International Journal of Radiology and Diagnostic Imaging

E-ISSN: 2664-4444
P-ISSN: 2664-4436
www.radiologypaper.com
IJRDI 2021; 4(1): 220-223
Received: 10-11-2020
Accepted: 19-12-2020

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Evaluation of ultrasonography as a diagnostic tool for appendicitis in paediatric patients

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DOI: http://dx.doi.org/10.33545/26644436.2021.v4.i1d.187

Abstract
Background: Appendicitis is a common cause of acute abdomen in paediatric patients. Although various criteria have been suggested in early diagnosis of appendicitis, these are not as applicable in pediatric patients.
Material and Methods: The present study was conducted on 120 paediatric patients with possible diagnosis of appendicitis at Subbaiah Institute of Medical Sciences and a tertiary care hospital over a period of one year. All of the patients underwent initial clinical evaluation followed by ultrasonography (USG), which was used to assess the existence of signs associated with appendicitis or its complications. USG Imaging findings were then compared in patients with and without complications. False positive, false negative, true positive, and true negative values were calculated. Sensitivity and specificity of ultrasonography in determining appendicitis was evaluated.
Results: Of the 120 paediatric patients, 71 (59.2%) were male and 49 (40.8%) were female. There were also 71 (59.2%) true positive and 49 (40.8%) true negative cases based on ultrasonography findings. In our study, USG sensitivity was 94.4%, specificity was 91.8%, positive predictive value was 94.4%, and negative predictive value was 91.8%.
Conclusion: Ultrasonography when used for the diagnosis of appendicitis in paediatric patients has optimal sensitivity and specificity in its diagnosis. Furthermore, it is a suitable, economical and non-invasive diagnostic tool for evaluating appendicitis and its complications.

Keywords: Appendicitis, paediatrics, abdomen, ultrasonography, diagnostic tool

Introduction

Acute appendicitis is a disease with a high prevalence, requiring early and accurate diagnosis to confirm or exclude perforation. It is the most common abdominal emergency and has a lifetime prevalence of about 7% [1]. The clinical diagnosis remains difficult, both in the paediatric and adult population, as the presentation is often atypical [2]. Symptoms are frequently non-specific and overlap with various other diseases. Despite all improvements in clinical and laboratory diagnosis and the publication of various scoring systems to guide clinical decision-making, the fundamental decision whether to operate or not remains challenging. In an ideal medical world, we would like to optimally diagnose and treat all patients with suspected appendicitis without unnecessary appendectomies. As appendicitis with perforation is associated with significant morbidity and an increase in mortality, there is broad agreement that high rates of negative appendectomies (around 15%) have to be accepted in order to reduce the rate of perforation [3, 4]. A negative appendectomy might also expose the patient to the risk of the surgical procedure [5].

Appendicitis occurs most often between the ages of 5 and 45 with a mean age of 28. The incidence is approximately 233/100,000 people. Males have a slightly higher predisposition of developing acute appendicitis compared to females, with a lifetime incidence of 8.6% for men and 6.7% for women [6]. The cause of appendicitis is usually from an obstruction of the appendiceal lumen. This can be from an appendicolith (stone in the appendix), or some other mechanical etiologies. Appendiceal tumors such as carcinoid tumors (rare), intestinal parasites, and hypertrophied lymphatic tissue (common) are all known causes of appendiceal obstruction and appendicitis. Often, the exact etiology of acute appendicitis is unknown. When the appendiceal lumen gets obstructed, bacteria will build up in the appendix and cause acute inflammation with luminal perforation and abscess formation [7].

Multi-detector computed tomography (MDCT) is considered the gold standard technique to evaluate patients with suspected appendicitis, because of its high sensitivity and specificity [7]. Magnetic resonance imaging (MRI) has also shown high accuracy in the detection of appendicitis, especially when radiation protection in children and in pregnant patients is of major concern [8]. On the other hand, research focusing on various aspects of USG in the diagnosis of appendicitis has gained major importance over recent years as lack of ionizing radiation protection, broad availability and cost effectiveness became increasingly important aspects of modern imaging techniques in the diagnosis of Acute appendicitis [9].

Accordingly, the focus will primarily be on USG, in paediatric patients with a clinical suspicion of appendicitis, as the first-line imaging modality in this clinical setting [10]. We do not know the cause of appendicitis, but there are probably many contributing factors to it.

Material and Methods

The present study is a prospective, observational and descriptive study which was performed in the Department of Radiodiagnosis at Subbaiah Institute of Medical Sciences and a tertiary care hospital over a period of one year. Of all the patients being referred to the medical college and hospital with the possible diagnosis of appendicitis, 120 paediatric patients were included.

Inclusion criteria: Patients between the age of 2 to 15 years, presenting with abdominal pain, pain in the right iliac fossa (RIF) or right lower quadrant and being in a stable hemodynamic condition.

Exclusion criteria: Patients with chronic infectious diseases like ileocecal tuberculosis were not included in this study.

Patients with carcinoid tumours and other neoplastic lesions of the appendix were not included in the study.

Ultrasonographic evaluation

All the paediatric patients were first clinically evaluated by a surgeon. Those with suspected appendicitis were then referred to the radiology department to undergo ultrasonographic evaluation, which was done by GE VOLUSON E8 AND LOGIQ P9, using a linear high frequency probe (3–11 mHz), and a convex low frequency probe (1–5 mHz). These patients were evaluated for right lower quadrant pain, and also underwent further ultra-sonographic evaluation for existence of complications of appendicitis, such as abscess formation, free fluid in the abdomen, hyper-echoic line under the mucosa, increased echogenicity of fatty tissue surrounding the appendix and serosal irregularity to look for area of perforation or impending perforation.

The accuracy of USG in diagnosing appendicitis was then compared with clinical diagnosis, laparotomy findings and resulting histopathological examination (HPE).

Statistical analysis: Wherever applicable, descriptive statistical analysis was done.

Result

In the present study, a total of 120 subjects were included out of which 71 (59.2%) were males and 49 (40.8%) were females (table-1).

Table 1: Distribution of gender

Gender	No. of patients	Percentage %
Male	71	59.2
Female	49	40.8
Total	120	100

Table 2: Distribution of different age groups of patients

Age	No. of patients	Percentage %
2-5 years	2	1.7
6-10 years	57	47.5
11-15 years	61	50.8
Total	120	100

In our study, most of the subjects were 11-15 years i.e., 61 out of 120 (50.8%), followed by 6-10 years, i.e., 57 out of 120 (47.5%).

Table 3: USG diagnosis of right iliac fossa (RIF) pain

Symptoms	No. of cases	Percentage %
Acute Appendicitis	67	55.8
Right Ureteic Colic	13	10.8
Pelvic inflammatory Disease	9	7.5
Ovarian Cyst	1	0.9
Appendicular Mass	2	1.6
Intestinal Ascariasis	1	0.9
Inconclusive	27	22.5
Total	120	100

In table 3, above observation shows that all the cases presented with pain in the right iliac fossa and clinical suspicion of acute appendicitis which were the selection criteria for the present study. Acute appendicitis symptoms were (55.8%), right ureteric colic (10.8%), pelvic inflammatory disease (7.5%), ovarian cyst (0.9%) and intestinal ascariasis (0.9%). 22.5% of cases were inconclusive.

Table 4: Clinical Symptoms

Symptoms	No. of cases	Percentage %
Pain Abdomen	120	100
Vomiting	83	69.1
Fever	21	17.5
Dysuria	7	5.8
Diarrhoea	1	0.8

In table 4, irrespective of the pathology, vomiting was found to be present in 69.1% of the cases. Murphy's triad of symptoms i.e. pain in abdomen, vomiting and fever held good in the diagnosis of acute appendicitis in our study.

Table 5: Clinical Signs

Signs	No. of cases	Percentage %
RIF tenderness	120	100
Rebound tenderness	113	94.1
Neutrophilia	77	64.1
Leucocytosis	63	52.5
Rovsing sign	57	47.5
Guarding	21	17.5
Urine Microscopy - Pus cells and RBCs	9	7.5

In table 5, Tenderness in right iliac fossa was the most common sign elicited in all the cases (100%).

Table 6: Correlation of USG Diagnosis with histopathological examination (HPE)

Total No. of cases	No. of cases
USG Positive	71
USG Negative	49
HPE positive	67
HPE negative	4
USG negative cases operated	8
HPE positive	4
HPE negative	4
Result	
Total cases of USG	120
USG Positive	71
HPE positive	67
True positive	67
True negative	45
False positive	4
False negative	4

In table 6, Out of the 71 operated cases, 67 were HPE positive and 4 were found to be negative on HPE. The sonologically negative cases were managed conservatively. In the conservative group of 49 cases, appendectomy was done for 8 cases due to the persistence of symptoms and due to the surgeon's suspicion. Out of these 8 operated cases, 4 were reported to be acute appendicitis on HPE and 4 cases of appendicular masses were treated conservatively and were subjected to interval appendectomy after a 3-month duration.

Table 7: Evaluation of USG

Evaluation of USG	Values (%)
Sensitivity	94.4%
Specificity	91.8%
Positive predictive Value	94.4%
Negative predictive value	91.8%
Diagnostic accuracy	93.3%
False positive error rate	8.2%
False negative error rate	5.6%
Likelihood ratio positive	11.5%
Likelihood ratio negative	0.06%

In table 7, the overall specificity (91.8%) and sensitivity (94.4%) of USG in diagnosis of appendicular pathology were high, indicating accurate diagnosis by USG in almost all paediatric patients with pain in RIF.

Discussion

Appendicitis is the most common surgical emergency in the developed world. Early and accurate diagnosis of appendicitis is important. A missed or delayed diagnosis is associated with increased morbidity and mortality secondary to perforation, and its complications [11].

USG is a valued tool for clinically suspected appendicitis and it enhances the diagnostic accuracy in cases with pain in the RIF and reduces the number of negative appendectomies. Of the 120 paediatric cases of appendicitis, pain abdomen and vomiting were the predominant clinical symptoms, which are not specific for acute appendicitis. Tenderness in RIF was present in almost all cases. Rebound tenderness, guarding and Rovsing's sign if present, are more specific for acute appendicitis. These findings tallied with the findings of the study by Bossuyt PM *et al.* [12].

In our study, leucocytosis was present in 52.5% of the cases and Neutrophilia in 64.1% of the cases. A study of 225 patients by Lourenco P showed leucocytosis in 42% and neutrophilia in 96% of the cases [13]. Abdominal USG could diagnose 71 cases as appendicitis out of a total of 120 cases who presented with clinical features similar to appendicitis, from which true positive cases of appendicitis were found after surgery and HPE. Kaewlai R *et al*. reviewed 140 cases of appendicitis in which they could diagnose 70 cases as appendicitis by USG [14]. In our study, the overall sensitivity and specificity were found to be 94.4% and 91.8% respectively, which showed that USG has a high sensitivity and specificity in diagnosing appendicitis. The overall specificity and sensitivity rates were at par with the values drawn by Trout AT *et al*. Binkovitz LA *et al*. whose specificity varied from 90-100% and sensitivity varied from 70-95% [15, 16].

Regarding negative appendectomy, a study by Larson DB *et al* showed that 79.5% of appendectomies had some degree of inflammation in the pathology report. Also, the rate of negative appendectomy was 20.5% [17]. However, in our study, the rate of negative appendectomy was 3.3%, which may be due to differences in the criteria for selection of patients, as well as the main purpose of the study was how to evaluate paediatric patients.

Conclusion

In conclusion, it is necessary to reduce the complications of appendicitis such as appendicular perforation, appendicular mass formation and to minimize the number of negative appendectomies. This can be done by getting a detailed history, a thorough clinical examination as well as using diagnostic tools such as ultrasonography. Based on the present study, ultrasonography with the above-mentioned protocol is an appropriate diagnostic tool in the evaluation of appendicitis in paediatric patients. In cases of non-visualized appendices, acute appendicitis can be ruled out with high confidence in the absence of secondary signs and by subjecting the patients to gold standard MDCT to look for Retrocecal appendix.

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