

Acute Appendicitis in Children Less Than Three Years of Age-Ultrasound, Combined with Modified Pediatric Appendicitis Score is the Most Useful Adjunct in Diagnosis

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Abstract

Aim: Appendicitis is uncommon under the age of three, with few series reported in the literature. The diagnosis has been reported to be delayed, with a perforation rate between 60-100%. The aim of this study is to delineate the presentation and outcome of appendicitis in children less than three years of age in the era of ultrasound.

Methods: An investigation was carried out based on retrospective review of children under the age of three who underwent an appendectomy over a 12-year period. Modified Pediatric Appendicitis Score (MPAS) was retrospectively applied with a score of 5 and above correlating with a high likelihood of acute appendicitis.

Results: Thirty children underwent appendectomy for acute appendicitis. The mean age was 26.4 months. Ultrasound was performed in 25 patients (83.3%) at presentation and diagnostic in 20. The remaining five patients had a high MPAS consistent with a high-likelihood of acute appendicitis. Perforation was noted in 13% of patients (n=4) and an appendicular mass was found in two patients. Ultrasound when combined with a MPAS had 100% accuracy in this population.

Conclusions: In children less than three years of age ultrasound combined with the MPAS seems to be an accurate diagnostic tool in acute appendicitis, with a low incidence of perforation.

Keywords: Appendicitis; Ultrasound; Pediatric appendicitis score

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Introduction

Acute appendicitis is the most common emergency presentation requiring surgical intervention in both adults and children. During 2013-2014 in Australia, almost 29,000 appendectomies were performed, comprising approximately 10% of all emergency surgery [1]. Acute appendicitis is relatively rare in infants and becomes increasingly common in childhood and early adult life [2]. They often lack classic clinical features seen in adults. This poses a challenge for the treating physician in making a timely diagnosis [3]. It's often a dilemma to confirm if the child is having appendicitis or not because many present with symptoms and signs that resemble other common but self-limiting causes [3].

Grading systems like the Alvarado and Samuel's pediatric appendicitis score (PAS) have been developed to aid accurate diagnosis of appendicitis [4-7]. The PAS is a score that was first reported by Samuel in Journal of Pediatric Surgery in 2002 [5].

Ultrasound has been commonly used to diagnose appendicitis with a range of reported sensitivities (71.2-99%) and specificities (91.3-98.2%) [8-15].

Pershad et al. found that performing ultrasound on all children with suspected appendicitis was the most cost-effective diagnostic approach [16].

The purpose of this study is to analyze the use of Modified PAS

combined with Ultrasound as an adjunct to aid early diagnosis of appendicitis in children below three years of age.

Patients and Methods

The study was a retrospective analysis of children below 3 years of age who underwent appendectomy over a period of 12 years at a tertiary Australian children's hospital between May 2005 and August 2017. Ethics approval was granted by the hospital Human Research and Ethics Committee.

Patients

The study involved 82 children below 3 years of age who underwent Appendectomy in a span of 12 years. About 52 patients were excluded from the study, as they had undergone opportunistic appendectomy whilst been operated for various other reasons like obstruction of bowel, intussusceptions, diaphragmatic hernia repair and gastrointestinal infections such as gastroschisis. Thirty patients were included in the study, who were diagnosed with AA supported with post operative histological diagnosis.

Methods

Clinical signs and symptoms: Clinical diagnosis of AA was determined by the treating Pediatric surgeon and the presentation of acute abdomen was recorded. The clinical history of right lower quadrant pain, vomiting, fever, anorexia, irritability with associated signs of percussion and rebound tenderness in the right lower quadrant of the abdomen, and cough tenderness was considered.

Since PAS score is usually used in children aged 4 to 15 years, we modified the score to include children under 3 years of age. Modifications included changes from anorexia to poor feeding or loss of appetite in infants and only pain instead of migratory symptoms of pain was considered. MPAS score calculated which included the following criteria mentioned in **Table 1** below.

MPAS of less than 5 was considered unlikely, and that of 5 and above was considered most likely for appendicitis. MPAS score was applied to all the children included in our study.

Laboratory tests: Blood tests for Leucocyte and differential count, C-reactive protein were defined, depending on the age of the child [17]. These investigations were done as per the protocols prevailing in our hospital.

Histologically proven appendicitis was considered as the gold

Table 1 Modified Pediatric appendicitis score includes the following criteria.

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

standard for our study. Histopathology reports of the appendix from those who underwent surgery were collected in order to confirm the diagnosis of appendicitis.

Ultrasonography: It was not done in children with apparent clinical indications of diffuse peritonitis and evident signs of peritonism to avoid delay in surgical management. Radiological diagnosis of AA was made by an accomplished sonologists. It depended on the accompanying criteria: representation of a non-compressible, aperistaltic, maximal outside diameter (MOD) diameter of more than 6 mm, using a graded compression technique giving an "objective like" cross-sectional perspective and a tubular appearing structure, encompassed by echogenic-aroused fat. Other features of hyperemia, presence of appendicolith, and the absence of gas in the lumen, free peritoneal fluid in the pelvis or right iliac fossa was considered sonographically diagnostic for appendicitis. Sonographic appearances similar to those shown in **Figure 1** were confirmed to be diagnostic for appendicitis.

Statistical analysis: Data were presented as mean and range for numeric data and as proportion where is possible for categorical data. The data was also subjected for statistical analysis using an unpaired t test. Sensitivity, specificity, predictive values, and diagnostic accuracy of ultrasonography and of clinical signs were calculated using Bayes' theorem. The differences were considered to be statistically significant when P values were lower than 0.05.

Results

The female to male proportion was about 1:1.5 in the children in the study (**Table 2**). The mean age of children was below three years. More than 80% of children showed symptoms of abdominal pain, fever, vomiting and tenderness; some of children

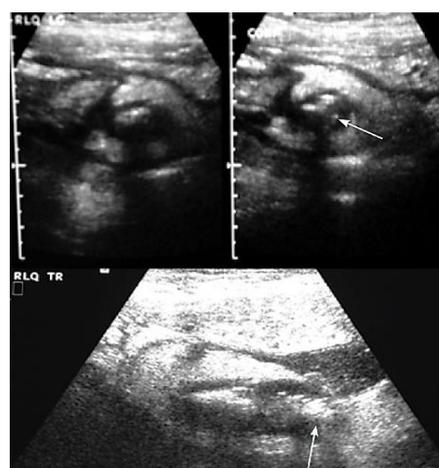


Figure 1 Ultrasound image of the right lower quadrant of the abdomen revealing a thick-walled, non compressible tubular structure (appendicolith).

Table 2 Demographic characteristics.

Characteristic	Value
Number of patients	30
Mean age in years \pm SD	2.27 \pm 0.57
Sex (Male and Female) (%)	38.7 and 61.3

also showed anorexia and diarrhea (**Table 3**). The mean WCC was 16.2×10^3 cells per litre. The CRP was 132.2 mg/L (**Table 4**).

Abdominal ultrasound was performed in 25 out of 30 (83.3%) of patients. 5 patients has a high MPAS score of more than 5 and were unwell and hence an abdominal ultrasound was not performed and underwent surgery immediately. USS was diagnostic for AA in 20 (80%) children. Appendicular mass were identified in 2 patients and perforation of the appendix was diagnostic in 4 (13%) (**Table 5**).

An receiver operating characteristic (ROC) curve (**Figure 2**)

Table 3 Symptoms observed in the patients.

Symptom	No symptom (%)	Symptoms observed (%)
Pain	12.9	83.9
Nausea	61.3	35.5
Vomiting	6.5	90.3
Fever	6.5	90.3
Loss of appetite/Poor feeding	32.3	64.5
Diarrhea	77.4	19.4
Tender	12.9	83.9
Distention	77.4	19.4

Table 4 Diagnostic results of the children.

Laboratory Test	Positive
WCC ($\times 10^3$ Cells/L)	16.02 ± 15.1
CRP (mg/L)	132.2 ± 71.9

Table 5 Abdominal Ultrasound findings.

USS done	Positive	Not diagnostic	Not done
n=25 (83.5%)	20 (80%)	5	5
Perforation	4 (13%)		
Appendicular mass	2		

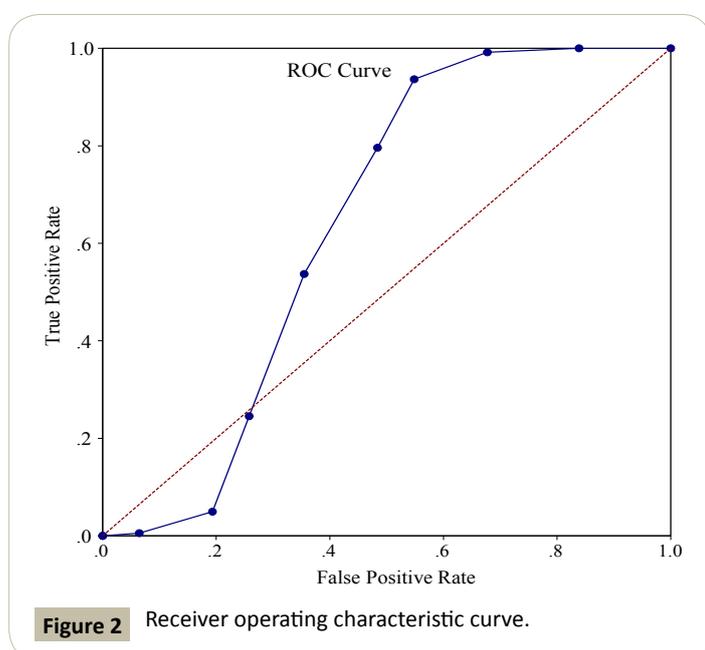


Figure 2 Receiver operating characteristic curve.

was constructed to assess MPAS and performance in the population tested. The outcome yielded an area under the curve of 0.6393. The best cut-point, calculated to maximize the sensitivity and specificity and found at specificity, potential negative appendectomy rate, and missed appendicitis rate were calculated. No other single cut-point offered an improved sensitivity and specificity.

Discussion

The investigation of AA in children is evaluated and compared from clinical view. The clinical findings including laboratory tests and ultrasonographic outcome were compared.

ROC were used to evaluate how precisely restorative analytic tests can segregate between two patient states i.e., disease vs. non-disease. A ROC curve depends on the principle of 'separator' scale, on which comes about for the infected and non-diseased structure a couple of covering conveyances [18]. The complete separation of the two underlying distributions suggests a segregating test while complete overlap implies no discrimination. In the current investigation, the ROC curve shows the trade-off between the true positive rate and false positive rate indicating the validity of the method employed.

In our study, the abdominal ultrasound demonstrated the high accuracy, specificity and, positive prescient findings. In contrast to the outcomes, the most noteworthy sensitivities and negative prescient values were accomplished by white blood cells and CRP which were elevated. Similar clinical findings such as ultrasonography and routine laboratory tests (leucocytes count and C-receptive protein) and clinical findings were reported in adults [5,19,20]. The clinical signs had the highest sensitivity, specificity and positive predictive value. A comparative affectability, however much higher specificity of clinical findings was found in a Dutch study [21].

In our study, abdominal ultrasound in 80% (observed in 20 children) were diagnostic for acute appendicitis and identified perforation in 13% and appendicular mass in 6% of patients (**Table 4**). These findings indicate that USS is sensitive method in diagnosis of acute appendicitis. Due to high sensitivity in terms of diagnosis of appendicitis, the use of abdominal ultrasound was considered as an essential diagnostic modality in numerous studies [7]. In this study we found that the better predictability of ultrasound in children for the diagnosis of AA. The abdominal ultrasound combined with modified appendicitis score had almost 100% accuracy and higher probability in identifying perforation and appendicular masses in this pediatric age group.

Limitations

Unfortunately, USS is in its poor predictability in comparison to CT scan making the method-limited use for diagnosis. The inverse is valid for CT examines, where intraperitoneal fat really enhances the predictability for appendicitis. Technical viewpoints influencing the capacity of the sonographer to accomplish sufficient pressure of the RLQ i.e., obesity, extreme agony or abdominal guarding, excess bowel gas and an uncooperative patient can all influence the accuracy of the ultrasound. In case

of appendicitis related to retrocecal segment, it is quite hard to recognize as high-recurrence transducers might fail to find the profound structures. Operator experience can likewise influence the study result. A perforated appendix can bring about an uncertain or false negative study. This is likely in cases of severe guarding in patient with peritonitis.

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Conclusions

We believe that the combination of clinical findings and calculating MPAS along with an abdominal ultrasound in children less than three years of age seems to be an accurate diagnostic tool in acute appendicitis and could help clinicians to prevent any delayed diagnosis appendicular mass formation or perforation.