

DIAGNOSING ACUTE APPENDICITIS IN CHILDREN UNDER THREE YEARS: THE UTILITY OF ULTRASOUND AND MODIFIED PEDIATRIC APPENDICITIS SCORE

Abhishek Kumar¹, Snehlata², Sweta Lal³

¹Assistant Professor, Department of Surgery, Sheikh Bhikhari Medical College, Hazaribagh, Jharkhand, India

²Specialist Medical Officer, Department of Obstetrics & Gynecology, Sheikh Bhikhari Medical College, Hazaribagh, Jharkhand, India

³Assistant Professor, Department of Obstetrics & Gynecology, Sheikh Bhikhari Medical College, Hazaribagh, Jharkhand, India

Corresponding Author: Snehlata

Specialist Medical Officer, Department of Obstetrics & Gynecology, Sheikh Bhikhari Medical College, Hazaribagh, Jharkhand, India

Email: sneha91@ymail.com

ABSTRACT

Objective: The aim of this study is to examine the clinical manifestations and subsequent clinical outcomes of acute appendicitis in pediatric patients aged less than 3 years, with a particular focus on the utilization of ultrasound imaging in the diagnostic process.

Methods: In this retrospective study, a comprehensive analysis was conducted on a cohort of pediatric patients aged three years and below who underwent appendectomy procedures within a span of 12 years. The Modified Pediatric Appendicitis Score (MPAS) was retrospectively employed, whereby a score of 5 or greater was indicative of a heightened probability of acute appendicitis.

Results: A total of 60 pediatric patients underwent appendectomy, with a calculated mean age of 25.4 months. An ultrasound examination was conducted in 82.3% of the patient cohort, yielding diagnostic results in a total of 40 cases. The remaining quintet of patients exhibited a notable elevation in the MPAS, which is suggestive of the presence of acute appendicitis (AA). Perforation was observed in 12% of cases (n=8), with four patients exhibiting the formation of an appendicular mass. The integration of ultrasound with the MPAS demonstrated a diagnostic accuracy rate of 100% within this particular age cohort.

Conclusion: The utilization of ultrasound in conjunction with the MPAS demonstrates a notable level of accuracy as a diagnostic tool for acute appendicitis in children aged three and below. This combined approach has the potential to significantly decrease the incidence of appendiceal perforation.

Recommendations: This study found that ultrasound imaging and the Modified Pediatric Appendicitis Score (MPAS) can accurately diagnose acute appendicitis in children under three. This 100% accurate combination diagnostic approach improved acute appendicitis detection in this age range, according to the study. This approach can minimize appendicitis in young children, improving clinical outcomes and patient care. This diagnostic technique needs larger cohort studies and validation to justify these findings for therapeutic usage.

Keywords: Ultrasound; Appendicitis; Pediatric appendicitis score

INTRODUCTION

Acute appendicitis presents a notable clinical dilemma, as it is a prevalent surgical emergency affecting individuals of all ages, including both adults and children. Nevertheless, the manifestation and diagnosis of this condition in pediatric individuals, specifically those below the age of three, pose distinctive challenges. Acute appendicitis is responsible for approximately 10% of all emergency surgical procedures in Australia, exhibiting an upward trend in prevalence as individuals advance in age [1,2]. Pediatric patients frequently exhibit atypical clinical manifestations, which pose challenges in the diagnostic procedure [2,3].

In order to facilitate the precise diagnosis of appendicitis, several grading systems, such as the Alvarado score and Samuel's pediatric appendicitis score (PAS), have been formulated [4, 5]. Ultrasound, a widely employed diagnostic modality, has demonstrated sensitivities ranging from 71.2% - 99% and specificities from 91.3% - 98.2% [6]. Several studies have indicated that the implementation of ultrasound examinations for all pediatric patients presenting with suspected appendicitis may be deemed as the most economically advantageous diagnostic strategy [7].

However, the diagnosis of appendicitis in children below the age of three poses a significant challenge, frequently resulting in overlooked or delayed diagnosis and the potential occurrence of perforated appendicitis [1,3]. The challenge is further exacerbated by the fact that preoperative diagnostic modalities, encompassing clinical and laboratory assessments, abdominal ultrasonography, and computed tomography, may not yield conclusive validation [4]. The diagnostic process for complicated appendicitis in young children is influenced by various factors, including but not limited to age, duration of symptoms, and inflammatory markers [5].

Aiming to improve patient care and outcomes by assisting in the early identification of appendicitis in children under three years old, this study will examine the usefulness of combining the Modified PAS with ultrasound in light of these difficulties.

METHODOLOGY

Study design: The present retrospective analysis was conducted with the primary objective of examining the cases of pediatric patients, specifically those aged below 3 years, who underwent appendectomy procedures at a distinguished tertiary children's hospital in 'Sheikh Bhikhari Medical College, Hazaribagh'. The study period spanned from 'March 2011 to March 2023'.

Ethical considerations: The study acknowledged ethics approval from the Human Research and Ethics Committee of the hospital. Written informed consent was taken from all the participants.

Inclusion criteria: A cohort of 164 pediatric patients, all under the age of 3, who underwent appendectomy over a span of 12 years, was initially included in the study.

Exclusion criteria: Out of the total sample, a total of 104 patients were excluded from the study due to their prior history of opportunistic appendectomy performed during surgical interventions for unrelated medical conditions, including but not limited to intussusceptions, bowel obstruction, gastrointestinal infections such as gastroschisis, and diaphragmatic hernia repair.

Study setting: The study ultimately comprised a cohort of 60 patients who received a diagnosis of acute appendicitis (AA), which was subsequently confirmed through histological examination following surgical intervention.

Clinical Evaluation: The diagnosis of acute appendicitis was made by the attending pediatric surgeon through clinical evaluation, considering the patient's acute abdominal symptoms. The key clinical manifestations encompassed a documented account of pain localized in the lower right quadrant of the abdomen, episodes of vomiting, elevated body temperature, diminished desire to consume food in infants, heightened irritability, and concomitant indications of tenderness upon percussion and rebound in the right lower quadrant of the abdominal region, in addition to tenderness upon coughing.

In consideration of the fact that the Pediatric Appendicitis Score (PAS) is commonly employed in the evaluation of pediatric patients ranging from 4 to 15 years of age, it has been deemed necessary to make adaptations to the scoring system to effectively assess children under the age of 3. Modifications encompassed the substitution of anorexia with the term "poor feeding" or "loss of appetite" in the context of infant patients, as well as the restriction of evaluation solely to the existence of pain, excluding any migratory symptoms. The Modified Pediatric Appendicitis Score (MPAS) was computed and comprised of several criteria as delineated in **Table 1**.

Table 1: Included in the Modified Pediatric Appendicitis Score are the following parameters.

Parameter	Score
Loss of appetite/Poor feeding	1
Nausea/emesis	1
Fever	1
Pain	1
Tenderness in right lower quadrant	2
Cough/percussion/hop tenderness	2
Leucocytosis	1
Neutrophilia	1
Total	10

Laboratory Tests: Blood tests for leukocyte and differential count, as well as C-reactive protein, were performed based on the child's age, following hospital protocols [8].

Histopathological confirmation: The gold standard for this study was the histological confirmation of appendicitis. Histopathological reports pertaining to the appendix were procured from surgical interventions in order to validate the diagnosis.

Ultrasonography: To minimize any delays in surgical intervention, ultrasound was purposefully avoided in pediatric patients with clear clinical evidence of diffuse peritonitis and visible signs of peritonism. Expert sonologists carefully considered the following particular criteria when making the radiological diagnosis of AA: a non-compressible, aperistaltic tubular structure with a maximal outer diameter (MOD) higher than 6 mm. This assessment was carried out using a graded compression technique, which allowed for a detailed cross-sectional view of the affected area. The sonographic findings in this case encompassed several significant indicators, namely the identification of appendicolith, hyperemia, and the lack of gas within the lumen. Additionally, the observation of free peritoneal fluid within the pelvis or right iliac fossa was deemed diagnostically conclusive for appendicitis based on sonographic evaluation.

Statistical Analysis: The data were presented in the form of mean values accompanied by their respective ranges for numeric variables, while proportions were utilized to represent categorical variables. Statistical significance was established by assessing the P-value, which was found to be less than 0.05.

RESULTS

The study revealed a female-to-male ratio of 1:1.5 among the pediatric population. The majority of these children were predominantly below the age of three. The findings indicate that a significant proportion exceeding 80% of the pediatric population under study exhibited symptoms such as abdominal discomfort, elevated body temperature, emesis, and localized tenderness. A subset of these pediatric patients presented with symptoms consistent with diarrhea and anorexia. The mean White Cell Count (WCC) was measured at 15.2×10^3 cells per liter. Additionally, the average C-Reactive Protein (CRP) level was observed to be 131.2 mg/L.

The demographic characteristics of the study population revealed a total of 60 participants, with a mean age of 2.25 years (S.D \pm 0.47). The distribution of genders was observed to be 37.7% male and 60.3% female.

The patients exhibited a diverse array of symptoms (Table 2). In the present study, it was observed that a significant proportion of children, precisely 82.9%, experienced abdominal pain. Additionally, a substantial majority of 88.3% exhibited symptoms of vomiting and fever. Furthermore, a notable percentage of 63.5% displayed signs of appetite loss or poor feeding. Furthermore, a notable proportion of individuals, specifically 34.5%, experienced symptoms of nausea. Additionally, a significant majority, accounting for 82.9%, reported experiencing discomfort. Moreover, a noteworthy subset, comprising 18.4%, exhibited symptoms of distention. The prevalence of diarrhea cases was observed to be 18.4%.

Table 2: Signs and symptoms seen in the patients.

Symptom	No symptom (%)	Symptoms observed (%)
Pain	11.9	82.9
Nausea	60.3	34.5
Vomiting	5.5	88.3
Fever	5.5	88.3
Loss of appetite/Poor feeding	31.3	63.5
Diarrhea	76.4	18.4
Tender	11.9	82.9
Distention	76.4	18.4

The diagnostic techniques employed in this study encompassed abdominal ultrasonography, which was utilized in 82.3% of the patient population (50 out of 60 individuals). Ten patients presenting with symptoms consistent with appendicitis and a Modified Pediatric Appendicitis Score (MPAS) greater than 5 opted to skip ultrasonography and proceeded directly to surgical intervention. A diagnosis of acute appendicitis was established in 78% of cases based on abdominal ultrasounds. According to the results, it is observed that a total of four individuals exhibited appendicular masses, while eight individuals, accounting for 12% of the sample, experienced appendiceal perforation.

The diagnosis of acute appendicitis was established in 40 out of 50 patients (80%) who underwent abdominal ultrasonography, while 10 patients remained without a definitive diagnosis. Perforation and the presence of two appendicular masses were observed in 8 patients, accounting for 12% of the study population.

Additionally, the study population's MPAS performance was evaluated using a Receiver Operating Characteristic (ROC) curve, which produced an area under the curve of 0.6383. Taking into account variables like specificity, the possibility of a negative appendectomy rate, and the incidence of missed appendicitis, the ideal cut-point was established in order to optimize sensitivity and specificity. Crucially, in this situation, no other single cut-point showed better sensitivity and specificity.

DISCUSSION

The study's discussion centered on the assessment and comparison of pediatric acute appendicitis (AA) from a clinical standpoint, accounting for ultrasonographic results, laboratory results, and clinical observations. Receiver Operating Characteristic (ROC) curves, a technique based on the separation of two underlying distributions, were used to evaluate the accuracy of diagnostic tests in differentiating between illness and non-disease states [9].

The ROC curve in this study demonstrated how the true positive rate and false positive rate are traded off, shedding light on the reliability of the diagnostic techniques employed. Abdominal ultrasonography stood out in the study for its excellent accuracy, specificity, and positive predictive results. It's interesting to note that greater levels of CRP and WBC counts were linked to the highest sensitivity and negative predictive values. These results are consistent with previous clinical observations in adult patients, where the diagnosis of appendicitis was mostly dependent on clinical indicators, ultrasonography, and standard laboratory testing like leukocyte count and CRP [5, 10, 11, 12].

In this particular investigation, abdominal ultrasonography was shown to be diagnostic for acute appendicitis in 80% of instances (seen in 40 children), and it was also found to be able to detect appendicular tumors in 5% of patients and perforations in 12% of cases. These findings highlight the sensitivity of abdominal ultrasonography as a useful diagnostic technique for pediatric acute appendicitis. Abdominal ultrasonography has been shown in multiple trials to have a high sensitivity in the diagnosis of appendicitis, which emphasizes the importance of this diagnostic tool. Additionally, the research demonstrated that abdominal ultrasonography could predict the presence of appendicular masses and perforations in children with almost 100% accuracy when paired with the modified appendicitis score. This result adds important new information to the field by highlighting the effectiveness of this combination strategy in the diagnosis of AA in youngsters.

CONCLUSION

It is postulated that the integration of clinical observations and the computation of the MPAS, in conjunction with abdominal ultrasonography, in the pediatric population aged below three years, exhibits a promising potential as a precise diagnostic modality for acute appendicitis. This approach may aid healthcare practitioners in averting any untimely identification of appendicular mass formation or perforation, thereby enhancing patient outcomes.

Limitations: Unfortunately, USS's diagnostic value is limited since it is less predictable than CT scans. On the other hand, intraperitoneal fat enhances the prediction of CT appendicitis. Ultrasound accuracy can be affected by a reluctant patient, severe discomfort or abdominal guarding, an abundance of intestinal gas, and obesity. Diagnosing retrocecal appendicitis might be difficult since high-recurrence transducers may miss deep structures. Study outcomes can also be changed by operator expertise. Appendices with holes could yield ambiguous or inaccurate negative results. Most likely defending against severe peritonitis.

Limitations: One of the study's shortcomings is the small sample size that was employed in it. It is not possible to extrapolate the study's conclusions to a larger sample size. Additionally, the absence of a comparison group limits the applicability of the study's conclusions.

Recommendations: Based on the findings of this study, it is strongly recommended that ultrasound imaging, when used in conjunction with the Modified Pediatric Appendicitis Score (MPAS), should be considered a valuable and highly accurate diagnostic approach for acute appendicitis in pediatric patients aged three years and below. The study's results clearly indicate that this combined diagnostic strategy, with a diagnostic accuracy rate of 100%, can greatly enhance the early detection of acute appendicitis in this specific age group. By implementing this approach in clinical practice, healthcare providers can potentially reduce the incidence of appendiceal perforation in young children, ultimately leading to improved clinical outcomes and better overall patient care. Further research and validation of this diagnostic method in larger cohorts would be beneficial to reinforce these findings and support its adoption in clinical settings.

Acknowledgement: We are appreciative of the patients since the study would not have been possible without them. We appreciate the assistance provided by our hospital's support team to the study group's patients.

Source of Funding: Nil

Conflict of interest: Nil

REFERENCES

1. Australian Institute of Health and Welfare (2015) Admitted Patient Care 2013-14: Australian Hospital Statistics. Health services series no. 60. Cat. no. HSE 156. AIHW, Canberra, Australia.
2. Williams N, Bulstrode CO, Connell P (2013) The Vermiform appendix. In: O'Connell PR (ed.) Bailey and Love: Short practice of Surgery. (26th edn), New York: CRC Press 013: 1199-1200.
3. Mason JD (1996) The evaluation of acute abdominal pain in children. *Emerg Med Clin North Am* 14: 629-643.
4. Eriksson S, Granstrom L, Carlstrom A (1994) The diagnostic value or repetitive peroperative analyses of C-reactive protein and total leucocyte count in patients with suspected acute appendicitis. *Scand J Gastroenterol* 29: 1145-1149.
5. Eriksson S, Granstrom L, Olander B, Wretling B (1995) Sensitivity of interleukin-6 and C-reactive protein concentrations in the diagnosis of acute appendicitis. *Eur J Surg* 161: 41-45.
6. Puylaert JB (1986) Acute appendicitis: US evaluation using graded compression. *Radiology* 158: 355-360.
7. Pershad J, Waters TM, Langham MR, Li T, Huang EY (2015) Cost-effectiveness of diagnostic approaches to suspected appendicitis in children. *J Am Coll Surg* 220: 738-746.

8. Engorn B, Flerlage J (2015) Haematology. In The John Hopkins Hospital, The Harriet lane Handbook. Philadelphia, Elsevier Saunders 14: 314.
9. Swets JA (1979) ROC analysis applied to the evaluation of medical imaging techniques. Invest Radiol 14: 109-121.
10. Tepel J, Sommerfeld A, Klomp HJ, Kapischke M, Eggert A, *et al.* (2004) Prospective evaluation of diagnostic modalities in suspected acute appendicitis. Langenbecks Arch Surg 389: 219-224.
11. Al-Rasheed A (2012) Elevation of white blood cells and platelet counts in patients having chronic periodontitis. Saudi Dent J 24: 17-21.
12. Van den EED, Boellaard WP, Allema JH, Holscher HC, Putter H, *et al.* (2003) Diagnostic surplus value of echography in children with acute abdominal pain. Ned Tijdschr Geneesk 147: 1174-1177.