

International Journal of Radiology and Diagnostic Imaging



E-ISSN: 2664-4444
P-ISSN: 2664-4436
IJRDI 2018; 1(1): 44-49
Received: 01-01-2018
Accepted: 08-02-2018

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To assess the diagnostic significance of specific ultrasonographic observations in cases of acute appendicitis

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DOI: <https://doi.org/10.33545/26644436.2018.v1.i1a.367>

Abstract

Background and objective: The objective is to examine the diagnostic significance of indirect indicators in appendicitis. To investigate the diagnostic significance of immediate indicators in appendicitis.

Method: The study was conducted on a cohort of patients. The study encompassed all individuals who satisfied the predetermined criteria for inclusion. Before commencing the trial, authorization was acquired from the Institutional Review Board (IRB). Informed written consent was obtained from the patient or their relative prior to the ultrasound examination. Consent was obtained from persons within the appropriate age category to assess the significance of different ultrasonographic observations in cases of acute appendicitis.

Result: The study population consisted of 63% (41) males and 37% (29) females. A prevalence rate of 63% was observed for uncomplicated acute appendicitis. A prevalence of 37% was observed for complicated acute appendicitis. Acute appendicitis was not observed in 4.2% of the cases. Histopathological investigation revealed positive results for acute appendicitis in all instances. The majority, specifically 68% (45), was straightforward. Out of the total cases, 34.5% (23) were classified as complex appendicitis accompanied by gangrene, perforation, or both. The mesenteric fat exhibited increased thickness and echogenicity in 93.5% (59) of cases. Only 9.3% (7) of the patients had focal fluid collection, while 55.9% (34) of the cases displayed free fluid.

Conclusion: According to the ultrasound criteria, all cases that were classified as Unequivocally Positive and Probably Positive for appendicitis exhibited positive histopathological findings. Ultrasound criteria have proven to be quite valuable in the prognostication of appendicitis.

Keywords: Ultrasonography, acute appendicitis, histopathology, mesenteric lymphadenopathy, hyperaemia

Introduction

Acute appendicitis is a prevalent etiology of acute abdominal pain. In Taiwan, the study reported an overall incidence rate of 107.76 per 100,000 individuals per year, while in the United States, the incidence rate was 23.3 per 10,000 population per year among the age group of 10-19 years. While historically regarded as a clinical diagnosis, the utilization of imaging modalities such as ultrasound and computed tomography has significantly contributed to enhancing the diagnostic process and facilitating the prediction of complications associated with appendicitis. Additionally, these imaging techniques have played a crucial role in reducing the occurrence of false negative emergency appendectomies. While the prognosis for appendicitis is generally favorable, a delay in diagnosis can lead to heightened susceptibility to complications such as perforation, abscess formation, peritonitis, sepsis, blockage, and potentially fatal outcomes. Ultrasound has been employed in the diagnostic process of appendicitis since the 1980s. The diagnostic modality in question is easily accessible, cost-effective, and devoid of any radiation-related hazards. Furthermore, the study does not necessitate any prior patient preparation. Computed tomography, despite its superior accuracy, is costly, not globally accessible, and has an additional radiation risk [1, 2, 3].

This should be specifically avoided in youngsters. Puylaert's influential study on appendix sonography introduced the graduated compression technique, which continues to be employed in contemporary practice. Baldisserotto M and Marchiori have described further procedures, including posterior manual compression and non-compression approach.

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Nevertheless, the documented sensitivities and specificities vary between 71.2% and 99% and 91.3% and 98.2% respectively. The challenges in utilizing ultrasound for appendicitis diagnosis are ascribed to the retrocaecal or retrocolic locations of the appendix, which hinder visibility, the limited acoustic window caused by ileus, and the reliance on the operator. Secondary symptoms of appendicitis are valuable in detecting acute appendicitis when the appendix is not visible. The objective of this study is to evaluate the diagnostic significance of specific sonographic indicators in cases of acute appendicitis, with a primary focus on the indirect indicators. The secondary objectives of this study include examining the diagnostic utility of direct indicators, establishing ultrasonography likelihood criteria for appendicitis, and retrospectively evaluating clinical scoring, specifically Mantrel's score, in cases where it is accessible [4, 5].

The field of histopathology is commonly considered as the standard for doing comparative analysis. The participants in this study are individuals who visit the Emergency department, general surgery outpatient department (OPD), or pediatric surgery outpatient department (OPD) with a suspected diagnosis of acute appendicitis. These individuals have urgent surgical intervention exclusively for the treatment of acute appendicitis. The investigation involves doing a thorough abdominal ultrasound scan, followed by using a non-compression technique provided by Baldisserotto M and Marchiori E to scan the right iliac fossa. Additionally, a graded compression strategy published by Puylaert is employed, along with the posterior manual compression technique [5, 6].

Materials and Methods

The prospective study was conducted on patients at Department of Radio- Diagnosis, Malla Reddy Institute of Medical Sciences, Hyderabad, India, from April 2017 to March 2018. The study included all patients who met the specified inclusion criteria. Prior to the initiation of the trial,

approval from the Institutional Review Board (IRB) was obtained. Prior to the ultrasound examination, the patient or their relative provided informed written consent. In order to determine the importance of various ultrasonographic observations in cases of acute appendicitis, consent was acquired from individuals within the appropriate age category.

Inclusion criteria

1. All individuals who seek medical attention at the emergency department or general surgery department Obstetrics and geriatric surgery OPD with a probable case of acute appendicitis
2. Individuals that receive emergency surgery at our facility are the ones mentioned above.

Exclusion criteria

1. Patients who get conservative management
2. Patients who decline ultrasound or surgery
3. Patients having a different diagnosis on ultrasound (USG)
4. Patients who did not exhibit any of the direct and indirect symptoms associated with acute appendicitis were not examined or recorded.

Results

Table 1: The occurrence of specific indirect indicators in instances where direct indicators were determined to be negative.

Indirect signs	%
Increased thickness and ecogenicity of mesenteric fat	85
Increased vascularity in RIF	65
Focal fluid collection	0
Free fluid	65
Thickened caecal wall	0
Hypoperistalsis of regional bowel	46
Probe tenderness	88
Masenteric lymphadenopathy in RIF	30

Table 2: Comparative analysis of the occurrence of indirect and direct sonographic indicators in children and adults.

Indirect sonographic finding	Incidence in paediatric group	Incidence in adult group
Increased echogenicity of mesenteric fat	92	96.3
Increased vascularity of RIF	59	52.1
Focal fluid collection	3	12.9
Free fluid	52	57.9
Thickened caecal wall	32	19.9
Hypoperistalsis of regional bowel	38	58.9
Probe tenderness	98	95.3
Masenteric lymphadenopathy in RIF	57	26.9
Direct sonographic findings	Incidence in paediatric	Incidence in adult group
Enlarged appendix	95	95.6
Non compressibility of appendix	95	95.6
Hyperaemia of appendicular wall	72	44.9
Loss of wall stratification	25	19.8
Appendicolith	34	13.5

Table 3: Mesenteric lymphadenopathy in RIF

	Present	Absent	Total
Acute appendicitis with perforation	15	21	36
Acute appendicitis without perforation	14	20	34
Total	29	41	70

Table 4: Multivariate analysis

Variables		OR	95%CI	P value
Caecal wall thickening	Absent	1.00	0.46 to 9.3	0.3
	Present	2.21		
Hypoperistalsis of regional bowel	Absent	1.00	1.93 to 27.94	0.002
	Present	8.23		
Mesenteric lymphadenopathy in RIF	Absent	1.00	0.37 to 5.11	0.68
	Present	1.53		

Discussion

The occurrence of acute abdomen is commonly attributed to acute appendicitis. Nevertheless, the diagnosis of this condition continues to pose difficulties due to the inherent anatomical variability in the positioning of the appendix, leading to a wide range of clinical presentations. Moreover, the clinical manifestations of acute appendicitis frequently exhibit similarities with those of various other medical conditions, some of which do not necessitate surgical intervention. Imaging plays a crucial part in the management algorithm of acute appendicitis. Although CT has shown to have higher sensitivity and specificity, USG offers the advantages of being widely available, considerably more affordable, and free from radiation exposure. The presence of ambiguous scans in circumstances when the appendix is not visible poses a substantial constraint in the field of ultrasonic imaging [7, 8]. This study aimed to assess the diagnostic effectiveness of indirect ultrasonographic indicators for acute appendicitis, as well as investigate the diagnostic usefulness of direct indicators.

The present study comprised a sample of 70 participants who satisfied the inclusion criteria of exhibiting clinical suspicion of acute appendicitis. The individuals in question underwent emergency appendectomy subsequent to receiving emergency ultrasonography, in accordance with the established study procedure. All 70 patients exhibited the presence of acute appendicitis as determined through histopathological analysis. Our investigation encompassed both adult and pediatric groups. The pediatric age category, defined as individuals aged 18 years, encompassed 40.3% of the population. The study sample comprised 61.3% male participants and 38.7% female participants. The appendix was visualized in 93.5% of the cases. This study bears resemblance to a prospective investigation carried out by Kessler *et al.*, wherein a noteworthy prevalence of appendix visualization was seen, reaching 101.96% [8, 9]. In addition, Lee *et al.* did a subsequent study that included additional scanning techniques alongside the traditional graded compression process. This approach yielded a visualization rate of 99.1% for the appendix. Previous studies have demonstrated higher percentages of incomplete visibility of the appendix, ranging from 28% to 46%. Technological improvements have improved the quality of ultrasonic scanning devices, resulting in enhanced rates of visualization.

A total of 62 cases of pathologically confirmed acute appendicitis were included in the study. Of the instances examined, 98.4% (61) exhibited the presence of at least one indirect signal, 95.2% displayed a minimum of two signs, and 77.4% displayed a minimum of three signs. Regarding RIF, the prevailing indirect indicators that were frequently noticed included probing tenderness (95.2%) and heightened echogenicity and thickness of mesenteric fat (91.9%) [9, 10]. The prevalence of these markers did not exhibit any

statistically significant disparity between the juvenile and adult cohorts. The occurrence of different indirect symptoms in cases of RIF was observed in a descending order as follows: free fluid was observed in 51.6% of cases, increased vascularity was observed in 50% of cases, hypoperistalsis of regional bowel was observed in 48.4% of cases, mesenteric lymphadenopathy was observed in 35.5% of cases, thickened caecal wall was observed in 19.4% of cases, and focal fluid collection was observed in 8.1% of cases. Adults had a higher prevalence of regional bowel hypoperistalsis (56.8%) in comparison to children (36%). Mesenteric adenopathy was more common in children (52%) than in adults (24.3%) [10, 11].

According to a study conducted by Kessler *et al.* (2004), the secondary indication that had the greatest diagnostic accuracy was inflammatory fat change, which had a negative predictive value (NPV) of 91% and positive predictive value (PPV) of 76%. There were 57 cases of acute appendicitis that were confirmed through pathological examination. In 91.2% of instances, there was seen inflammatory fat change, while caecal wall thickening was observed in 24.5% of cases. Lymphadenopathy was observed in 31.5% of cases, and free fluid was detected in 50.8% of cases. The percentages observed are consistent with the results obtained from our investigation. Furthermore, N. Kouamé *et al.* did a retrospective investigation which shown that the hypertrophy of mesenteric fat exhibits the best specificity in detecting RIF, representing 96.7% of cases. Moreover, the attribute exhibiting the most significant negative predictive value is probing tenderness, accounting for 83.3% of instances. In our investigation, each of these indications demonstrated the highest frequency [11, 12].

Five cases of verified acute appendicitis were observed, wherein the direct indications had unfavorable outcomes. In the treatment group receiving RIF, the most often seen indirect signs were probing tenderness (80%), as well as increased echogenicity and thickness of mesenteric fat (80%). The observed prevalence of these symptoms in the study of all cases of acute appendicitis is comparable to this conclusion. The occurrence of different indirect symptoms in RIF was seen in a descending sequence as follows: 60 percent of cases exhibited free fluid, 60 percent had enhanced vascularity, 40 percent had hypoperistalsis of the regional colon, and 20 percent had mesenteric lymphadenopathy. There were no observed occurrences of caecal wall thickening or concentrated fluid accumulation.

There are certain observations that exhibit a greater magnitude than what is recorded in the existing literature, although others demonstrate equal magnitudes. In a retrospective study undertaken by Estey *et al.* (2013), a total of 160 cases of acute appendicitis were evaluated in a pediatric population. Within this set of cases, a total of 17 occurrences were documented in which the appendix was not observable. The evaluation of indirect indications was

conducted in a total of 17 instances. The incidence of inflammatory changes was determined to be 11.7%, which is significantly lower than the 80% observed in our study. The study revealed a prevalence rate of 35.2% for lymphadenopathy, which aligns with the 20% seen in our independent investigation. The study revealed a prevalence rate of 58.8% for free fluid, which is consistent with the 50% discovered in our own research [12, 13].

Ross *et al.* (2014) did a retrospective investigation on a pediatric population. There were 82 cases of acute appendicitis that were confirmed through histological examination. These cases either showed no visible appendix or had inadequate visibility. The study found that the occurrence of fat stranding was 10.9%, free fluid was 20.7%, and abscess was 6%. Moreover, the instances in which at least one secondary signal was identified were limited to a modest 40.2%. The present finding is in opposition to the outcomes of our research, which demonstrate that a minimum of two and a maximum of three secondary indications are detected in 80% of cases. Nevertheless, more validation is necessary as a result of the restricted size of our sample.

There was a positive direct signal in 91.9% of the cases, a minimum of two positive signs in 90.3% of the cases, and a minimum of three good signs in 66.1% of the cases. An enlarged appendix (91.9%) and a lack of appendix compressibility (91.9%) were the most frequently observed direct signs. The appendix was found to be non-compressible in all cases when it demonstrated hypertrophy. The prevalence of these markers did not exhibit any statistically significant disparity between the juvenile and adult cohorts. In descending order of occurrence, the other immediate symptoms consisted of high blood pressure in the appendix (50%), the presence of a lump in the appendix (21%), and the absence of a distinct layer in the appendix (19.4%). The prevalence of appendicolith was found to be significantly greater in the pediatric age group (32%) compared to adults (13.5%). The prevalence of appendicular wall hyperaemia was found to be higher in children (64%) in comparison to adults (40.5%) [14, 15].

According to the findings of Kessler *et al.*, an appendicular diameter of 6 mm or more demonstrated the highest level of accuracy as a direct indication, with a precision rate of 98% for Sn, Sp, NPV, and PPV. The study revealed a prevalence rate of 94.7% for appendicular diameter more than or equal to 6mm, which aligns with the 91.9% recorded in our own study. The study revealed a prevalence rate of 92.9% for appendix non-compressibility, which is consistent with the 91.9% seen in our own research. The prevalence of appendicular wall hyperaemia was 49.1%, which corresponds to the 50% seen in our study. The specificity of hyperaemia to the wall has been reported to be 96% in a review study produced by Reddan *et al.*, while its sensitivity has been reported to be 52%. Moreover, it is anticipated that the occurrence of appendicolith in children is approximately 50%. The application of ultrasound (USG) probability has played a significant role in improving the comprehension of cases that were previously recorded as uncertainty in USG scans for acute appendicitis. There were four likely criteria: unequivocally positive when an inflamed appendix was observed, probably positive when the appendix was not observed but there were indirect signs of inflammation, probably negative when the appendix was not observed and there were no indirect signs, and unequivocally negative

when the appendix was abnormal and there were no secondary signs. Out of the total number of cases, 91.9% were categorized as indisputably positive, indicating that all patients displayed good outcomes on histology. The classification of likely positive cases accounted for 6.5% of the total cases, although all instances exhibited positive results on histology. There existed a singular instance that had a distinct and unequivocal negative nature [16, 17].

The presence of mild acute appendicitis was verified through histological testing. Hence, the diagnostic accuracy attained a comprehensive rate of 100% in both the unquestionably positive and probably positive classifications. A retrospective analysis was undertaken by Larsen *et al.* in 2015, focusing on a 5-category interpretive scheme. The proposed scheme has been found to have superior diagnostic accuracy compared to the usual binary interpretive system. Based on its clinico-pathological presentation, acute appendicitis can be classified into two primary types: difficult and uncomplicated. This particular case encompassed various complications, including gangrene and perforation. Distinguishing between imaging and management is of utmost importance in light of significant advancements within the sector. In our study, a comprehensive analysis was conducted on a set of 13 criteria in order to ascertain their link with perforation. There were a total of eight indirect signs and five direct signs within the set of signage. The research revealed a statistically significant association between area bowel hypoperistalsis and perforation, as evidenced by a p-value of 0.003 (95% CI: 1.93 to 27.4) [17, 18].

The experimental results yielded probabilities of 7.34, a sensitivity of 81%, and a specificity of 68.3%. The univariate analysis revealed that two supplementary symptoms, namely caecal wall thickening and mesenteric lymphadenopathy, demonstrated a p-value below the threshold of 0.05. Nevertheless, multivariate analysis revealed that these variables did not demonstrate statistical significance. A separate investigation carried out by Tulin-Silver *et al.* (year) in the field of literature demonstrates a favorable association between hypoperistalsis of the localized bowel and perforation. Other notable indicators identified in the literature include the manifestation of complex fluid buildup in the recurrent intrafacial (RIF) area, an enlarged appendix diameter, the presence of an appendicolith, and the lack of the usual hyperechogenicity of the submucosa. No statistically significant link was observed between the aforementioned variables and perforation in our experiment. The phenomena that has been seen can be ascribed to the restricted sample size of 21 cases that demonstrate perforation. During the course of the investigation, we encountered other imitators that were subsequently excluded. Meckel's diverticulitis, 'pink appendix', and inflammatory mesothelial inclusion cyst in the RIF are the diseases that might cause a false positive interpretation in ultrasonography (USG) of suspected acute appendicitis [19, 20].

Conclusion

Indirect ultrasonographic indications were observed often, with probing soreness being the most common at 95.2%, followed by increased echogenicity of mesenteric fat in the RIF at 91.9%. Additional indirect indicators, listed in descending order of occurrence, are the presence of free fluid in RIF (51.6%), heightened vascularity in RIF (50%),

reduced blood flow in the nearby bowel (48.4%), lymphadenopathy in the mesenteric region of RIF (35.5%), thicker caecal wall (19.4%), and the accumulation of fluid in a specific area (8.1%). In 98.4% of the cases, there was at least one indirect indicator, in 95.2% of the cases there were at least two indirect signs, and in 77.4% of the cases there were at least three indirect signs. In the absence of explicit indications, the indirect indicators that exhibited the highest frequency were probing tenderness in the case of RIF (80%), as well as heightened echogenicity and increased thickness of mesenteric fat in RIF (80%). The remaining indirect indicators, arranged in descending order of occurrence, included the presence of free fluid in RIF, heightened vascularity in RIF, regional bowel hypoperistalsis, and mesenteric lymphadenopathy in RIF.

Despite the limited sample size of this particular subgroup in the study, the findings exhibit a similarity to the prevalence of these symptoms when all instances of acute appendicitis were examined. The most common direct indications were an enlarged appendix (91.9%) and a lack of appendix compressibility (91.9%). The remaining direct indicators, listed in descending order of occurrence, included hyperaemia of the appendicular wall, the existence of an appendicolith, and the loss of stratification in the appendicular wall. In 91.9% of the cases, there was at least one positive direct indicator, in 90.3% of the cases, there were at least two positive signs, and in 66.1% of the cases, there were at least three positive signs. Consequently, direct indicators are quite valuable in the diagnosis of acute appendicitis. The occurrence of indirect or direct indications did not exhibit a statistically significant disparity between the pediatric and adult cohorts. The connection between perforation and 8 indirect indicators and 5 direct signs was evaluated.

The study found a statistically significant connection between hypoperistalsis of regional bowel and perforation, as shown by an odds ratio of 7.34 and a p-value of 0.003 (95% CI: 1.93 to 27.4). Therefore, it can be advantageous in the process of diagnosing perforated appendicitis, a condition that frequently presents with varying therapy approaches. Additional indicators indicating a potentially significant connection in the initial univariate analysis included the thickening of the caecal wall and the presence of lymphadenopathy in the mesenteric region. According to the ultrasound criteria, all cases that were classified as Unequivocally Positive and Probably Positive for appendicitis exhibited positive results on histopathology. Ultrasound criteria have proven to be quite valuable in the prognostication of appendicitis.

Funding support

None

Conflict of interest

Nil

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