

Inflammatory and Molecular Determinants of Disease Severity in Pediatric Acute Abdomen: Implications for Surgical Decision-Making

Maite Raquel Figueroa Montilla¹, Patricia Johanna Muyulema Campoverde², Verónica Viviana Vásquez Villamil³, Dilanys María Ferrer Parejo⁴

¹ ResearchCycles, United States. Email: researchers@researchcycles.com. ORCID: <https://orcid.org/0009-0003-9921-5641>

² Universidad Católica de Cuenca – Cuenca, Ecuador. Email: pjmuyulemac55@est.ucacue.edu.ec. ORCID: <https://orcid.org/0009-0000-1911-1788>

³ Universidad del Tolima – Ibagué, Colombia. Email: vvasquezv@gmail.com.

⁴ Universidad Simón Bolívar – Barranquilla, Colombia. Email: dilanysmaria15@gmail.com

ABSTRACT

Acute paediatric abdomen is a frequent emergency in paediatric surgery, with acute appendicitis being the most common surgical cause. In recent decades, laparoscopy has progressively displaced laparotomy as the standard approach in hemodynamically stable children, although controversies persist in complex scenarios such as complicated appendicitis or abdominal trauma. This article aims to compare, based on the evidence published in the last five years, the results of surgical management of pediatric acute abdomen using open and laparoscopic techniques, considering indicators of safety, efficacy and postoperative recovery. A narrative review of the literature in biomedical databases was conducted, including observational studies, clinical trials, and systematic reviews on acute appendicitis, abdominal trauma, and other causes of acute abdomen in children under 18 years of age. Recent evidence suggests that laparoscopy is consistently associated with less postoperative pain, reduced hospital stay, and a lower rate of surgical wound infection, with no overall increase in intra-abdominal complications, even in complicated appendicitis, when applied in experienced centers. However, open surgery continues to be necessary in unstable patients, in contexts of limited resources or in contraindications to pneumoperitoneum. It is concluded that laparoscopy should be considered the technique of choice in the management of acute pediatric abdomen in appropriately selected patients, reserving the open approach for specific situations.

Keywords: *acute pediatric abdomen; acute appendicitis; laparoscopy; laparotomy; pediatric surgery.*

INTRODUCTION

Acute paediatric abdomen represents one of the most frequent and challenging reasons for consultation in children's surgical emergency departments. It is characterized by a sudden onset of abdominal pain associated with clinical signs that suggest a potentially serious pathology and that often requires immediate surgical intervention to avoid complications such as sepsis, perforation, or hemodynamic compromise (Kurian et al., 2024). In the pediatric population, the evaluation of acute abdomen is particularly complex due to clinical variability according to age, limited expressive language in infants and preschoolers, and increased susceptibility to dehydration and rapid clinical deterioration (Pediatria Integral, 2024).

In recent years, acute appendicitis has continued to consolidate itself as the main surgical cause of acute abdomen in children and adolescents, representing between 30% and 70% of urgent interventions in pediatric surgery according to different series (Nikolov et al., 2024). However, other pathologies, such as intussusception, intestinal volvulus, incarcerated hernias, complicated Meckel's diverticulum, secondary peritonitis, and abdominal trauma, also contribute to the clinical picture and require prompt and safe surgical decision-making (Bašković et al., 2024). The etiological diversity requires a comprehensive diagnostic approach based on clinical-radiological correlation, where ultrasound remains the initial tool of choice due to its safety and efficacy in the pediatric population (Wadood & Sams, 2020).

Historically, laparotomy has been the standard procedure for the surgical management of acute pediatric abdomen. However, with the advancement of minimally invasive surgery, laparoscopy has gained prominence for its advantages, including reduced postoperative pain, shorter recovery times, fewer wound complications, and better aesthetic outcomes (Neogi et al., 2021). This change has been especially evident in acute appendicitis, where multiple systematic reviews have demonstrated the safety and efficacy of the laparoscopic approach even in cases of complicated, perforated, or diffuse peritonitis appendicitis (Makkadafi et al., 2024; Pham et al., 2023).

Laparoscopy not only provides benefits in inflammatory pathologies but has also expanded to the field of abdominal trauma. In hemodynamically stable pediatric patients, its use can reduce the number of negative laparotomies, improve the diagnostic evaluation of hollow viscera lesions, and offer less invasive therapeutic solutions (Bašković et al., 2024). However, its use remains limited by factors such as equipment availability, specialized training required, and the relative contraindication of pneumoperitoneum in unstable patients. The COVID-19 pandemic introduced new challenges and presentation patterns of acute abdomen. Recent studies have pointed to an increase in cases diagnosed in advanced stages, such as perforated appendicitis, attributed to delayed consultation and gastrointestinal manifestations of SARS-CoV-2 that mimic acute abdomen (Abo-Halawa et al., 2024). These findings have reinforced the need for an agile and safe surgical approach, regardless of epidemiological fluctuations.

In this context, the comparison between open and laparoscopic surgical techniques acquires strategic relevance to optimize pediatric care. Although laparoscopy has demonstrated extensive advantages, there are still scenarios where open surgery continues to be essential, especially in the face of limited resources, complex conditions, or a lack of specialized surgical experience (Nikolov et al., 2024). Decision-making, therefore, must be based on recent scientific evidence, but also on the individualisation of the paediatric patient and the healthcare reality of each centre. The purpose of this study is to comparatively analyze the clinical, perioperative and postoperative results of both surgical approaches in the management of acute pediatric abdomen, with the purpose of offering an updated vision that contributes to the improvement of surgical practice in this age group.

THEORETICAL FRAMEWORK

Acute pediatric abdomen encompasses a set of clinical entities characterized by sudden, progressive, and potentially severe abdominal pain, which requires immediate evaluation to rule out pathologies that compromise the life or integrity of the patient (Kurian et al., 2024). This concept integrates both surgical and non-surgical causes, which vary according to the age, neurological development, and inflammatory response of children, elements that directly influence clinical presentation and surgical decision-making (Pediatria Integral, 2024).

Epidemiology and clinical relevance of pediatric acute abdomen

Acute appendicitis is the most common surgical cause of acute abdomen in children, with a peak incidence between 10 and 14 years of age. Recent studies show that up to 30–70% of pediatric emergency surgeries involve appendectomies (Nikolov et al., 2024). Although its diagnosis may be simple in adolescents, in

infants and preschoolers the presentation is usually more nonspecific, which is related to a high proportion of perforated appendicitis in this age group (Makkadafi et al., 2024). Other relevant pathologies include intussusception, intestinal volvulus, primary bacterial peritonitis, abdominal trauma, and complications of Meckel's diverticulum, all of which are amenable to urgent surgical management (Bašković et al., 2024). The prevalence of these conditions varies by region, access to health services, and population characteristics. The COVID-19 pandemic significantly impacted the presentation patterns of the acute abdomen. An increase in severe cases was observed in children, likely due to delays in consultation and overlap with gastrointestinal symptoms of SARS-CoV-2 (Abo-Halawa et al., 2024).

Diagnostic evaluation of acute pediatric abdomen

Clinical and analytical examination

The evaluation should begin with a detailed medical history and a thorough physical examination, looking for signs of peritoneal irritation, fever, bilious vomiting, and abdominal distension. In children, the expression of symptoms may be ambiguous, which justifies the use of scales such as the Pediatric Appendicitis Score to support the diagnostic suspicion (Kurian et al., 2024).

Laboratory tests include inflammatory biomarkers (CRP, leukocytosis, procalcitonin), which, although not specific, allow estimating severity and risk of perforation.

Diagnostic imaging

Abdominal ultrasound is the imaging test of first choice due to its high sensitivity, absence of radiation, and availability in most pediatric centers (Wadood & Sams, 2020). CT scans are reserved for complex or traumatic cases, while MRI is increasingly being used in specialized settings to avoid unnecessary radiation exposure (Kurian et al., 2024).

Open surgery on the acute pediatric abdomen

Open surgery, by laparotomy, has been the standard for abdominal emergencies in children for decades. Its main advantage is direct and wide access to the surgical field, which facilitates the resolution of complex conditions such as severe peritonitis, multiple abdominal trauma or intra-abdominal masses (Bašković et al., 2024). However, recent studies indicate that laparotomy is associated with a significant increase in surgical wound complications, greater postoperative pain, and longer hospital stays compared to laparoscopy (Nikolov et al., 2024). A higher incidence of post-surgical adhesions has also been observed, which may predispose to future intestinal obstructions.

Laparoscopic surgery in the acute pediatric abdomen

Laparoscopy has emerged as the preferred approach in the surgical management of acute pediatric abdomen, especially in acute appendicitis. Among its main advantages are less trauma to the abdominal wall, decreased postoperative pain, faster functional recovery, and a lower rate of surgical site infections (Neogi et al., 2021).

In the case of complicated appendicitis, recent literature shows that laparoscopy is as safe as open surgery, with no significant increase in the incidence of intra-abdominal abscesses and a favorable trend in patient recovery and satisfaction (Pham et al., 2023; Makkadafi et al., 2024).

Comparison between laparoscopy and laparotomy

The latest meta-analyses confirm that, for most surgical pathologies of the acute paediatric abdomen, laparoscopy offers better clinical results, provided that it is performed in centres with sufficient experience (Nikolov et al., 2024; Perbandingan Luanan..., 2023). However, the choice of approach depends on factors such as:

- Hemodynamic stability of the patient
- Complexity of the painting

- Surgeon Experience
- Technology availability
- Contraindications of pneumoperitoneum

Role of laparoscopy in pediatric abdominal trauma

In blunt abdominal trauma, the current trend is to prioritize nonoperative management in stable patients. However, laparoscopy has established itself as a safe method for diagnostic and therapeutic evaluation in selected cases, reducing the need for unnecessary exploratory laparotomies (Bašković et al., 2024).

Table 1. Main causes of acute pediatric abdomen

Category	Main pathologies	Clinical Comments
Inflammatory	Acute appendicitis, peritonitis, inflamed Meckel's diverticulum	Higher prevalence in schoolchildren and adolescents
Obstructive	Invagination, volvulus, strangulated hernia	High surgical urgency in infants
Infectious	Gastroenteritis severa, MIS-C abdominal	Can simulate surgical pathology
Trauma	Hepatic, splenic, intestinal injury	Management depends on hemodynamic stability

(Authors' elaboration based on Kurian et al., 2024; Comprehensive Pediatrics, 2024; Bašković et al., 2024)

Table 2. Comparison between open and laparoscopic surgery in children

Parameter	Open surgery	Laparoscopic surgery
Postoperative pain	Elder	Minor
Hospital stay	Prolonged	Short
Wound complications	Most frequent	Less common
Intra-abdominal abscesses	Similar	Similar
Surgical times	More homogeneous	Variables according to experience
Cost	Minor	Higher in some centers
Main advantage	Wide access	Rapid recovery

(Based on Neogi et al., 2021; Nikolov et al., 2024; Makkadafi et al., 2024)

Table 3. Relative Indications for Laparoscopy in Pediatric Acute Abdomen

Clinical situation	Relevance of laparoscopy
Apendicitis simple	Ideal
Complicated appendicitis	Safe in trained centers
Uncertain diagnosis	Useful for exploration
Stable abdominal trauma	It can be diagnostic and therapeutic
Unstable patient	Contraindicated

(Based on Bašković et al., 2024; Pham et al., 2023)

METHODOLOGY

The present study corresponds to a narrative review of the literature aimed at comparing the clinical results of surgical management of the acute pediatric abdomen using open and laparoscopic techniques. This type of review makes it possible to integrate recent findings, identify knowledge gaps, and contextualize advances in pediatric surgery (Kurian et al., 2024; Nikolov et al., 2024).

Study design

A systematized narrative review was carried out, following methodological criteria similar to those proposed by Barnett et al. (2020) for structured clinical reviews, in order to ensure completeness, clarity, and rigor in the selection and analysis of the literature. The comparative approach was based on including

clinical studies (clinical trials, cohorts, case-control studies) and systematic reviews evaluating open and laparoscopic surgical interventions in the pediatric population with acute abdomen. Evidence published between January 2020 and January 2025 was prioritized to ensure timeliness and relevance (Nikolov et al., 2024; Makkadafi et al., 2024).

Sources of information

The following databases were consulted:

- PubMed/MEDLINE
- Scopus
- Web of Science
- ScienceDirect
- SciELO

These platforms contain most of the relevant studies in pediatric surgery, trauma, and minimally invasive techniques, considered reliable sources and widely used in biomedical research (Neogi et al., 2021).

Search strategy

The strategy was designed in accordance with the PRISMA recommendations adapted to narrative reviews. MeSH terms and keywords in English and Spanish related to pediatric acute abdomen were used.

3.1 Boolean keywords and operators

Combinations were generated with the AND/OR operators:

- “Pediatric acute abdomen” AND “laparoscopy”
- “Pediatric appendicitis” AND (“laparoscopic surgery” OR “open surgery”)
- “Abdominal trauma” AND “children” AND “laparoscopy”
- “Pediatric minimally invasive surgery” AND “appendectomy”
- “Open appendectomy” OR “laparotomy” AND “pediatric patients”

Filters were used by year (2020–2025), language (English and Spanish), and population (children).

Table 1. Search strategy and operators used

Database	Main Terms	Filters applied
PubMed	“Pediatric acute abdomen”, “laparoscopic appendectomy”, “open surgery”	2020–2025, Human, <18 years old
Scopus	“Pediatric surgery”, “abdominal trauma children”, “laparoscopy”	Year, medical theme
Web of Science	“Minimally invasive pediatric surgery”, “appendicitis”	Peer Review
SciELO	"Pediatric appendicitis," "laparoscopic surgery"	Spanish/Portuguese Language

Inclusion and exclusion criteria

Inclusion

- Studies published between 2020 and 2025.
- Population: children and adolescents (<18 years old).
- Pathologies: acute surgical abdomen (appendicitis, trauma, volvulus, peritonitis).
- Comparison between open and laparoscopic surgery or analysis of laparoscopic performance alone.
- Designs: clinical trials, cohorts, retrospective studies, and systematic reviews/meta-analyses (Neogi et al., 2021; Pham et al., 2023).

Exclusion

- Studies in adults.
- Publications prior to 2020.
- Letters to the editor without clinical data or case series with fewer than 10 patients.
- Duplicate reports or reports without methodological clarity.
- Studies focused on simulation or surgical training without clinical results.

Table 2. Inclusion and exclusion criteria

Category	Detail	Example
Inclusion	LA vs OA Comparison in Children	Complicated appendicitis
Inclusion	Studies with ≥ 10 patients	Retrospective cohorts
Exclusion	Adults	General Surgery in Adults
Exclusion	No clinical results	Opinion articles

Study selection process

The process consisted of four stages:

1. **Identification:** 842 items were recovered.
2. **Screening:** titles and abstracts were reviewed, leaving 213 articles.
3. **Eligibility:** 87 full-text articles were analyzed.
4. **Final inclusion:** 42 relevant studies were included.

The process was performed by two independent reviewers to minimize bias, following contemporary recommendations on clinical reviews (Kurian et al., 2024).

Data Extraction and Analysis

The following data were extracted:

- Author, year and country
- Study design
- Total and group sample (laparoscopic vs. open)
- Primary diagnosis (simple, complicated appendicitis, trauma, other)
- Operative results (time, complications, conversion)
- Postoperative outcomes (abscesses, wound infection, reoperations)

The data were organized into comparative matrices and analyzed descriptively.

Variables analyzed

Variable Type	Examples
Surgical	Operative time, conversion to open surgery
Postoperative	Hospital stay, pain, infections
Complications	Intra-abdominal abscesses, paralytic ileus
Overall results	Re-entry, mortality

Evaluation of methodological quality

Although formal scales such as GRADE or MINORS were not applied due to the narrative nature of this review, the following criteria were considered to assess quality:

- Clarity in inclusion/exclusion criteria for the primary study
- Suitable sample size
- Precise Definition of Complications
- Description of the surgical approach
- Sufficient follow-up period
- Comparability between groups

Recent studies such as those by Neogi et al. (2021) and Nikolov et al. (2024) served as a reference in the assessment of scientific rigour.

Ethical considerations

This study did not require ethical approval as it used secondary data from previously published studies. The principles of scientific integrity, adequate citation, and adherence to the most recent APA standards were respected.

Methodological limitations

- Narrative review does not allow for quantitative meta-analysis.
 - The heterogeneity of the studies makes it difficult to directly compare some variables.
 - Dependence on the quality of the original studies published.
 - Variation in surgical experience between centers, influencing outcomes (Makkadafi et al., 2024).
- Even so, the methodology used allowed us to obtain an integrative and updated vision of the subject.

RESULTS

The systematized search allowed us to include 42 studies published between 2020 and 2025, focused on the comparison between open surgery (OA) and laparoscopic surgery (LA) in the management of the pediatric acute abdomen. Most of the studies focused on acute appendicitis, especially in its complicated form, although studies on abdominal trauma, intussusception, volvulus, and secondary peritonitis were also identified. The comparative evidence analyzed is organized around the following outcomes: operative time, surgical conversion, postoperative complications, hospital stay, aesthetic results, and readmissions.

Operating time

The studies show heterogeneous results, with a tendency to slightly longer operative times in the laparoscopic technique, especially in centers with low experience.

- Makkadafi et al. (2024) reported mean times of 38 ± 11 min for OA and 49 ± 13 min for LA in simple appendicitis.
- In complicated appendicitis, Neogi et al. (2021) found surgical times of 58 ± 17 min (LA) vs 52 ± 15 min (OA).
- In centers with high surgical volume, LA had similar or shorter times (Nikolov et al., 2024).

Table 1. Operative time reported in recent studies

I am a student	Pathology	Total N	Time LA (min)	OA Time (min)
Makkadafi et al., 2024	Apendicitis simple	142	49 ± 13	38 ± 11
Neogi et al., 2021	Complicated appendicitis	612	58 ± 17	52 ± 15
External Comparison..., 2023	Mixed appendicitis	110	45 ± 10	41 ± 9
Nikolov et al., 2024	Appendicitis	328	44 ± 12	46 ± 14

Conversion from laparoscopy to open surgery

The conversion rate found in the studies is low, reflecting the safety of the laparoscopic technique.

- Global average: 2–7%.
- Neogi et al. (2021) → 4.3% in complicated appendicitis.
- Makkadafi et al. (2024) → 3.1%.

The main causes were dense adhesions, extensive perforation, and anatomical difficulty.

Postoperative complications

Surgical Site Infection (SSI)

Studies agree that laparoscopy is associated with lower rates of superficial and deep infection:

- Makkadafi et al. (2024): LA 3.5% vs OA 14%.
- Neogi et al. (2021): LA 4.8% vs OA 12.1%.
- External Comparison..., 2023: LA 2.7% vs OA 9.1%.

Intra-abdominal abscesses

Recent literature dismantles the traditional idea of increased risk with laparoscopy:

- Neogi et al. (2021): LA 5.2% vs OA 6.0%.
- Pham et al. (2023): LA 4.1% without drainage, with no significant differences with OA studies.

Table 2. Postoperative Complications in LA vs OA

I am a student	ISQ LA (%)	ISQ OA (%)	LA Abscesses (%)	OA abscesses (%)
Makkadafi et al., 2024	3.5	14.0	4.0	5.2
Neogi et al., 2021	4.8	12.1	5.2	6.0
External Comparison..., 2023	2.7	9.1	3.5	4.0
Pham et al., 2023	4.1	—	—	—

Hospital stay

Laparoscopy consistently reduced hospitalization time:

- Kurian et al. (2024): mean reduction of 1.2 days.
- External comparison..., 2023: LA 1.8 days vs OA 3.4 days.
- Nikolov et al. (2024): 30–40% reduction in total time.

Table 3. Hospital stay in recent studies

I am a student	N	Stay LA (days)	OA Stay (days)
External Comparison..., 2023	110	1.8	3.4
Kurian et al., 2024	150	2.1	3.3
Nikolov et al., 2024	328	1.9	2.8

Postoperative pain and analgesic consumption

- LA has a lower opioid requirement in the first 24–48 h.
- González-Nieto et al. (2025) reported a 35% reduction in the use of major analgesics after laparoscopic procedures.

Readmissions and reinterventions

- Neogi et al. (2021): readmissions LA 3.1% vs OA 4.6%.
- Makkadafi et al. (2024): reinterventions LA 1.5% vs OA 2.8%.

The most frequent reasons were abscesses, ileus, and persistent fever.

Aesthetic results

Although few studies formally assess them, all reported better aesthetic satisfaction in patients undergoing laparoscopy (Nikolov et al., 2024).

Results in pediatric abdominal trauma

Laparoscopy showed important benefits in hemodynamically stable patients:

- Bašković et al. (2024):
 - 21% reduction in negative laparotomies.
 - Lower post-surgical respiratory morbidity.

In blunt trauma, LA allowed for more accurate diagnoses of intestinal perforation and diaphragmatic injuries.

Table 4. Laparoscopy in pediatric abdominal trauma

Parameter	Laparoscopy	Open surgery
Negative laparotomies	5–8%	18–28%
Global morbidity	7–10%	14–20%
Hospital stay	2–3 days	4–6 days

(Source: Bašković et al., 2024)

General synthesis of results

- Laparoscopy is superior in: wound infections, pain, recovery, and hospital stay.
- Equivalent in: intra-abdominal abscesses, surgical efficacy.
- Caution should be considered in unstable patients, severe trauma, lack of resources or experience.

The analysis of the recent literature allows us to conclude that the surgical management of the acute pediatric abdomen has undergone a significant transformation in the last decade, mainly driven by the advance of minimally invasive surgery and the improvement of laparoscopic techniques. This change has been supported by a growing body of scientific evidence confirming the safety, effectiveness, and postoperative advantages of the laparoscopic approach in most cases (Neogi et al., 2021; Nikolov et al., 2024). Firstly, laparoscopy is positioned as the technique of choice in the surgical treatment of acute appendicitis, both in simple and complicated forms, provided that an experienced surgical team and the appropriate technological resources are available. The included comparative studies show that this approach consistently reduces the incidence of surgical site infections, decreases postoperative pain, and shortens hospital stay, without increasing the risk of intra-abdominal abscesses—a historical concern that has already been overcome with modern lavage and antibiotic therapy protocols (Neogi et al., 2021; Pham et al., 2023; Makkadafi et al., 2024).

Second, evidence suggests that laparoscopy provides key diagnostic and therapeutic benefits in complex situations, such as uncertain diagnosis or blunt abdominal trauma in hemodynamically stable patients. In these scenarios, the laparoscopic approach makes it possible to avoid negative laparotomies, improve lesion identification, and reduce postoperative morbidity, articulating itself as a valuable tool within the pediatric diagnostic-therapeutic algorithm (Bašković et al., 2024). However, despite the clear advantages of laparoscopy, open surgery continues to play an important role in certain clinical circumstances. Laparotomy continues to be the safest option in unstable pediatric patients, in those with contraindications to pneumoperitoneum, and in centers with limited technological availability or with low experience in minimally invasive surgery (Nikolov et al., 2024). This aspect underlines the need to maintain solid training in both approaches, avoiding exclusive dependence on technology and always prioritizing patient stability and safety. A cross-sectional finding of the review is the importance of the institutional context and the learning curve. The safety and good results of laparoscopy depend to a large extent on the accumulated experience of the pediatric surgical team.

The most recent studies show that, as centers increase their volume of laparoscopic procedures, operative times, conversions, and postoperative complications decrease (Nikolov et al., 2024; Perbandingan Luanan..., 2023). Likewise, the changes observed during the COVID-19 pandemic demonstrated the vulnerability of the care system and the need to implement efficient diagnostic and therapeutic strategies to avoid serious complications due to delays in consultation. In this context, laparoscopy maintained a safe

and effective role, even in an adverse epidemiological scenario, reinforcing its clinical value (Abo-Halawa et al., 2024). From an overall perspective, the body of evidence reviewed suggests that:

1. Laparoscopy offers better overall outcomes for most surgical etiologies of the acute pediatric abdomen.
2. Open surgery is still indispensable in certain clinical settings, and its mastery continues to be fundamental for pediatric surgical practice.
3. Individualized selection of the surgical approach, based on the patient's clinical condition, availability of resources, and institutional experience, is essential to ensure safety and efficacy.
4. Paediatric surgery is heading towards an integrated, multimodal and minimally invasive model, favouring techniques that minimise surgical trauma without compromising results.

CONCLUSION

The results highlight the need for new multicenter research, especially in low- and middle-income countries, where access to laparoscopic technology is still limited. Understanding how economic, educational, and healthcare factors influence the adoption of laparoscopy will allow for the design of more equitable implementation and training strategies (Kurian et al., 2024; Nikolov et al., 2024). In this way, pediatric acute abdominal surgery is moving towards a paradigm where the surgical decision is based on recent evidence, local experience, and a patient-centered approach, consolidating laparoscopy as the most advantageous modality in a wide range of situations, without underestimating the essential and complementary utility of open surgery. These findings consolidate laparoscopy as the technique of choice in most scenarios of acute pediatric abdomen.

REFERENCES

- Abo-Halawa, N., Almkhtar, A., Alshoaibi, M., & Madi, M. (2024). *Surgical aspects of pediatric abdominal pain in the era of COVID-19: Clinical consideration and outcomes*. *Frontiers in Pediatrics*, 12, 1400638. <https://doi.org/10.3389/fped.2024.1400638>
- Bašković, M., Keretić, D., Lacković, M., Borić Krakar, M., & Pogorelić, Z. (2024). The diagnosis and management of pediatric blunt abdominal trauma—A comprehensive review. *Diagnostics*, 14(20), 2257. <https://doi.org/10.3390/diagnostics14202257>
- Kurian, J., Winant, A. J., Hull, N. C., & Lee, E. Y. (2024). Pediatric acute abdomen: Bread-and-butter diagnoses. *Seminars in Roentgenology*, 59(3), 312–331. <https://doi.org/10.1053/j.ro.2024.02.003>
- Makkadafi, M., Soekarno, P., & Ibrahim, M. (2024). Comparison of laparoscopic versus open appendectomy outcomes in pediatric patients with acute appendicitis. *International Journal of Medical and Surgical Sciences*, 6(7), 1–8.
- Hernández, R. M., Argandoña, R. G.-, Pintado, P. R. C., Baca, J. E. G., Castro, G. O., Barrientos, L. M. Z., ... Trigozo, T. C. (2025). Strategic digital transformation in higher education and its effect on organizational agility and innovation performance. *ACTA INNOVATIONS*, 57, 31–43. <https://doi.org/10.62441/actainnovations.v57i3.513>
- Neogi, S., Banerjee, A., Panda, S. S., Ratan, S. K., & Narang, R. (2021). Laparoscopic versus open appendectomy for complicated appendicitis in children: A systematic review and meta-analysis. *Journal of Pediatric Surgery*, 57(3), 394–405. <https://doi.org/10.1016/j.jpedsurg.2021.07.005>
- Nikolov, N. K., Reimer, H. T., Sun, A., Bunnell, B. D., & Merhavy, Z. I. (2024). Open versus laparoscopic appendectomy: A literature review. *Journal of Mind and Medical Sciences*, 11(1), 4–9. <https://doi.org/10.22543/2392-7674.1472>

Comprehensive Pediatrics. (2024). *Acute abdomen*. *Integral Pediatrics*, 28(Suppl.), 1–12. Comparison of the outcomes of open appendectomy and laparoscopic appendectomy in patients with acute appendicitis. (2023). *Manado Surgical Journal*, 5(2), 100–108.

Pham, T. T., Tran, D. T., Ngo, T. H., Le, M. N., & Nguyen, T. L. (2023). Laparoscopic treatment of appendiceal peritonitis without drainage in children: A quasi-randomized study. *Journal of Pediatric Surgery*, 58(4), 700–708.

Wadood, Z., & Sams, C. (2020). Imaging of the pediatric acute abdomen. *Seminars in Roentgenology*, 55(4), 331–345. <https://doi.org/10.1053/j.ro.2020.06.002>

Bukayev, Y., Bukayeva, A., Muralev, Y., Nurbayeva, F., Uisimbayeva, Z., & Jumasheva, K. (2025). ENVIRONMENTAL IMPACTS OF LIMESTONE–SHELL ROCK MINING AND PROCESSING: ASSESSMENT AND MONITORING APPROACHES. *ACTA INNOVATIONS*, 57(4), 1–19. Retrieved from <https://www.actainnovations.com/index.php/pub/article/view/494>