Male: Female ratio was 1:1.33. The mean age ± standard deviation of the study patients was 11.02 ± 1.83 years. The mean time ± standard deviation of general anesthesia was 46.03 ± 11.46 minutes. At all of the time interval, the medium of VAS was less than 3. Anyhow, statistically significant difference between them (P value = 0.029) with higher pain occurred 4 hours after operation. No statistically significant difference between different time interval regarding vital signs and oxygen saturation. 6 (9.52%) patients developed nausea and vomiting, 14 (22.22%) developed moderate-severe pain necessitating additional opioid or other drugs like nefopam and 12 (19.04%) patients needed additional drugs other than opioid for example corticosteroids (dexamethasone and hydrocortisone), a benzodiazepine drugs for instance (midazolam) or even an antiemetic drug which is the ondansetron (it is also call devomit or zofran) and the last one used is sugammedex. **Conclusion:** Multimodal analgesia is an effective and safe strategy for managing postoperative pain in children after appendectomy. The use of paracetamol and NSAIDs as first-line drugs, along with local anesthetic drug and a small dose of ketamine that's the analgesic dose at immediate phase of recovery period leads in lowering pain scores, less opioid intake and fewer opioid side effects.

KEYWORDS: Anesthesia, Appendix, Children, Iraq, Mosul, Relief.

1. INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies in children, and appendectomy is still the definitive therapy.[1] Every year, a considerable number of children have appendectomy at Mosul city, creating significant pressure on the care services. Effective pain management during the perioperative and postoperative periods is an essential component of pediatric surgical management, since uncontrolled pain can result in serious physiological, psychological, and clinical consequences.[2]

Children feel pain differently from adults, and their capacity to express it varies with age and developmental level.[3] Poorly controlled perioperative pain may cause increased stress responses, including as tachycardia, hypertension, and raised cortisol levels, which can have a deleterious impact on wound healing and recovery.[4] Additionally, untreated or inadequately treated acute pain in children has been linked to the development of chronic pain syndromes, behavioral disorders, sleep difficulties, and more anxiety toward future medical operations.[5]

Perioperative analgesia works by providing effective pain relief before, during, and immediately after surgery.[6] Perioperative analgesia in pediatric appendectomy often consists of the use of systemic non-opioid analgesics, intra-operative opioids in properly titrated dosages, and local anesthetic methods such as wound infiltration. When used properly, perioperative analgesia can minimize central sensitization, postoperative pain severity, and total analgesic needs.[7]

Postoperative pain after an appendectomy can range from mild to severe, especially during the first 24 hours.[8] Inadequate postoperative analgesia can delay mobility, compromise respiratory function, prolong hospital stay, and raise the risk of surgical complications.[9] Traditionally, opioid analgesics have been the cornerstone of postoperative pain management; nevertheless, their use in children has been linked to serious side effects such as respiratory depression, nausea, vomiting, ileus, pruritus, and drowsiness.[10-11] These hazards are particularly significant in settings with inadequate monitoring resources, such as general pediatric wards in low- and middle-income countries.

Multimodal analgesia is being utilized as a safe and effective approach to perioperative and postoperative pain control in pediatric surgery.[12] This strategy combines analgesic drugs and techniques with distinct mechanisms of action, resulting in greater analgesia while reducing opioid use and associated side effects.[13] Paracetamol, nonsteroidal anti-inflammatory medications (NSAIDs), local anesthetic wound infiltration, nefopam for adolescent (aged more than 12) and the appropriate use of opioids as rescue treatment are all common components of multimodal analgesia. The synergistic impact of various modalities enables greater pain management with lower individual medication dosages.[14-15]

Multimodal analgesia during the perioperative period stabilizes hemodynamic responses to surgical stimuli, and allows for a smoother emergence from anesthesia.[16] It has been proven to improve postoperative pain scores, ncrease patient comfort, encourage early ambulation and oral intake, and limit the occurrence of opioid-related adverse effects.[17] Importantly, most components of multimodal analgesia are affordable, widely available, and simple to administer, making this method ideal for limited healthcare facilities.[18]

Advanced regional anesthetic treatments, such as ultrasound-guided peripheral nerve blocks like transversus abdominis plane block (TAP block), may not be routinely accessible at Mosul Hospitals, and conventional analgesic regimens are often used for postoperative pain management. Additionally, there are limited range of drugs in Mosul hospitals. For instance, there is no morphine as a narcotic pain killer to relieve the postoperative pain for most ages of children in the governmental surgical ward. Moreover, there is no tramadol for children 12-14 years. Evaluating perioperative and postoperative pain management measures using easily available drugs has the potential to improve analgesic practices, patient outcomes, and the quality of pediatric surgical care.

The aim of this study is to evaluate the efficacy of multimodal analgesia in the perioperative and postoperative management of pain in children undergoing appendectomy at Mosul city, Ibn Al-Atheer Teaching Hospital, Republic of Iraq, with a focus on pain scores, opioid requirements and adverse effect.

2. PATIENTS AND METHODS

This is a hospital-based prospective observational study. It was conducted between the 1st of July of year 2025 to the 10th of November of year 2025 at Mosul city, Ibn Al-Atheer Teaching Hospital, Republic of Iraq. The study included 63 patients. The age of children involved in this study was from 4-14 years. Ethical approval was obtained from the Directorate of Health at Mosul and the administration of Ibn Al-Atheer Teaching Hospital in Mosul. Written informed consent was obtained from the parents. Patient confidentiality was strictly maintained.

All of the children aged less than 14 years, who underwent either open or laparoscopic appendectomy for acute appendicitis were enrolled in the study. Additionally, all of the patients had American Society of Anaesthesiologists (ASA) physical status of I or II. On the other hand, those patients with known allergy to study medications or those with chronic pain conditions or long-term analgesic use, or patients with developmental delay or neurological disorders affecting pain assessment and patients with complicated

appendicitis requiring additional procedures were excluded from the study.

Regarding the analgesic protocol, all of the patients received Fentanyl in a dose of 1 mcg/kg but can be increased into 2-3 mcg/kg during operation according to relief of pain that's measured by heart rate by the use of pulse oximetry together with other clinical observations such as sweating, tachycardia, tachypena. Paracetamol 15 mg/kg during operation then every 6 hours at everyday of postoperative period according to pain sensation (in other word; 4 times daily until disappearance and discontinuation of pain, diclofenac whenever needed at recovery in a dose of 1 mg/kg every 8 hours (in other word; 3 times daily). As well as lignocaine 2% plain kind as a skin infiltration technique, before skin incision (for example grid iron incision) and after wound suturing at the end of operation. Ketamine 0.25-0.5 mg/kg was given during immediate postoperative recovery stage in the presence of mild-severe pain respectively.

The investigator conducted direct interviews with parents to complete self-administered questionnaires. The questionnaire was composed from five parts. The first part for patients' demographic information such as name, age and gender. The second part for patient type of surgery. The third part patients' postoperative (visual analogue scale pain scores) which is a 10-cm horizontal line. Anchors read "no pain" at one end and "worst pain imaginable" at the other. The child marks a point on the line to express the pain. The score is measured in millimeters (0-100) or converted to a 0–10 scale, in addition to patient general condition such as sleeping, moving in the ward, sitting in the bed and started eating or not yet. The fourth part for patients' doses of drugs, and possible complications such as nausea, vomiting, visual and/or auditory hallucination, over sedation, cyanosis, need for additional opioid or other drugs. The fifth part for the time of general anesthesia needed in order to complete the operation. The primary outcomes were to evaluate postoperative pain score at time of immediate recovery and at 2, 4, and 8 hours after operation, whereas the secondary outcomes were to assess the patients' side effect of drugs, such as hallucination and secondary outcome.

The information gathered was processed, categorized, and evaluated using relevant statistical significance tests. Statistical analysis was conducted using SPSS version 30.0 (SPSS Inc., Chicago, USA). Quantitative data were presented as mean ± standard deviation and medium (interquartile range). Qualitative data were presented as frequency and percentages. A p value of <0.05 was considered statistically significant.

RESULTS

The study includes 63 pediatric age patients; of them 27 patients were male and 36 patients were females. Male: Female ratio was 1:1.33. The mean age ± standard deviation of the study patients was 11.02 ± 1.83 years. As shown in figure 1.

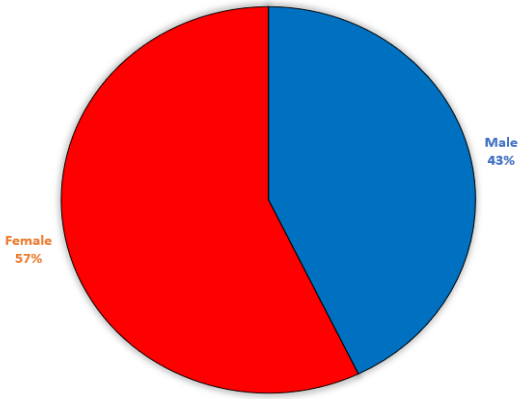

Figure 1: Distribution of the study patients according to their gender.

The majority of patients underwent open appendectomy. As shown in figure 2.

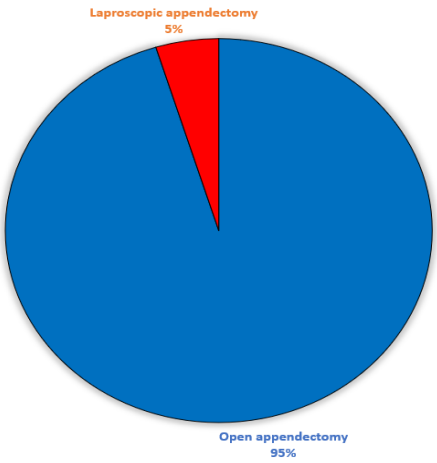

Figure 2: Distribution of the study patients according to their type of surgery.

All patients were given a standardized multimodal analgesia regimen that included paracetamol (15mg/kg), diclofenac (1mg/kg), local anesthetic wound infiltration of lignocaine (plain 2%) twice before skin incision and after wound closure instead of plain bupivacaine due to lack of plain bupivacaine in the governmental hospitals. While opioid analgesics like fentanyl (1-3 µg/kg) was used during the surgical operation as a part of the general anesthesia to eliminate the pain. Ketamine HCL was given at immediate phase of recovery period. Furthermore, about 30 patients out of 63 patients didn't need ketamine at immediate recovery period because they didn't develop pain at that time period. The mean time ± standard deviation of general anesthesia was 46.03 ± 11.46 minutes.

Table 3.1 shows the mediums (interquartile range) of pain severity according to visual analogue scale (VAS). At all of the time interval, the medium of VAS was less

than 3 (in other word, mild pain). Of note, the interquartile range of VAS was ranged from 0-2 at immediate recovery time to 2-5 at four hours after operation. Anyhow, statistically significant difference between them (P value = 0.029) with higher pain occurred 4 hours after operation.

Table 3.1: Mediums and interquartile ranges of pain severity according to visual analogue scale (VAS) at different time intervals (number=63).

Visual analogue score	Medium (interquartile range)
Immediate recovery time	2 (0-2)
Two hours after operation	0 (0-5)
Four hours after operation	2 (2-5)
Eight hours after operation	0 (0-3)
P value = 0.029	

Table 3.2 shows the mediums (interquartile range) of patients' pulses at different time interval. No statistically significant difference between them at different time interval.

Table 3.2: Mediums and interquartile ranges of patients' pulses at different time interval (number=63).

Pulse rate	Medium (interquartile range)
Immediate recovery time	83 (78-96)
Two hours after operation	81 (88-97)
Four hours after operation	86 (80-97)
Eight hours after operation	87 (80-95)
P value = 0.567	

Table 3.3 shows the mediums (interquartile range) of patients' oxygen saturation at different time interval. No statistically significant difference between them at different time interval.

Table 3.3: Mediums and interquartile ranges of patients' oxygen saturation at different time interval (number=63).

Oxygen saturation	Medium (interquartile range)
Immediate recovery time	98 (97-99)
Two hours after operation	99 (98-99)
Four hours after operation	99 (98-99)
Eight hours after operation	99 (98-99)
P value = 0.268	

Table 3.4 shows the mediums (interquartile range) of patients' respiratory rate at different time interval. No statistically significant difference between them at different time interval.

Table 3.4: Mediums and interquartile ranges of patients' respiratory rate at different time interval (number=63).

Respiratory rate	Medium (interquartile range)
Immediate recovery time	19 (16-25)
Two hours after operation	18 (16-24)
Four hours after operation	18 (16-25)
Eight hours after operation	18 (16-25)
P value = 0.729	

Table 3.5 shows post operative drug side effects reported by the patients. 6 (9.52%) patients developed nausea and vomiting, 14 (22.22%) developed moderate-severe pain necessitating additional opioid and 12 (19.04%) patients needed additional drugs other than opioid.

Table 3.5: Mediums and interquartile ranges of patients' side effect of drugs (number=63).

Complication	Number (%)
Nausea and vomiting	6 (9.52%)
Auditory and/ or visual hallucination	0 (0%)
Over sedation	0 (0%)
Cyanosis	0 (0%)
Need for additional opioid or nefopam	14 (22.22%)
Need for additional drug other than opioid or nefopam *	12 (19.04%)

* 6 patients need dexamethasone alone, 2 patients need dexamethasone with hydrocortisone, 2 patients need ondansetron, 1 patient needs midazolam and another 1 patient needs sugammedex.

4. DISCUSSION

The present discussion focuses on the function and beneficial effects of multimodal analgesia in pediatric appendicectomy, highlighting is effectiveness, safety, and impact on recovery outcomes. This method is especially useful in pediatric appendicectomy since children are more susceptible to opioid-related problems such as respiratory depression, nausea, vomiting, over sedation, addiction at high and frequent doses and constipation, as well as midazolam is useful for decreasing visual and auditory hallucination and vivid dream as a side effect of ketamine. The use of non-opioid analgesics as the core of pain treatment provides a good analgesia while reducing the need for opioids.

In contrast to other studies[19-20], the present study found acute appendicitis affect females more than males, this result might occur due to small sample size of the study population. Anyhow, acute appendicitis is a significant risk for both gender and diagnosis in females can be more complicated necessitating surgery. Additionally, the mean of patients age was around 11 years, as this is the period of peak size and abundance of lymphoid tissue in the appendix. This lymphoid tissue plays a key role in the pathophysiology of the condition. Similar findings obtained by Podany et al[21] and Armağan et al[22] studies.

Open approach of appendectomy was used in most of the study patients, in contrast to the modern studies[23-24] which show a significant shift towards laparoscopic approach, due to its benefits like faster recovery and fewer complications, though open approach remains common in very young children or complex cases where laparoscopy is challenging.[25] Furthermore, general anaesthesia last 45 minutes in average which runs with the typical range reported by other study.[26]

The present study found the pain scores were generally low to moderate during the first 8 hours postoperatively. Moreover, the pain intensity was significant more tense after 4 hours of operation, as well as most patients (77.77%) achieved adequate pain control without requiring additional opioid analgesia. Indicating that the multimodal analgesia is effective method for reducing perioperative and postoperative pain due to the synergistic analgesic effects of the used drugs. Teja had consistent findings.[27] Additionally, the study observed no significant adverse outcomes when multimodal appropriately used, depending on patients recorded vital signs, confirming the safety of this strategy in appendectomy pain relief, which in agreement with Özmert et al study findings.[28]

Regarding postoperative nausea and vomiting (PONV) which are common side effects of surgery and could be a side effects to any drug and not necessarily a particular drug per see, PONV was reported in minority of the study patients (9.52%), as multimodal analgesia directly contribute to lower this rate by sparing emetogenic opioids. Villeret et al showed comparable findings.[29] On the other hand, dexamethasone was frequently used in (12.69%) patients, which in agreement with Ng et al study findings.[30] Dexamethasone when given at operation of appendectomy to children with bronchial asthma or pneumonia or bronchitis it has a bronchodilator effect. In addition, it exerts antiemetic effect and analgesic criteria, therefore it helps to reduce postoperative nausea and vomiting and manage pain also as an aid at recovery period in the ward. This agent either given before induction of general anaesthesia, or during operation or at recovery area of operating theatre at immediate phase before sending the child to the ward.[31] Midazolam (given to one patient only) can be given before induction of general anaesthesia to sedate a child with anxiety, yet it can be given after end of surgical operation at immediate phase of recovery to eliminate the adverse effects of the analgesic dose of the frequently used ketamine such as auditory or visual hallucination according to anaesthesia guideline published by Cettler et al.[32] This selective individual use agrees published paediatric anaesthesia studies rather than routine administration.[33] the same with sugammedex to achieve rapid and reliable recovery from muscle relaxant as an antidote to only rocuronium and vecuronium that's much faster than the neostigmine, indicating sugammadex is reserved for specific cases which need prompt recovery rather than routine administration, Naguib et al showed similar results.[34] Regarding movement after operation in the surgical ward, most of the study patients move to toilet for micturition about 2-3 hours after appendectomy operation or even they moved outside the bed, sometimes to eliminate the chance of deep vein thrombosis (DVT) and other related complications of prolonged stay at bed. Moreover, most of study patients started oral feeding 12-18 hours after end of the operation, except for complicated appendectomy patients who may put a drain for the surgical wound may start oral feeding after three days behind the operation and these children were excluded from the study. Consistent to Cettler et al. study findings.[32]

The current study's limitations. First, due to the small sample size, the results may not be as generalizable to other populations. Second, the study was carried out in a single hospital environment, which may have compromised the external validity of the results.

5. CONCLUSIONS AND RECOMMENDATIONS

Multimodal analgesia is an effective and safe strategy for managing postoperative pain in children after appendectomy. This strategy, which combines analgesic drugs with various modes of action, provides better pain control than single-modality or opioid-based regimens. The use of paracetamol and NSAIDs as first-line drugs,

along with local anesthetic drug and a small dose of ketamine that's the analgesic dose at immediate phase of recovery period leads in lowering pain scores, less opioid intake and fewer opioid side effects.

Conflict of intertest

The authors of this study report no conflicts of interest.

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