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## Importance of clinical, laboratory and imaging parameters in evaluating acute appendicitis

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### Abstract

**Background:** Appendicitis is a frequent cause of abdominal pain, caused by acute inflammation of the appendix, and occurs in approximately 8 to 10% of the population (over a lifetime). Appendicitis has its highest incidence between the ages of 10 and 30 years. The ratio of incidence in men and women is 3:2 through the mid-20s and then equalizes after age 30. Appendicitis is the most common abdominal surgical emergency and a challenge for the world.

**Aims and Objectives:** To assess the Importance of clinical, laboratory and imaging parameters in evaluating acute appendicitis.

**Materials and Methods:** A prospective study of 162 patients who were admitted, Department of Surgery in Mahavir Institute Of Medical Sciences, Vikarabad, during Jan 2020 to July 2021; and underwent appendectomy at first presentation. Age of presentation was between 5 years to 35 years. Data collected for each patient included demographics (age and sex), clinical information (duration of symptoms, physical signs at examination on admission to the department of surgery), laboratory tests (WBC and neutrophil counts), results of imaging tests, and pathology results. We compared the pathology reports of 162 patients with the preoperative assessment of acute appendicitis.

**Results:** In One and half year period, 162 children were admitted and underwent appendectomy at first presentation in Department of Surgery for suspected acute appendicitis. The study population included 162 patients 90 males (55.55%) and 72 females (44.44%) who underwent surgery for suspected acute appendicitis. The age at presentation was between 5 years to 35 years. The study population was divided into 2 groups according to the pathology results. Group I consisted of 150 patients (92.6%) diagnosed with acute appendicitis. Group II included 12 (7.4%) patients who had a normal appendix based on pathological examination. No differences were found between acute and normal appendices with regard to clinical complaints. However, laboratory and imaging results showed differences between groups. Fever on admission to hospital was higher in patients with acute appendicitis ( $37.5^{\circ}\text{C} \pm 0.8$  vs.  $36.8^{\circ}\text{C} \pm 0.7$ ) as were WBC values ( $14.5 \pm 4.9 \times 10^3/\text{mL}$  vs.  $10.2 \pm 3.6 \times 10^3/\text{mL}$ ) and neutrophils ( $75\% \pm 10.1$  vs.  $60.0\% \pm 12.9$ ). Ultra sonogram (USG) was performed in all patients. The appendicular diameter was significantly smaller in patients with a normal appendix compared to those with acute appendicitis ( $0.7 \pm 0.08\text{cm}$  vs.  $0.9 \pm 0.2\text{cm}$ , respectively).

**Conclusion:** USG may be a useful tool for evaluating cases with suspected appendicitis, regardless of age or gender, and should be the first choice of imaging modalities. The results of laboratory tests (WBC, Neutrophils) and Imaging (USG) contributed far more than clinical parameters to the accurate diagnosis of acute appendicitis. When these 3 parameters were positive, the probability of normal appendix was less than 1%. The contribution of USG was particularly high as its results matched the final diagnosis.

**Keywords:** Imaging parameters, appendicitis, acute appendicitis (AA), ultrasonography (USG), WBC, neutrophils, laboratory parameters

### Introduction

Despite the high incidence of appendicitis during childhood, the diagnosis remains difficult with risk of diagnostic delay and perforation, as well as negative appendectomies. Acute appendicitis (AA) is a disease with a high prevalence, requiring rapid and accurate diagnosis to confirm or exclude perforation. It is the most common abdominal emergency and has a lifetime prevalence of about 7%<sup>[1]</sup>. A male preponderance exists, with a male to female ratio of 1.4:1; the overall lifetime risk is 8.6% for males and 6.7% for females in the United States<sup>[2]</sup>. Appendicitis is most common between the ages of 5 and 40 years; the median age is 28 years<sup>[3]</sup>. The cause of acute appendicitis is unknown but is probably multifactorial; luminal obstruction and dietary and familial factors have all been suggested<sup>[4]</sup>.

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Historically, the diagnosis was based primarily on clinical signs and symptoms. Nevertheless, acute appendicitis is often very difficult to diagnose, especially in younger children [5, 6, 7]. The clinical diagnosis remains difficult, both in the paediatric and adult population, as the presentation is often atypical [8]. Symptoms are frequently non-specific and overlap with various other diseases [9]. 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 [6, 7, 8, 9]. As acute appendicitis with perforation is associated with significant morbidity and an increase in mortality [8]. After the first 36 hours from the onset of symptoms the average rate of perforation is between 16% and 36%, and the risk of perforation is 5% for every subsequent 12 hour period [10]. There is broad agreement that high rates of negative appendectomies (around 15%) have to be accepted in order to reduce the rate of perforation. A negative appendectomy might not only expose the patient to the risk of the surgical procedure. Recently, a higher risk of acute myocardial infarction related to surgical removal of the tonsils and appendix before age 20 has been reported [11]. A recent study demonstrated that increased use of pre-operative imaging in patients with acute appendicitis resulted in a cost-effective way to decrease the negative appendectomy rate (NAR) [12]. This study was done to evaluate accuracy of Clinical, Laboratory and Imaging (USG) parameters in diagnosing acute appendicitis.

### Materials and Methods

A prospective study of 162 patients who were admitted, department of surgery in Mahavir Institute of Medical Sciences, Vikarabad, during Jan 2020 to July 2021; and underwent appendectomy at first presentation. Age of presentation was between 5 years to 35 years.

### Exclusion Criteria

- Patients who underwent incidental appendectomy during abdominal surgery for other reasons,
- Diagnosed with peri-appendicular abscess who underwent appendectomy after conservative treatment (interval appendectomy),
- Patients who treated conservatively at first presentation and who underwent appendectomy after conservative treatment (interval appendectomy) or subsequent presentation,
- Patients with Diabetes.

We compared the pathology reports of 162 patients with the preoperative assessment of acute appendicitis. We used

Ultrasonogram (USG) for imaging in all patients. Ultrasonographic criteria for acute appendicitis were enlarged appendix (6 mm or larger in the transverse plane), fluid in the appendiceal lumen, lack of compressibility of the appendix, inflammatory changes in the peri-enteric fat in the right lower quadrant, right lower quadrant lymph nodes, and peritoneal fluid [Figure 2, 3]. The histological criteria for acute appendicitis require the presence of polymorphonuclear leukocytes or eosinophils in the muscularis propria. Mucosal ulceration with cryptitis and crypt abscesses are diagnosed as mucosal appendicitis after a thorough search for leukocytes in the muscularis mucosa fails [Figure 4, 5, 6]. When the appendix was not visualized by USG and the clinical signs were suspicious for acute appendicitis, the patient was admitted for further observation and managed conservatively. Data collected for each patient included demographics (age and sex), clinical information (duration of symptoms, physical signs at examination on admission to the Surgery Department), laboratory tests (WBC and neutrophil counts), results of imaging tests, and pathology results. Statistical analysis was performed using SPSS, version 18.0 software.

### Results

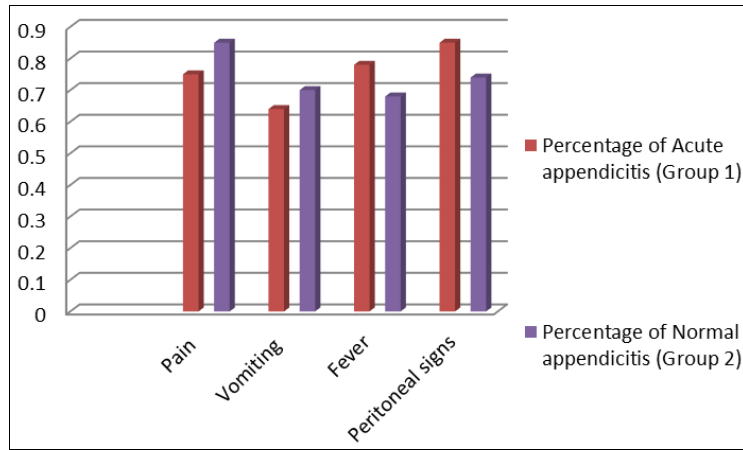
Over One and Half year period during Jan 2020 to July 2021, 162 children were admitted and underwent appendectomy at first presentation in Department of Surgery for suspected acute appendicitis. The study population included 162 patients 90males (55.55%) and 72 females (44.44%) who underwent surgery for suspected acute appendicitis. The age at presentation was between 5years to 35 years. We had done 65 laparoscopic appendectomy and 97 open appendectomy. The study population was divided into 2 groups according to the pathology results. Group I consisted of 150 patients (92.6%) diagnosed with acute appendicitis. Group II included 12 (7.4%) patients who had a normal appendix based on pathological examination. This represents the false positive appendectomy rate. No differences were found between acute and normal appendices with regard to clinical complaints [Table1 and Figure 1]. However, laboratory and imaging results showed differences between groups [Table 2]. Fever on admission to hospital was higher in patients with acute appendicitis ( $37.5^{\circ}\text{C} \pm 0.8$  vs.  $36.8^{\circ}\text{C} \pm 0.7$ ) as were WBC values ( $14.5 \pm 4.9 \times 10^3 / \text{mL}$  vs.  $10.2 \pm 3.6 \times 10^3 / \text{mL}$ ) and neutrophils ( $75\% \pm 10.1$  vs.  $60.0\% \pm 12.9$ ) USG was performed in all patients. The appendicular diameter was significantly smaller in patients with a normal appendix. Compared to those with acute appendicitis ( $0.7 \pm 0.08$  cm vs.  $0.9 \pm 0.2$  cm, respectively).

**Table 1:** Distribution of clinical parameters post which surgery happened in the patients

Parameters	No of Patients of Acute appendicitis (Group 1) N=150	Percentage of Acute appendicitis (Group 1).	No of Patients of Normal appendicitis (Group 2) N=12	Percentage of Normal appendicitis (Group 2)
Pain	113	75%	10	85%
Vomiting	96	64%	8	70%
Fever	117	78%	8	68%
Peritoneal signs	128	85%	9	74%

75% out of 150, means 113 patients had pain major symptom shown before initializing the surgery, similarly 64% of 150, 96 patients had vomiting major symptom shown, and 117 patients which is 78% of 150, had major shown symptom, 85% of 150, 128 patients had shown peritoneal signs as a major sign before

surgery of acute appendicitis in group 1. Similarly in group 2, 85% of 12, 10 patients had pain, 70% and 68% had shown vomiting and fever respectively 8 patients and 74% of 12 patients means 9 patients had peritoneal signs a major symptom in normal appendicitis in group 2.



**Fig 1:** Distribution of major Clinical parameters measured in both the group

**Table 2:** Quantitative parameters used to predict acute appendicitis in subjects

Parameters	Percentage of Acute appendicitis (Group 1) N=150 (92.6%)	Percentage of Normal appendicitis (Group 2) N=12 (7.4%)
Fever	37.5 °C ± 0.8	36.8 °C ± 0.7
WBC (Neutrophils %)	14.5 ± 4.9 × 10 <sup>3</sup> /ml	10.2 ± 3.6 × 10 <sup>3</sup> /ml
Ultrasonogram (Appendix diameter)	75% ± 10.1	60.0% ± 12.9
Peritoneal signs	0.9 ± 0.2 cm	0.7 ± 0.08 cm

To determine which of the above parameters could predict acute appendicitis, the sensitivity, specificity, positive predictive value (PPV), and accuracy of the parameters were calculated. The combination of US, WBC, and percentage of neutrophils had the highest positive predictive value (99.1%).



**Fig 4, 5, 6:** Showing presence of polymorphonuclear leukocytes or eosinophils in the muscularis propria.



**Fig 2:** USG showing Transverse diameter appendix



**Fig 3:** USG showing inflamed appendix

**Discussion**

In a similar adult study (30) comparing ultrasonography with routine laboratory tests (white blood cell count and C-reactive protein) and clinical findings (Ohmann score), ultrasonography showed the highest accuracy, specificity, and positive predictive value. Contrary to our results, the highest sensitivities and negative predictive values were achieved by white blood cell count and C-reactive protein. Acute appendicitis is the most common abdominal emergency and has a lifetime prevalence of about 7%. A male preponderance exists, with a male to female ratio of 1.4:1 while in our study male to female ratio is 1.3:1. Age of presentation in our study was between 5 years to 35 years which is comparable with other studies by Ellis H *et al.* In 2003, Newman *et al.* [13] summarized data on appendicitis complications obtained from 30 pediatric hospitals and found an average perforation rate of 37% (range 20-76%). Another multicenter study found a 13% rate of intra-abdominal abscess following surgery for perforated appendicitis [14]. On the other hand, the reported rate of operations where the appendix was normal-i.e., “negative appendectomies” – in children is 5– 40% [15, 16]. In our study negative appendectomy were 7.5%. Symptoms commonly include right lower abdominal pain, nausea, vomiting, and decreased appetite. However, approximately 40% of people do not have these typical symptoms [17]. Several different clinical protocols and clinical scores have been designed to assist in diagnosing acute appendicitis. The paediatric appendicitis score (PAS) developed in 2002 by Samuel included parameters such as RLQ tenderness, hopping tenderness, pain migration, anorexia, vomiting, fever, leukocytosis, and neutrophilia. This score had a sensitivity of 100%, a specificity of 92%, a positive predictive value of 96%



and a negative predictive value of 99% [18]. A few studies that attempted to validate the PAS did not achieve the above values. Schneider *et al.* [19]. Prospectively studied 2 clinical scores in 588 children: the Alvarado score (one of the most frequently used scores in adult population) and PAS. They concluded that, even though the scores provide useful diagnostic information, their positive predictive values were not high enough to become the sole basis for the decision to operate [19]. In our study also no differences were found between acute and normal appendices with regard to clinical complaints. While there is no laboratory test specific for appendicitis, a complete blood count (CBC) is done to check for signs of infection. Although 70–90 percent of people with appendicitis may have an elevated white blood cell (WBC) count, there are many other abdominal and pelvic conditions that can cause the WBC count to be elevated [20, 21]. Acute appendicitis is characterized by local intestinal inflammation and a systemic inflammatory reaction. The 2 most widely used inflammatory markers are white blood cell count, which increases in the early phase of the inflammatory response and C-reactive protein level, which rises later in the disease process. As noted in the literature, laboratory studies may be less useful in young children than in adults. A WBC count of less than 10 000 / mL moderately decreases the likelihood of appendicitis (LR = - 0.22), but a WBC count over 10000 / mL only minimally increases the likelihood (LR = 2.0). Raising the WBC count cut-off value to more than 15000 / mL is not helpful. Kim *et al.* [22] reported respective sensitivities of 88, 69, and 60% for predicting acute appendicitis using leukocytosis, CRP or both. The PPV of those markers were 81, 57, and 45%, respectively and were even higher for predicting perforated appendicitis (93, 81, and 75%, respectively). Therefore, they concluded that leukocytosis was the most reliable marker. Similarly, another study which examined the use of differential white blood cell count found a sensitivity of 80% and specificity of 94% when diagnosing acute appendicitis when there was leukocytosis with left shift [23]. In contrast, Beltrán *et al.* [24] found that any of the above markers (WBC and CRP), either alone or in combination, had a high sensitivity for diagnosing acute appendicitis, but low sensitivity for perforated appendicitis. In our study WBC values for acute appendicitis were  $14.5 \pm 4.9 \times 10^3$  / mL vs.  $10.2 \pm 3.6 \times 10^3$  / mL for normal appendix and neutrophils for acute appendicitis were  $75\% \pm 10.1$  vs.  $60.0\% \pm 12.9$  for normal appendix. USG is rapid, non-invasive, inexpensive, and requires no patient preparation or contrast material administration [25, 26, 27, 28]. Although operator skill is an important factor in all US examinations, it has particular importance in the examination of the patient with right-lower-quadrant pain. In experienced hands, US has reported sensitivities of 75%–90%, specificities of 86%–95%, accuracies of 87%–96%, positive predictive values of 91%–94%, and negative predictive values of 89%–97% for the diagnosis of acute appendicitis. [25, 26, 27, 28] The appendix appears on ultrasound as a lamellate, elongated, blind-ending structure. Unlike normal bowel, the inflamed appendix is fixed, non-compressible, and appears round on transverse images. Measurements of appendix are performed with full compression. Traditionally, the diagnosis of appendicitis is made when the diameter of the compressed appendix exceeds 6 mm. In contrast, the thick-walled and non-compressible appendix, maintained in a fixed position by the compressing transducer, will show circumferential colour when inflamed. Appendiceal perforation can be diagnosed when the appendix demonstrates irregular contour or when periappendiceal fluid collections are identified [26, 27, 28]. In our study The appendicular diameter was

significantly smaller in patients with a normal appendix. Compared to those with acute appendicitis ( $0.7 \pm 0.08$  cm vs.  $0.9 \pm 0.2$  cm, respectively). Today, both abdominal CT and USG are widely used to assist in the preoperative diagnosis of acute appendicitis. A meta-analysis of 26 studies published between 1986 and 2004 (9356 children) found that CT had a higher sensitivity than USG (94 vs. 88%) and that both had similarly high specificities (94 – 95%) for diagnosing acute appendicitis in children [29]. USG is the first choice imaging modality and CT is performed sparingly only under unusual circumstances and when the appendix was not identified by USG [30]. Although CT accuracy is reported to be very high we discourage routine CT scanning because of radiation exposure. The definitive diagnosis is based on pathology. The histologic finding of appendicitis is neutrophilic infiltrate of the muscularis propria. Periappendicitis, inflammation of tissues around the appendix, is often found in conjunction with other abdominal pathology [31]. When we combined the 3 most statistically significant parameters USG appendicular diameter > 6 mm, WBC count > 10 000 / mL, neutrophils > 66%, the PPV was 99%.

### Conclusion

USG may be a useful tool for evaluating children with suspected appendicitis, regardless of age or gender, and should be the first choice of imaging modalities. The results of laboratory tests (WBC, Neutrophils) and Imaging (USG) contributed far more than clinical parameters to the accurate diagnosis of Acute Appendicitis. When these 3 parameters were positive, the probability of normal appendix was less than 1%. The contribution of USG was particularly high as its results matched the final diagnosis better than diagnosis based on clinical parameters alone.

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**Conflict of Interest:** None

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