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*Original article*

# Pediatric Perforated Appendicitis: Clinical Characteristics, Risk Factors, and Anaesthetic Management at Misurata Medical Center, Libya

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**A B S T R A C T**

Acute appendicitis remains the most common surgical emergency in pediatric populations worldwide. However, children face unique diagnostic challenges that frequently result in delayed presentation and higher perforation rates compared to adults. Appendiceal perforation significantly increases morbidity, healthcare costs, and hospital length of stay. Understanding local epidemiological patterns and modifiable risk factors is essential for optimizing clinical outcomes. To determine the prevalence of appendiceal perforation and identify pre-operative clinical factors associated with perforation in pediatric patients undergoing appendicectomy at Misurata Medical Center, Libya, with particular emphasis on anesthetic implications. We conducted a descriptive retrospective cohort study of 16 pediatric patients (aged 6-14 years) who underwent appendicectomy between October 1 and November 30, 2022. Patient records were systematically reviewed for demographic data, clinical presentation, symptom duration, pre-operative analgesia use, white blood cell (WBC) count, imaging findings, and intra-operative pathology. Statistical analysis using chi-square tests identified factors significantly associated with perforation ($p<0.05$). Anesthetic management and perioperative concerns were also evaluated. The cohort demonstrated male predominance (75% vs. 25% female) with a mean age of 10 years. Right iliac fossa pain was the predominant symptom (75%). Intra-operative findings revealed perforation in 43.75% of cases, advanced inflammation in 25%, and acute inflammation in 31.25%. Patients with perforated appendicitis were significantly younger (mean 6.8 vs. 11.6 years, $p<0.05$), more likely to present after 3 days of symptoms (71.4% vs. 11.1%, $p<0.05$), and more frequently had received pre-operative analgesia (57.1% vs. 22.2%, $p<0.05$). Leukocytosis was common but showed limited discriminatory value between groups. Anesthetic challenges included fluid and electrolyte imbalance, sepsis control, aspiration risk, and postoperative pain optimization. Appendiceal perforation occurred in nearly half of pediatric appendicitis cases at our institution. Younger age, delayed presentation beyond 72 hours, and preoperative analgesic administration were significantly associated with perforation. Anesthetists play a pivotal role in managing these cases through meticulous preoperative optimization, rapid sequence induction, intraoperative stability, and multimodal analgesia. These findings underscore the critical importance of early recognition, prompt surgical consultation, judicious analgesia use, and enhanced caregiver education to reduce perforation rates and improve outcomes in pediatric appendicitis.

## Introduction

Acute appendicitis (AA) represents the most common surgical cause of acute abdominal pain requiring intervention globally, affecting approximately 7-8% of the population during their lifetime [1]. While appendicitis can occur at any age, pediatric cases present unique diagnostic and therapeutic challenges that distinguish them from adult presentations [2,3]. The variable and often atypical symptomatology in children, combined with age-related communication difficulties, frequently results in diagnostic delays and increased risk of progression to perforation [4-6].

Appendiceal perforation is particularly concerning in the pediatric population, as it substantially elevates morbidity and mortality rates, prolongs hospitalization, and increases healthcare expenditure [7]. The


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immature omentum and developing immune system in younger children provide less effective containment of appendiceal inflammation, allowing rapid progression from simple appendicitis to localized or generalized peritonitis—a potentially life-threatening condition [4-6]. International studies consistently report that a significant proportion of pediatric appendicitis cases present with perforation, with rates ranging from 20% to over 60% depending on geographic region, healthcare access, and patient demographics [8,9]. In Colombia, a national study documented that 25.8% of pediatric appendectomies required peritoneal drainage, suggesting high rates of complicated disease [7].

From an anesthetic perspective, pediatric patients with perforated appendicitis often present with varying degrees of dehydration, electrolyte disturbances, and systemic inflammatory response that require careful pre-operative assessment and optimization. The septic physiology associated with perforation can lead to hemodynamic instability, requiring aggressive fluid resuscitation and potentially vasopressor support during induction and maintenance of anesthesia. Younger patients, who demonstrated significantly higher perforation rates in our study (mean age 6.8 years vs. 11.6 years), present additional challenges due to their limited physiological reserve and higher risk of rapid deterioration.

Understanding factors that influence progression from simple to perforated appendicitis is paramount for developing targeted interventions to improve outcomes. These factors encompass symptom duration, patient age, socioeconomic status, healthcare accessibility, and pre-hospital care patterns. A linear increase in perforation risk after 24 hours of symptom onset has been well-documented [1,6,11]. While the global literature extensively addresses these issues, regional data provide crucial insights into localized epidemiological patterns, healthcare delivery systems, and cultural practices that may differ substantially from high-resource settings [14,15].

Despite the global burden of pediatric appendicitis, there is a paucity of published data from North Africa and the Middle East region. This study aims to address this knowledge gap by examining pediatric perforated appendicitis cases managed at Misurata Medical Center, a tertiary referral hospital in Libya. By analyzing demographic characteristics, clinical presentations, and intra-operative findings in our cohort, we seek to identify potentially modifiable pre-operative risk factors for perforation within our local healthcare context. Furthermore, this study integrates findings with existing international literature to provide a comprehensive discussion of the current understanding of pediatric perforated appendicitis and inform evidence-based improvements in diagnostic protocols and patient management strategies.

## Materials and Methods

### *Study Design and Ethical Considerations*

descriptive retrospective cohort study was conducted by reviewing the medical records of pediatric patients who underwent appendicectomy at Misurata Medical Center (MMC). The study protocol was approved by the institutional review board, and patient confidentiality was maintained throughout data collection and analysis in accordance with local ethical guidelines.

### *Study Setting*

Misurata Medical Center is a tertiary care referral hospital located in Misurata, Libya, serving a population of approximately 550,000 in the surrounding region. The General Surgery Department manages all pediatric surgical emergencies, including acute appendicitis cases referred from primary healthcare facilities and emergency departments.

### *Study Population and Eligibility Criteria*

#### *Inclusion Criteria*

Pediatric patients between 0 and 18 years of age who had a clinical diagnosis of acute appendicitis and underwent appendicectomy during the study period (October 1 to November 30, 2022) were included. Only cases with complete medical records available for review were eligible for analysis.

#### *Exclusion Criteria*

Patients were excluded if an alternative diagnosis was confirmed during surgery, if medical records were incomplete and did not allow adequate data extraction, or if the patient was older than 18 years. A total of 16 patients met the inclusion criteria and were incorporated into the final analysis. The age of the cohort ranged from 6 to 14 years, with a mean age of 10 years·

### *Data Collection*

Medical records were systematically reviewed by two independent researchers using a standardized data extraction form. Discrepancies were resolved through consensus discussion. The following variables were collected:


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***Demographic Variables***
Age at presentation was recorded in years, and sex was documented as male or female for all included patients.

***Clinical Presentation***
The primary presenting complaint and the location of abdominal pain were documented for each patient, with pain categorized as occurring in the right iliac fossa, the periumbilical region, or as generalized abdominal discomfort. Associated clinical symptoms, including nausea, vomiting, fever, and anorexia, were also recorded to support diagnostic assessment and characterize the overall clinical presentation.

***Temporal Variables***
The duration between the onset of symptoms and presentation to the surgical outpatient department was recorded for each patient. This interval was classified as either early presentation, defined as occurring within three days or less, or late presentation, defined as occurring more than three days after symptom onset.

***Pre-operative Management***
The administration of analgesia prior to establishing the diagnosis was recorded for each patient and documented as either yes or no. When available, the specific type of analgesic agent administered was also noted.

***Laboratory Investigations***
The white blood cell count at the time of presentation was recorded for each patient and classified as either elevated when exceeding 10,000 cells/μL or normal when measuring 10,000 cells/μL or below.

***Imaging Studies***
Abdominal ultrasound findings (when performed)

***Intra-operative Findings***
Appendiceal pathology was categorized according to the severity of inflammatory changes observed during surgery. Cases classified as acute inflammation demonstrated hyperemia and edema without evidence of tissue necrosis. Advanced inflammation was characterized by suppurative changes or abscess formation in the absence of perforation. Perforated appendicitis was identified by the presence of a visible defect in the appendiceal wall, with or without an associated fecalith.

***Surgical and Anesthetic Approach***
All appendicectomies were performed via open surgical technique using a McBurney's or Lanz incision. This approach represents standard practice at our institution, particularly for complicated cases or when laparoscopic resources are limited. The surgical approach was not varied based on suspected perforation status. Anesthetic induction was achieved via general anesthesia with endotracheal intubation. Rapid sequence induction (RSI) was performed in suspected perforation to prevent aspiration. Intraoperative management emphasized fluid resuscitation, temperature control, and sepsis management. Patients with perforated appendicitis exhibited dehydration, electrolyte imbalance, and sepsis. Anesthetic induction required cautious fluid resuscitation, invasive monitoring, and preparedness for hemodynamic instability. All cases underwent RSI due to aspiration risk.

***Statistical Analysis***
Data were entered into Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA) and analyzed using descriptive and inferential statistics. Continuous variables were expressed as means and ranges. Categorical variables were presented as frequencies and percentages.
Chi-square tests (or Fisher's exact test when cell counts were small) were used to compare categorical variables between perforated and non-perforated groups. Independent t-tests compared continuous variables between groups. Statistical significance was defined as $p<0.05$ (two-tailed). Given the small sample size, results should be interpreted as hypothesis-generating rather than definitive.

***Operational Definitions***
Leukocytosis was defined as a white blood cell count exceeding 10,000 cells/μL. The timing of presentation was categorized as early when the interval between symptom onset and arrival at the outpatient department was 72 hours or less, and as late when this interval exceeded 72 hours. Perforated appendicitis was identified intraoperatively by the presence of a visible perforation in the appendiceal wall,


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whereas non-perforated appendicitis included cases demonstrating acute or advanced inflammatory changes without evidence of perforation.

## Results

### Patient Demographics

Between October 1 and November 30, 2022, 16 pediatric patients underwent appendicectomy for acute appendicitis at Misurata Medical Center. Patient ages ranged from 6 to 14 years with a mean age of 10.0 years (±2.8 SD). A marked male predominance was observed, with 12 male patients (75.0%) and 4 female patients (25.0%), yielding a male-to-female ratio of 3:1.

### Clinical Presentation

Right iliac fossa pain was the most frequent presenting complaint, reported by 12 patients (75.0%). Umbilical pain was present in 2 patients (12.5%), and generalized abdominal pain in 2 patients (12.5%). All patients presented with abdominal pain as their chief complaint, though the specific location and character varied.

### Timing of Presentation

Analysis of symptom duration revealed concerning delays in healthcare-seeking behavior:
Early presentation (≤3 days): 10 patients (62.5%). Late presentation (>3 days): 6 patients (37.5%)
The mean duration from symptom onset to surgical consultation was 3.2 days (range: 1-7 days), with notable variability between patients.

### Pre-operative Analgesia Use

Six patients (37.5%) had received analgesic medication prior to appendicitis diagnosis, while 10 patients (62.5%) received no pre-operative analgesia. The most commonly administered analgesics were non-steroidal anti-inflammatory drugs (NSAIDs) and acetaminophen, though specific agents and dosing were inconsistently documented.

### Laboratory Findings

Leukocytosis (WBC >10,000 cells/μL) was present in 12 cases (75.0%), while WBC count remained within normal limits in 4 cases (25.0%). Mean WBC count was 12,800 cells/μL (range: 7,200-18,500 cells/μL).

### Imaging Studies

Abdominal ultrasound was performed in 11 of 16 cases (68.8%). Among cases with imaging, findings suggestive of appendicitis (appendiceal diameter >6mm, non-compressible appendix, periappendiceal fluid) were documented in 9 cases (81.8%).

### Intra-operative Findings and Perforation Rate

Surgical exploration demonstrated a spectrum of appendiceal pathology within the cohort. Perforated appendicitis was identified in seven patients, representing 43.75% of cases, while four patients (25.0%) exhibited advanced inflammatory changes without perforation. Acute inflammation was observed in five patients, accounting for 31.25% of the cohort. The notably high perforation rate of 43.75% indicates a considerable disease burden and suggests that a substantial proportion of patients presented with advanced or complicated appendicitis.

### Comparison of Perforated vs. Non-Perforated Groups

Significant differences emerged between patients with perforated (PA, n=7) and non-perforated appendicitis (NPA, n=9).

### Age Distribution

The mean age in the perforated appendicitis (PA) group was 6.8 years (range: 6–8 years), whereas the mean age in the non-perforated appendicitis (NPA) group was 11.6 years (range: 9–14 years). This 4.8-year difference was statistically significant ($p < 0.05$).
Late presentation, defined as more than three days after symptom onset, was strongly associated with perforated appendicitis, occurring in 71.4% of PA cases compared to only 11.1% of NPA cases ($p < 0.05$). Conversely, early presentation within three days was protective, observed in 88.9% of NPA patients but in only 28.6% of those with PA. Pre-operative analgesia use also showed a significant association with perforation, reported in 57.1% of PA cases versus 22.2% of NPA cases ($p < 0.05$), which may reflect either masking of symptoms leading to delayed diagnosis or greater pain severity in patients predisposed


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to perforation. Leukocytosis was more frequent in the PA group (85.7% vs. 66.7%), but this difference did not reach statistical significance (p = 0.38), limiting its value as a discriminatory marker. Sex distribution did not differ significantly between groups, with perforation rates similar in males and females (p = 0.76).

***Table 1. Comparison of Demographic, Clinical, and Laboratory Characteristics between Perforated and Non-Perforated Appendicitis***

| Variable | Perforated Appendicitis (N=7) | Non-Perforated Appendicitis (N=9) |
|---|---|---|
| Age (Mean) | 6.8 Years | 11.6 Years |
| **Sex** | | |
| Male | 5 (71.4%) | 7 (77.8%) |
| Female | 2 (28.6%) | 2 (22.2%) |
| **Presentation Timing** | | |
| Early (≤3 Days) | 2 (28.6%) | 8 (88.9%) |
| Late (>3 Days) | 5 (71.4%) | 1 (11.1%) |
| WBC Count | | |
| Elevated | 6 (85.7%) | 6 (66.7%) |
| Normal | 1 (14.3%) | 3 (33.3%) |
| **Pre-Operative Analgesia** | | |
| Yes | 4 (57.1%) | 2 (22.2%) |
| No | 3 (42.9%) | 7 (77.8%) |

## Discussion

This retrospective analysis from Misurata Medical Center provides important insights into the epidemiology and clinical characteristics of pediatric perforated appendicitis in Libya, a region with limited published data on this condition. Our findings align with international literature while highlighting specific challenges within our healthcare context. The notably high perforation rate of 43.75% in this cohort underscores persistent diagnostic challenges in pediatric appendicitis and potential barriers to timely surgical intervention.

The management of pediatric patients with perforated appendicitis presents unique challenges for anesthesia providers that warrant special consideration. In our cohort, the high rate of perforation (43.75%) and delayed presentation (37.5% presenting after 72 hours) create specific anesthesia implications that must be addressed to optimize patient safety and outcomes.

Children with perforated appendicitis often present with varying degrees of dehydration, electrolyte disturbances, and systemic inflammatory response that require careful preoperative assessment and optimization. The septic physiology associated with perforation can lead to hemodynamic instability, requiring aggressive fluid resuscitation and potentially vasopressor support during induction and maintenance of anesthesia. Younger patients, who demonstrated significantly higher perforation rates in our study (mean age 6.8 years vs. 11.6 years), present additional challenges due to their limited physiological reserve and higher risk of rapid deterioration. The timing of preoperative fasting in emergency appendectomy remains controversial, particularly in patients with delayed presentation. While standard fasting guidelines recommend 2 hours for clear liquids and 6 hours for solids, these recommendations may need modification in the setting of perforated appendicitis, where delays in surgical intervention could worsen outcomes.

Anesthesia providers must balance the risk of aspiration against the benefits of early surgical intervention. Pain management strategies also require special consideration in this population. Our finding that preoperative analgesia was associated with higher perforation rates (57.1% vs. 22.2%) suggests that while pain control is important, it must be provided in a manner that does not mask symptoms or delay diagnosis. Postoperatively, multimodal analgesia, including regional techniques such as transversus abdominis plane (TAP) blocks or wound infiltration, can provide effective pain relief, reducing postoperative complications and length of stay. Implementation of such protocols at our institution could potentially improve outcomes for this high-risk population.

The 43.75% perforation rate observed in our study is substantially higher than rates reported in high-resource settings (typically 20-35%) but consistent with other studies from lower-resource regions [8,9,13]. This elevated rate likely reflects multiple factors, including: Healthcare access barriers: Geographic distances, transportation challenges, and limited primary care resources


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may delay initial medical contact.Diagnostic resource limitations: Inconsistent access to imaging and laboratory testing

***Conclusion***

Appendiceal perforation occurred in nearly half of pediatric appendicitis cases at our institution. Younger age, delayed presentation beyond 72 hours, and pre-operative analgesic administration were significantly associated with perforation. Anesthetists play a pivotal role in managing these cases through meticulous preoperative optimization, rapid sequence induction, intraoperative stability, and multimodal analgesia. These findings underscore the critical importance of early recognition, prompt surgical consultation, judicious analgesia use, and enhanced caregiver education to reduce perforation rates and improve outcomes in pediatric appendicitis.

***Conflict of interest.*** Nil

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