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Sonographic Evaluation of Acute Appendicitis -A Study at a Tertiary Care Hospital of Tribal, Hilly, Wayanad in Kerala.

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ABSTRACT

Background: Acute appendicitis (AA) is one of the most frequent causes of an acute abdomen requiring emergency surgery. Classically, the clinical findings consist of periumbilical pain migrating to the right lower quadrant, accompanied by fever and leukocytosis. However, the classic signs are not always present, and symptoms can be nonspecific and overlap with other causes of abdominal pain. While the clinical diagnosis may be straightforward in patients who present with classic signs and symptoms, atypical presentations may result in diagnostic confusion and delay in treatment. Among imaging methods, Ultrasound (US) is a valuable tool, which is widely available, can be performed at the bedside, does not use ionizing radiation, is relatively inexpensive, and may show evidence of other causes of abdominal pain. **Methods:** We evaluated the role of ultrasound in the diagnosis of AA, at a tertiary care hospital of tribal, hilly, Wayanad in Kerala, involving 224 patients from Jan 2015 to July 2016. Ultrasound findings were finally compared with surgical / pathological report of appendices removed at surgery. **Results:** The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of ultrasound in diagnosis of AA, in our study were found to be 99.2 %, 76.7 %, 87.2% , 98.5% and 90.6 % respectively. **Conclusion:** Although the sensitivity, specificity, and accuracy of sonography vary greatly in studies evaluating the imaging diagnosis of acute appendicitis, it should be the first imaging modality when there is clinical concern for acute appendicitis.

Keywords: Abdominal Pain, Acute Abdomen, Acute Appendicitis, Appendectomy, Sonography, Ultrasound.

INTRODUCTION

Acute appendicitis (AA) is the commonest cause of emergency abdominal surgery. The overall incidence of this condition is approximately 11 cases / 10,000 population / year. AA may occur at any age, although it is relatively rare at the extremes of age. The overall life time risk of developing AA is 9% for males and 6% for females. Most of patients are white skin individuals (74%) and is very rare in black skin individuals (5%).A male preponderance exists, with a male to female ratio of 1:1 to 3:1.[1-4]

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The most common symptom of appendicitis is abdominal pain. Typically, symptoms begin as periumbilical or epigastric pain migrating to the right lower quadrant of the abdomen. Later, a worsening progressive pain along with vomiting, nausea, and anorexia are described by the patient. Although AA has typical clinical presentation in 70% of the cases, about 30% of the patients have an uncertain pre-operative diagnosis due to which there is negative laparotomy in as high as 20-25% cases. The rate of such unnecessary laparotomies is even higher (35-45%) in women of child bearing age, because of the female pelvic organs and complications of pregnancy in this group. [5]

In the past 2 decades, the negative appendectomy rate has been relatively constant with slight decline after 2000, but the rate of perforated appendicitis seems to be increasing. [6]

Historically, computed tomography (CT) has been the first choice of imaging in AA with acute abdominal pain, with sensitivity of up to 96% and specificity of up to 97%.[7-10] However, because of the increasing awareness of the radiation dose imparted to patients by CT and the theoretical increased risk of cancer that it causes [11], there is a nationwide campaign to reduce the radiation from diagnostic imaging in children (Image Gently).[12]

Therefore, US should be used as the primary diagnostic modality in the evaluation of suspected AA in children and young women, in whom the radiation dose to the reproductive organs should be minimized and for whom it is important to exclude ovarian and uterine conditions that might mimic appendicitis. If compared to other diagnostic tests, US is inferior to CT as to sensitivity; due to its low negative predictive value for appendicitis, it may not be as useful for excluding appendicitis. More recently, color and power Doppler examination of the appendix have proven to be a useful adjunct to improve the sensitivity by demonstrating increased flow in an inflamed appendix.[13,14] The purpose of this study was to evaluate the diagnostic accuracy of the US method in the diagnosis of AA.

MATERIALS AND METHODS

The study was approved by the Institutional Review Board. An electronic medical record search at a large tertiary care hospital for patients referred for right lower quadrant sonography to rule out AA, between January 2015 and July 2016, identified 340 patients. All Patients irrespective of age and sex clinically suspected to be having AA, were included in the study. 116 of these patients were excluded from the study, because of previous US reports were not available or not done.

The study group comprised 224 patients out of which 118 female and 106 male; age range, 6–92 years were included in our study. After a detailed history and clinical examination, the standard US evaluation of the abdomen was done, based on the American Institute of Ultrasound in Medicine practice guidelines[15], which includes imaging of the appendix. US examinations of the abdomen & pelvis were performed by experienced radiologists with 2 – 5 MHz curvilinear transducer with the patient's bladder partially filled using US machine (Voluson S6; GE). By using a linear array transducer 4-12 MHz and a standardized protocol involving graded compression technique described by Puylaert[16], longitudinal and transverse images of the right lower quadrant were obtained. Compression sonography was performed with an empty bladder, with documentation of the appearance of the appendix during compression. A normal appendix compresses. The complete appendix should be visualized, including the tip. Doppler imaging is helpful to evaluate for hyperemia; however, a necrotic appendix will have decreased or no blood flow. The maximal outer wall diameter and the wall thickness should be measured along the course of the appendix.

US findings were retrospectively graded using a 5 point scale: 1- represented identification of a normal appendix; 2- indicated that the appendix was not seen, but no inflammatory changes or free fluid were evident; 3- indicated that the appendix was not seen, but secondary signs of appendicitis were present, such as a faecolith, pericecal fluid, or increased pericecal echogenicity consistent with infiltration of the mesenteric fat; 4- represented identification of an appendix of borderline enlarged size (5–6 mm); and 5- indicated acute appendicitis, defined as an enlarged non-compressible appendix with an outer diameter of greater than 6 mm. Findings graded 1 or 2 were classified as negative, and those graded 3 to 5 were classified as positive for AA . Original reports were reviewed and graded using the same criteria. US findings were compared with subsequent surgical and pathologic findings to determine the sensitivity and specificity of the Sonographic examinations.

RESULTS

Our study was a retrospective study of 224 patients in the age group of 6–92 years clinically suspected for AA. Age prevalence showed less than 6.6 % of patients in the age group of 1-10 years and 4.9 % of patients above the age group of 50 years were affected. These results were comparable to the study done by Lewis et al [17] who observed that less than 10% of patients were affected in the age group of 1-10 years and less than 10% of patients were affected in the age group of 50 years and above with male: female ratio of 2:1. In our study, females were more commonly affected than males, with a male: female ratio of 1:1.11 probably due to more female population compared to males in kerala (Sex Ratio1.084). Our study showed that highest number of AA occurred in the age group of 11-20 years followed by age group of 21-30 years which is consistent with the findings shown by Addis et al [18] that it is most common in 10 to 19 year old age group.

Among the patients who underwent US examination for clinically suspected AA, the sonographic findings were negative in 86 (38.39%) and positive in 138 (61.6%).In 50% of patients, enlarged appendix more than 6 mm in diameter (Grade 5) were observed and 5-6 mm diameter (Grade 4) in 5.8%. Secondary signs of appendicitis (Grade 3) were present in 5.8% [Table 1].

Table 1: US Grading of Acute Appendicitis patients in the study with reference to the Age.

US Grade	Age group in years						Total number
	1-10	11-20	21-30	31-40	41-50	>50	
1	0	0	0	0	0	0	0
2	5	36	18	14	9	4	86
3	5	06	00	01	0	1	13
4	0	08	02	03	0	0	13
5	5	53	28	11	9	6	112
Total	15	103	48	29	18	11	224

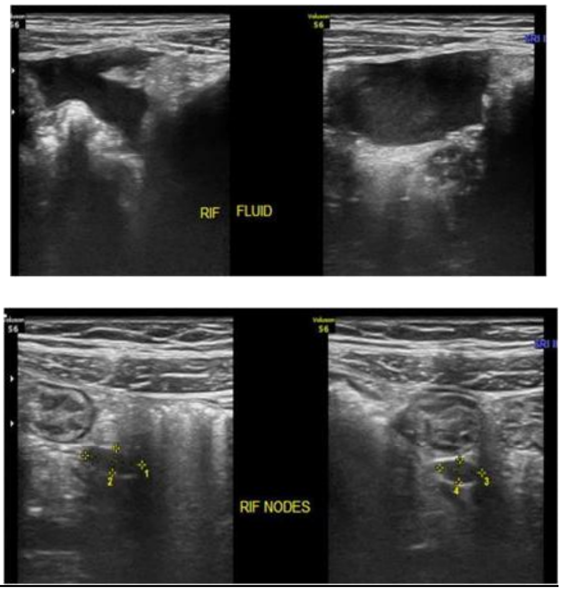


Figure 1: (A, B). 9 year old female child with sonogram of right lower quadrant shows focal free fluid & lymph nodes adjacent to the echogenic bowel loop. The appendix is not seen (Grade 3).

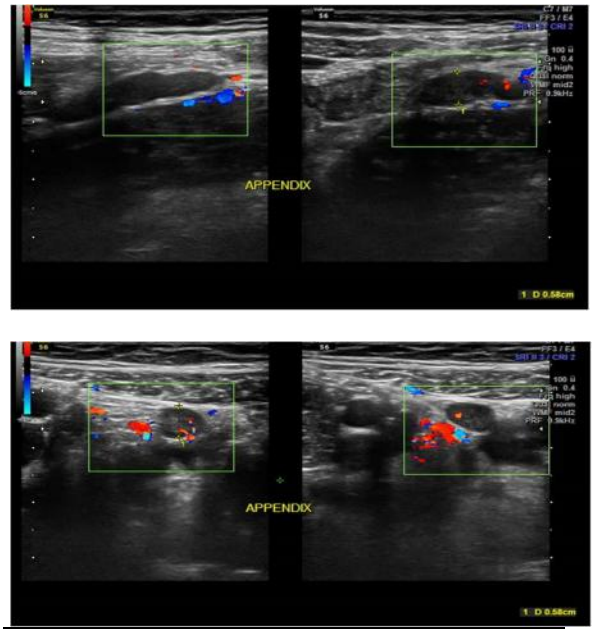
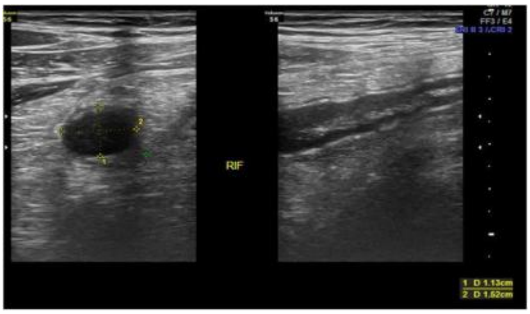


Figure 2: (C,D). Longitudinal & Transverse sonogram of the right lower quadrant in a 11 years old female child reveals border line enlarged appendix of thickness 5.8mm (Grade 4).



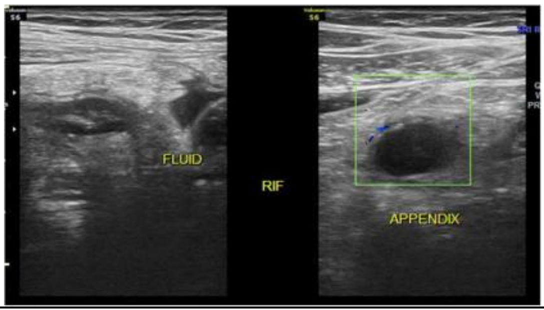


Figure 3: (E,F). E. Transverse & longitudinal sonogram of the right lower quadrant in a 27 years old adult male shows a dilated, thickened non-compressible appendix with an outer diameter of 11 mm suggestive of acute appendicitis. F. Transverse color Doppler image shows dilated appendix with increased flow in the wall (Grade 5).

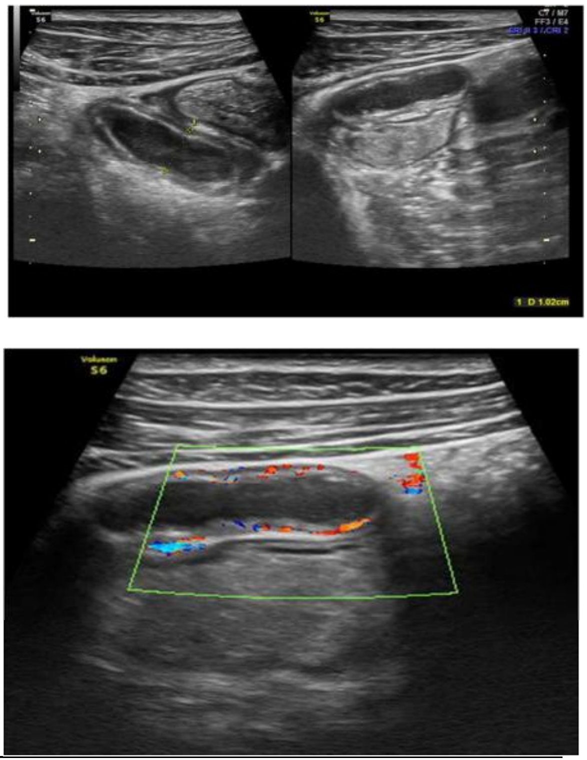
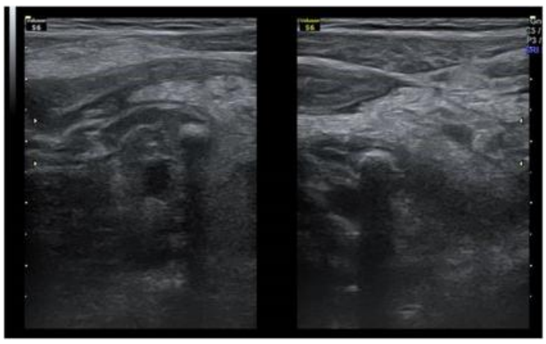


Figure 4: (G,H). G. Longitudinal sonogram of Subhepatic region in a 36 years old female shows findings of Subhepatic Acute Appendicitis. H. Color Doppler image shows dilated appendix with increased flow in the wall (Grade 5).



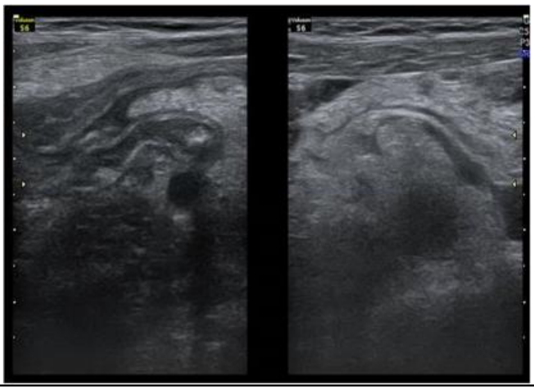


Figure 5: (I,J).Longitudinal US image of the right lower quadrant in a 9 years old male child, showing an echogenic shadowing structure within a dilated appendix suggestive of an appendicolith associated with appendicitis.

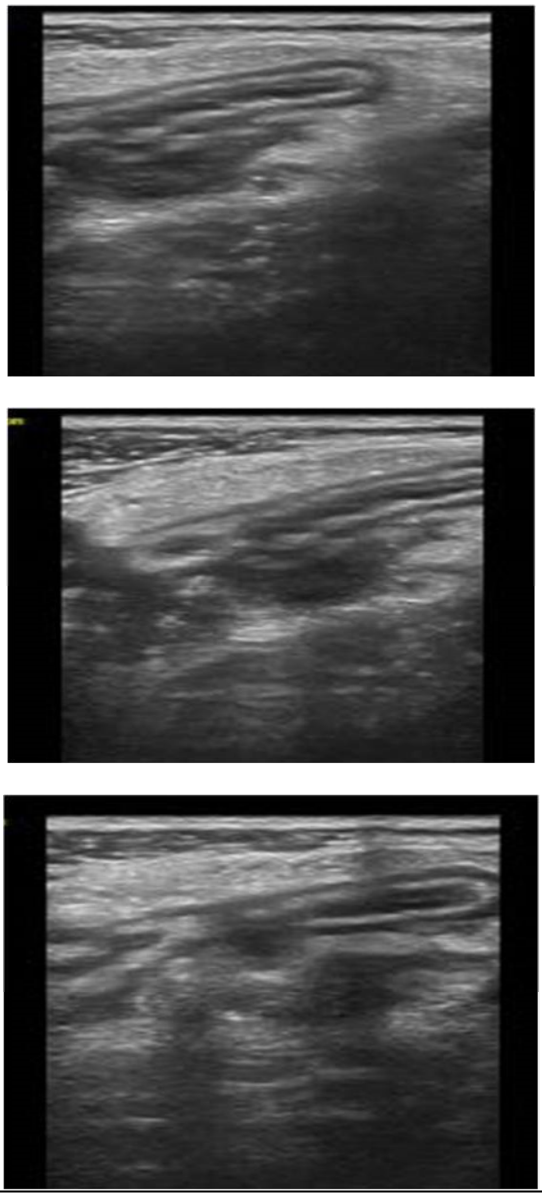


Figure 6: (K-M). Right lower quadrant longitudinal sonogram reveals Perforated Appendix with periappendiceal hypoechoic fluid collection.

Figure 7: (N,O).Right lower quadrant sonogram of 9 years old male child with perforated appendix & Appendicular Abscess appearing as a debris-filled fluid collection with surrounding echogenic fat.

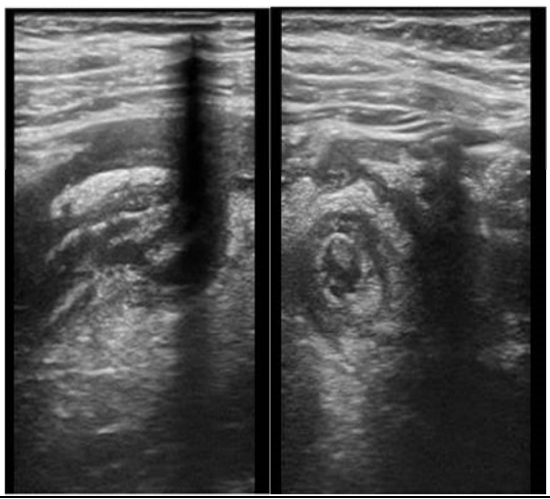


Figure 8: (P,Q).Right lower quadrant Longitudinal & Transverse sonogram shows Acute appendicitis with inflamed surrounding fat & mesentry forming early mass.

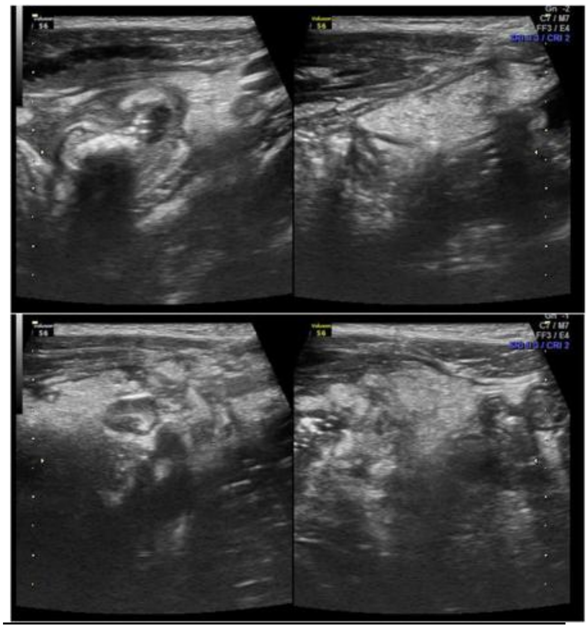


Figure 9: (R,S). US of right lower quadrant in a 9 years old male child, reveals perforated appendix, inflamed echogenic surrounding fat and adherent bowel loops forming Appendicular mass.

The urinalysis was abnormal in 33 (14.7%) patients, which revealed pyuria and heamaturia. Uterine & ovarian abnormalities were found in 9 patients (4%), urinary calculi in 13 patients (5.8%). All the patients underwent surgery. The surgical & histopathological findings were positive for appendicitis in 157 patients (70%). Twenty, patients with negative sonographic findings did have AA according to surgical and pathologic findings [Table 2].

Table 2: Sonographic Diagnosis compared with Surgical/ Pathologic findings in patients who Underwent Surgery.

Sonography	Surgery		Total
	Negative	Positive	
Positive	1	137	138
Negative	66	20	86
Total	67	157	224

Diagnostic role of ultrasound was evaluated by calculating sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy using standard formulae and values obtained.

Table 3: Results of Sonographic Studies in Diagnosis of Acute Appendicitis

Total No of Cases	Proven On Histopathology	Sonography			
		True Positive	True Negative	False Positive	False Negative
224	157	137	66	20	01

On the basis of the final diagnosis, the Sensitivity of sonography was 99.2% and Specificity 76.7 %. In conclusion, in our study Sonography was found to have a high Negative Predictive Value of 98.5% for the exclusion of AA, even if the appendix was not visualized.

DISCUSSION

The vermiform appendix is a tubular structure attached to the base of the caecum at the confluence of the taeniae coli. In humans it is regarded as a vestigial organ, and acute inflammation of this structure is called acute appendicitis [AA]. The normal appendix is blind ended, maximal outer wall diameter is less than 6 mm, lumen is compressible and the mural thickness is less than 2 mm. It is not always necessary to identify a normal appendix to consider the findings negative.[19]

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 requiring surgery and has a lifetime prevalence of about 7 %.[20] The clinical diagnosis remains difficult, both in the paediatric and adult population, as the presentation is often atypical.[21] Symptoms are frequently non-specific and overlap with various other diseases.[22]

The primary cause of AA, is probably luminal obstruction, which may result from faecoliths, lymphoid hyperplasia, foreign bodies, parasites and primary neoplasms or metastasis.[23]

Abdominal pain is the primary presenting complaint, followed by vomiting with migration of the pain to the right iliac fossa, described first by J Murphy in 1904.[23] The initial pain represents a referred symptom resulting from the visceral innervation of the midgut, and the localized pain is caused by involvement of the parietal peritoneum, after progression of the inflammatory process. The patient is often flushed, with a dry tongue and an associated fetor oris.

The presence of pyrexia (up to 38°C) with tachycardia is common. Loss of appetite is often a predominant feature. Constipation and nausea with profuse vomiting may indicate development of generalized peritonitis after perforation but is rarely a major feature in simple appendicitis. Perforation should be suspected whenever the temperature exceeds 38.3 C. If perforation does occur, periappendiceal phlegmon or abscess will result if the terminal ileum, caecum, and omentum are able to "wall off" the inflammation. Peritonitis usually develops if there is free perforation into the abdominal cavity.[1-3]

A failure to recognize other presentations of AA, will lead to a delay in diagnosis and increased patient morbidity. Patients with a retrocaecal appendix or those presenting in the later months of pregnancy may have pain limited to the right flank or costovertebral angle. Male patients with a retrocaecal appendix may complain of right testicular pain. Pelvic or retroileal locations of an inflamed appendix will have pain referred to the pelvis, rectum, adnexa, or rarely, the left lower quadrant. Subcaecal and pelvic suprapubic pain and urinary frequency may predominate.[24]

In the setting of AA, the appendix is non-compressible with maximal outer wall diameter greater than 6 mm. The wall may be hyperemic. An appendicolith may be present, helping the diagnosis; however, an appendicolith can be present without AA, and the presence of an appendicolith does not confirm AA. There may also be secondary signs of inflammation, such as hyperechoic surrounding fat, free fluid, or an abscess. Enlarged nodes can also be seen in the right lower quadrant, but this finding is nonspecific and can also be seen in patients without appendicitis. The surrounding bowel may be dilated with loss of normal peristalsis due to ileus.[26]

Pathologically AA is divided into 3 types. 1. Catarrhal appendicitis - the wall of the appendix shows three layers. 2. Phlegm nous appendicitis - indistinct three layered structure of appendix. 3. Gangrenous Appendicitis - no layered structure of appendix. The histologic finding of appendicitis is neutrophilic infiltration of the mucosa, sub-mucosa and muscularis propria.

The differential diagnosis of AA, is essentially the diagnosis of the acute abdomen. Thus, an essentially identical clinical picture can result from a wide variety of acute processes within the peritoneal cavity that produce the same alterations of function as does AA.

Physical examination reveals generally soft abdomen with localized tenderness at or about McBurney's point.[1] The following signs of AA, are the mostly described, but all of them occur in less than 40% of patients with AA, and even their absence should not prevent the examiner from establishing an accurate diagnosis. Muscular rigidity in the right iliac fossa with rebound tenderness (Blumberg's rebound pain), pain is referred to the area of maximal tenderness during percussion or palpation of the left lower quadrant (Rovsing's sign), right lower quadrant pain with extension of the right hip (Psoas sign), right lower quadrant pain with flexion and internal rotation of the right hip (Obturator sign).[1,2,21].

A good review of laboratory markers for the diagnosis of AA is provided by DJ Shogilev et al.[22]. The degree of white blood cell elevation, the value of C-reactive protein, the proportion of polymorphonuclear cells, a history of fever and other factors have been studied extensively for the diagnosis of AA, but lack sufficient specificity either alone or in combination. On the contrary, the absence of all of these laboratory parameters can potentially rule out the diagnosis of AA.[22] Interestingly, the combination of an elevated CRP, elevated WBC, or neutrophilia greater than 75% improves the sensitivity to 97%-100% for the diagnosis of AA. The urinalysis is abnormal in 19%-40% of patients with AA. Abnormalities include pyuria, bacteriuria, and heamaturia.[24] In our study urinalysis was abnormal in 14.7% of patients.

Many clinical scoring systems (CSS) have been developed to assist clinicians in appropriately stratifying a patient's risk of having appendicitis. These are the Alvarado score, introduced by Alvarado in 1986 and sometimes referred as the MANTRELS score (acronym of the eight criteria), and the Paediatric Appendicitis Score (PAS) or Samuel score, reported by Samuel in 2002.[25] The Alvarado score has been reported in numerous studies in paediatric and adult patients with a suspicion of AA.

Alvarado score for the diagnosis of appendicitis [25].

Clinical finding	Points
Migration of pain to the right lower quadrant	1
Anorexia	1
Nausea and vomiting	1
Tenderness in the right lower quadrant	2
Rebound pain	1
Elevated temperature (>_99.1degree F = 37.3 C)	1
Leukocytosis (_10,000 white blood cells per mm3)	2
Shift of WBC count to the left (>75 percent neutrophils)	1

Patients with a score of 7 or more points have a high risk of appendicitis. Patients with a score below 5 points have a very low risk of appendicitis.

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 AA without unnecessary appendectomies. Imaging should be done only in patients in whom a clinical and laboratory diagnosis of appendicitis cannot be made.

Multi-detector computed tomography (MDCT) is considered the gold standard technique to evaluate patients with suspected AA, because of its high sensitivity and specificity.

Magnetic resonance imaging (MRI) has also shown high accuracy in the detection of AA, especially when radiation protection in children and in pregnant patients is of major importance.[21, 22]

High-resolution real time Ultrasonography [US] is non-invasive diagnostic modality which is readily available and enables direct visualization of an inflamed appendix or periappendiceal abscess. Extended sonography is also of value in patients without evidence of acute appendicitis. It can provide echo morphologic findings that may suggest an alternate diagnosis such as mesenteric adenitis, terminal ileitis, gynecologic disorders and urologic diseases.[5]

At the start of the examination, it is helpful to ask the patient to point to the site of maximal tenderness and begin scanning in this location. The most reliable way to identify the appendix is to find the ascending colon, follow the colon proximally to the cecum, and then find the appendix extending off the cecum. If the appendix cannot be seen in the supine position, it may be helpful to place the patient in the left lateral decubitus position to cause a retrocecal appendix to be better seen. Scanning with a full bladder may also be helpful because it can better delineate a deep pelvic appendix that might be obscured by overlying bowel. If an abscess is suspected, a lower- frequency curved array transducer may be used for a larger field of view and deeper penetration.[26]

It is crucial to avoid two potential situations in patients with suspected AA: (1) any delay in diagnosis and subsequent perforation of the appendix; (2) an unnecessary appendectomy. There is agreement that imaging techniques improve both of these clinical scenarios, due to the potential for early diagnosis and the high sensitivities (CT, MRI) and specificities (US, CT, MRI) of these techniques.[21, 27, 28].

In a study of AA, by Tauro LF et al [29], who showed US Sensitivity of 91.37 %, Specificity of 88.09 %, diagnostic Accuracy of 90 %, Positive predictive value (PPV) of 91.37% and Negative predictive value (NPV) of 88.09 %.

In 2007, a systematic review including 9121 patients of 25 studies reported a Sensitivity of 83.7 %, a Specificity of 95.9 %, an Accuracy of 92.2 %, a Positive predictive value (PPV) of 89.8 % and an NPV of 93.2 % for the US diagnosis of AA.[30]

In our study involving 224 patients, the US Sensitivity for the diagnosis of AA, was found to be 99.2%, Specificity 76.7%, Accuracy of 90.6%, Positive predictive value (PPV) 87.2% and Negative predictive value (NPV) 98.5%, which are similar to study done by Tauro LF et al[29], and nearly correlated with the study by Al-Khayal KA et al[30].

In a recent review of the literature, there was an extremely variable diagnostic accuracy of US with sensitivities ranging from 44 % to 100 % and specificities ranging from 47 % to 100 %.[31]

In our study, US not only diagnosed AA but also identified other conditions mimicking appendicitis like renal calculi & hydronephrosis (5.8%), uterine & ovarian abnormalities (4%). This is consistent with the studies of Gaensler et al[32] and Emmie M Fa et al[33].

After the first 36 hours from the onset of symptoms of AA, the average rate of perforation is between 16% and 36%, and the risk of perforation is 5% for every subsequent 12 hour period.[34] Once a diagnosis is made, appendicectomy should therefore be done without any unnecessary delays.

Open Appendicectomy is a relatively safe procedure with a mortality rate for non-perforated appendicitis of 0.8 per 1000. The mortality and morbidity are related to the stage of disease and increases in cases of perforation; mortality after perforation is 5.1 per 1000.[35] Rates of postoperative wound infection vary from < 5% in simple appendicitis to 20% in cases with perforation and gangrene. Intra-abdominal or pelvic abscesses may form in the postoperative period after gross contamination of the peritoneal cavity.[36]

Laparoscopic appendicectomy is becoming increasingly common, and clinical evidence suggests that it has some advantages over open surgery. All of our patients underwent laporoscopic appendicectomy and post procedure follow up was uneventful.

Some of the limitations in our study include, some patients who were highly suspicious for appendicitis from physical examination went directly to surgery. This study was also limited by its retrospective design, which is particularly relevant to sonography because the examinations are highly operator dependent.

CONCLUSION

Acute appendicitis is the commonest acute abdominal condition, requiring emergency surgery. If clinical signs and the symptoms are combined with US findings, the diagnostic accuracy is significantly increased. Abdominal sonography when performed using rigorous technique and criteria for diagnosis, is an excellent screening tool for diagnosing AA, particularly in children and young female patients for whom the gonadal radiation dose should be kept to a minimum, and for whom it is important to exclude ovarian and uterine conditions that might mimic appendicitis, thus reducing the cost of treatment and preventing negative laparotomies. Although the sensitivity, specificity, and accuracy of sonography vary greatly in studies evaluating the imaging diagnosis of acute appendicitis, it should be the first imaging modality when there is clinical concern for acute appendicitis. Only if the examination is equivocal or if the appendix cannot be identified, should other imaging modalities such as CT abdomen or MRI be considered.

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