



The Clinical, Laboratory and Imaging Tests in Diagnosing Acute Appendicitis in Children: A Retrospective Study in a Tertiary University Hospital in Tehran, Iran

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Abstract

Background: Acute Appendicitis (AA) is a common cause of emergency room visits among children. Non-specific symptoms of appendicitis may pose a major challenge. Due to the lack of access to imaging modalities in all facilities and its high cost, the evaluation of clinical symptoms and examination results is important in diagnosing acute appendicitis.

Methods: This study is a retrospective cross-sectional study. Patients admitted to our emergency department and were suspected of having acute appendicitis by pediatric residents, and underwent an appendectomy during 2013-2018 were included. A checklist of the patients' clinical signs and symptoms, and laboratory results and imaging findings completed from the records of these patients.

Results: We reviewed the files of 300 patients with a clinical diagnosis of acute appendicitis and having an appendectomy. Leukocytosis was found in 248 (82.7%), neutrophilia in 240 (80%) and CRP level equal or above 12 mg/L was observed in 107 (35.7%) patients. Ultrasound was performed in 283 patients (94.33%); of which 228 (80.56%) were reported as acute appendicitis. Abdominal CT scan was performed in 19 patients (6.33%); of which acute appendicitis was reported in 17 patients (89.47%).

Conclusion: The results of this research showed that RLQ tenderness, and nausea/vomiting are the most common signs and symptoms, and leukocytosis is the most common laboratory finding in children with acute appendicitis. It can be suggested that relying just on the clinical presentation of AA (RLQ tenderness, fever, nausea/vomiting, anorexia and leukocytosis), can lead to the correct diagnosis of 78% of the suspected patients.

Keywords: Acute appendicitis, Children, Computed tomography, Ultrasound

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Introduction

Acute Appendicitis (AA) is a common cause of abdominal pain and emergency room visits among children, making the appendectomy one of the most common surgeries in the world (1). Typical symptoms are not always present nor reliably reported by children, especially those of less than 5 years of age (2). Non-specific symptoms of appendicitis may pose a major challenge, and the possibility of complications is higher in children than in adults (3).

Each year, 80,000 children in the United States are operated on for appendicitis. The most common age of appendicitis is between 12-18 years old. The incidence in children under 14 is 4 per 1,000. The highest prevalence in children is between 11 and 12 years. It is rare (less than 5%) among the children less than 5 years and very rare (less than 1%) in children below 3 years of age (1).

The diagnosis of AA in children is more difficult than in adults. Lack of ability of children to express the presentation of the disease, delayed diagnosis by parents and physicians, and the presence of non-specific gastrointestinal disorders are other causes of late diagnosis of AA in children (4). Importantly, delay in diagnosis leads to increased morbidity and mortality (5).

Children may have more appendicitis perforation than adults, and peritonitis is more likely to occur due to the absence of omentum growth, rendering complications more common (6). In children under five years of age, the risk of appendix rupture is even higher (7). Difficult diagnosis of the disease usually delays the start of treatment and, in many cases, leads to perforation. Due to the rapid course of AA, appendicitis is on the list of important diseases in children (8). Despite the existence of radiologic techniques, AA is still difficult to diagnose, and the risk of perforation has been reported in various centers from 16 to 57%. If the appendix ruptures, the risk of complications increases (9,10).

Imaging techniques, such as Abdominal and pelvic Ultrasonography (AUS) and Abdominal Computed Tomography (ACT), are being used for confirmation of the diagnosis of AA, and the sensitivity and the specificity of AUS have been reported to range from 71 to 92% and 83%, and of ACT have been reported 98 and 91%, respectively (11). Due to the lack of

access to imaging modalities in all facilities and its high cost, the evaluation of clinical symptoms and examination results is important in diagnosing AA.

Materials and Methods

This study was a retrospective cross-sectional study. Patients admitted to our emergency department, suspected of having AA by pediatric residents, and underwent an appendectomy during 2013-2018 were included in the study. The patients who were suspected of having appendicitis were referred to the pediatric surgeon consultant. A checklist of the patients' clinical signs and symptoms (RLQ tenderness, fever, nausea/vomiting, anorexia), and laboratory results [leukocytosis, neutrophilia, C-reactive protein (CRP)] and imaging findings (diagnosis confirmation in AUS and ACT) was completed from the records of these patients.

Leukocytosis of more than $10,000/\mu\text{l}$ and neutrophilia of more than $7500/\mu\text{l}$, were considered positive. As in the Emergency department, patients had the laboratory tests as soon as their arrival, and C-reactive protein (CRP) rises in time after the onset of the disease presentation, we considered CRP of equal or more than 12 mg/dl , which is two times of normal range, as positive results. When the consultant surgeon asked for AUS or ACT, they were also performed.

The results were expressed as mean and standard deviation ($\text{mean}\pm\text{SD}$) for quantitative variables and as a frequency (percentage) for stratified qualitative variables. The data were analyzed using SPSS for Windows version 16 (SPSS inc., Chicago, IL, USA).

Results

We reviewed the files of 300 patients with a clinical diagnosis of AA and having an appendectomy. The mean age of children was 8.17 ± 2.73 years, ranging from 1 to 16 years of age. The number of boys and girls in this study was 203 (67.7%) and 97 (32.3%), respectively (Table 1).

The evaluation of signs and symptoms in hospitalized patients is shown in Table 2. Nausea/vomiting was present in 236 (78.7%) and anorexia in 202 (67.3%) of the patients. The most common sign in patients was RLQ tenderness (Table 2).

Leukocytosis was found in 248 (82.7%), neutrophilia in 240 (80%) and CRP level equal or above 12 mg/L

Table 1. Demographic information of the patients

Variable	N(%)	
Age	8.17±2.73	
Gender	Male	203(67.7%)
	Female	97(32.3%)

was observed in 107 (35.7%) patients. Comparing males with females, the incidence of nausea and vomiting was significantly higher in girls ($p=0.009$) (Table 3).

Table 2. Signs and symptoms in patients

Variable	N(%)
Nausea/vomiting	236 (78.7%)
Anorexia	202 (67.3%)
RLQ tenderness	280 (93.3%)
Temperature>38 °C	39 (13%)
WBC>10,000/ μ l	248 (82.6%)
Neutrophils>7500/ μ l	240 (80%)
CRP>12 mg/L	98 (32.7%)

CRP: C-reactive protein; RLQ: right lower quadrant; WBC: white blood cells.

Table 3. Comparison of signs and symptoms between male and female patients

	Gender		p-value
	Male	Female	
Nausea/vomiting	151 (74.4%)	85 (87.6%)	0.009
Anorexia	139 (68.5%)	63 (64.9%)	0.195
RLQ tenderness	189 (93.1%)	91 (93.8%)	0.547
Temperature>38°C	26 (12.8%)	13 (13.4%)	0.936
WBC>10,000/ μ l	167 (82.3%)	81 (83.5%)	0.994
Neutrophils>7500/ μ l	163(80.8%)	77 (79.4%)	0.661
CRP>12 mg/L	67 (33%)	31 (32%)	0.226

CRP, C-reactive protein; RLQ, right lower quadrant; WBC, white blood cells

In the pathologic report, AA was reported in 234 patients (78%), lymphoid follicular hyperplasia was reported in 51 patients (17%), and normal in 15 patients (5%).

Ultrasound was performed in 283 patients (94.33%), of which 228 (80.56%) were reported as AA. ACT scan was performed in 19 patients (6.33%), of which AA was reported in 17 patients (89.47%).

Discussion

Different male:female ratios have also been reported in other studies. Some authorities believe that the lifetime risk of appendicitis is estimated to be 25% in females and 12% in males, and the most common age is between 10-18 years (12). Also, some studies found the male to female ratio of 4:1 in children with AA (13), and another research showed a slightly male dominance in AA and a male to female ratio of 1.39:1 (14). We had 203 (67.7%) boys and 97 (32.3%) girls in our sample (Table 1). It is estimated that 10-30%

of laparotomies for appendicitis is misdiagnosis (15). Our research indicated that a 78% of the appendectomies had confirmed pathological report of appendicitis. The difference could be due to our sample size or the experience of the team.

We found that the most common clinical manifestations were RLQ tenderness (93.3%), leukocytosis (82.6%), neutrophilia (80%), nausea/vomiting (78.7%), and anorexia (67.3%). The incidence of nausea and vomiting was significantly higher in girls ($p=0.009$). There was no similar study regarding the difference in the prevalence of nausea/vomiting in boys and girls. Furthermore, 98 patients (32.7%) had CRP levels above 12 mg/L, and 39 patients (13%) had an axillary temperature above 38 °C. Among the patients for whom an imaging was performed, ABU suggested the diagnosis of AA in 80.56% of cases and ACT in 89.47%.

In this study, the symptoms of nausea/vomiting were written together in the files by the pediatric residents

and these two symptoms were not separately recorded. Nausea/vomiting (78.8%) and anorexia (67.3%) were the most common symptoms in our study. Some studies have found that vomiting (96%), fever (85%), and abdominal pain (81%) were the most common symptoms in AA (16). Other studies showed that the prevalence of vomiting was 64.3% (17). The most common sign upon examination is abdominal tenderness, reported in more than 80% of patients in previously published reports (18). In the current study, RLQ tenderness was observed in 93.3% of the patients.

Although White Blood Cell (WBC) counts are taken in children with the probability of AA, the accuracy of this test is limited. In a retrospective study examining the association between increased WBC and CRP in 763 children with AA, the sensitivity and specificity of leukocytosis were 69.6 and 43.1%, while the sensitivity and specificity of CRP were 95.4 and 24.5%, respectively (19). WBC can be normal in 20% of AA cases (14). In our study, the WBC counts above 10,000/ μ L were found in 82.6%, and neutrophilia (above 7,500/ μ L) was recorded in 80% of the patients, while CRP above 12 mg/L (reference range of <6 mg/L) was observed in 32.7% of the patients, which indicates the CRP level is not a reliable criterion for diagnosing AA in our patients, who had CRP test by the time of their arrival to the emergency department. CRP levels of more than 50 mg/L is suggestive of complicated appendicitis, and the specificity of CRP increases with duration of time, while the accuracy of CRP in diagnosis of AA is the highest within 12 hours from onset of the symptoms (20). The CRP level in this study was taken as soon as the patient entered the emergency department and the trend of CRP levels was not checked later. This may explain the reason that CRP level was not useful in diagnosing AA.

In the study conducted in 2018 on 320 children between 5-15 years of age, the sensitivity and specificity of ultrasound in the diagnosis of AA were 58 and 68%, respectively (21). In 2015, a study carried out on 230 patients with suspected appendicitis, reported that the ultrasound was able to find AA in 89.7% of cases (22). Ultrasound is a valuable method in evaluating differential diagnoses of AA. In our study, AA was suggested by ABU in 80.56%, and by ACT in 89.47% of cases. In our center, ACT was used in 19 patients

(6.33%).

In a study conducted in 2020, the pathologic results of 1,092 children who underwent appendectomy with a diagnosis of appendicitis were examined, and it was reported that 90.4% of the subjects who underwent surgery had AA (23). In 2011, a study conducted in our hospital evaluated the pathologic results of appendectomy in 947 children between the years of 1988-2009. The results of this study showed that the histopathology of 82.7% of the samples were abnormal including; AA (26.1%), acute purulent appendicitis (48.6%), gangrenous appendicitis (10.4%), perforated appendicitis (11.8%), chronic appendicitis (0.8%), peri-appendicitis (0.7%), miscellaneous findings (1.1%), oxyuriasis (0.2%), carcinoid appendicitis tumor (0.3%) and mycobacterial infection (0.5%) (24). In this study, the final pathologic diagnosis was reported as AA in 229 patients (76.3%), lymphoid follicular hyperplasia in 51 patients (17%), and normal in 15 patients (5%).

This study demonstrated that RLQ tenderness is the most common sign, nausea and vomiting are the most common symptoms, and leukocytosis is the predominant laboratory finding of AA among children. Among the signs, a fever higher than 38°C, and among laboratory data, CRP has had little diagnostic value. Ultrasound and abdominal CT scans are highly sensitive in diagnosing appendicitis in children.

Conclusion

The results of this research showed that RLQ tenderness, and nausea/vomiting are the most common signs and symptoms, and leukocytosis is the most common laboratory finding in children with AA. Ultrasound and CT scans are very useful in diagnosing AA. Leukocytosis and neutrophilia were detected in approximately 80% of the patients, but CRP levels on admission were not raised enough to predict AA. It can be suggested that relying just on the clinical presentation of AA (RLQ tenderness, fever, nausea/vomiting, anorexia and leukocytosis), can lead to the correct diagnosis of 78% of the suspected patients.

Limitations

The patients of this study were collected from the emergency department of a crowded teaching hospital

and they were all received initially by the pediatric residents and interns and later assessed by surgical consultants. The need for an imaging modality was decided by the surgeon consultant, therefore it might be ordered in somehow more difficult cases. The CRP level trend was not followed by taking serial samples and the levels were just the initial one at the patients' arrival in the ED, and maybe there was not sufficient time to have elevated levels.

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