ULTRASONOGRAPHIC (USG) EVALUATION OF ACUTE APPENDICITIS
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ABSTRACT: BACKGROUND: The diagnosis of acute appendicitis is mainly clinical and to augment the clinical diagnosis ultrasonography (USG) of the abdomen is being used to help in diagnosis of the disease. AIM: To find out the role of USG in the diagnosis of acute appendicitis in clinically equivocal cases and to correlate USG findings with histopathological reports (HPR) of removed appendix. MATERIALS AND METHODS: This study was performed during the period from November 2012 to March 2014. It was a non-randomized, prospective study of 56 clinically suspected cases of acute appendicitis. All of them underwent ultrasound evaluation. A histopathological examination was performed on all surgically removed appendices, which formed the basis for definitive judgment. Patients not undergoing surgery were excluded for calculating sensitive and specificity. The diagnostic accuracy of sonography was examined using the NPV, positive predictive value (PPV), negative and positive likelihood ratios, sensitivity, specificity, and their respective 95% confidence intervals (CIs). RESULTS: Out of 56 patients, 38 patients were correctly diagnosed as having acute appendicitis on USG out of 47 finally diagnosed cases based on histopathological reports. This showed that USG scan has sensitivity of 89.74%, specificity of 77.78%, positive predictive value of 94.44% and negative predictive value of 87.23%. The most accurate appendiceal finding for appendicitis was a diameter of 6 mm or larger followed by non-compressibility of inflamed appendix. CONCLUSION: USG has high accuracy in diagnosing acute appendicitis and reduces negative appendectomies. Greater than 6-mm diameter of the appendix under compression is the most accurate USG finding with high positive predictive value for the diagnosis of acute appendicitis. Surgery followed by histopathological examination was the ultimate proof of acute appendicitis. KEYWORDS: Appendix, appendicitis, ultrasonography, appendectomy.

INTRODUCTION: The cause of acute appendicitis is unknown but is probably multifactorial.¹ Appendicectomy is the treatment of choice. Acute appendicitis is the most common surgical abdominal emergency with a life time prevalence of one in seven.² In order to improve the diagnostic accuracy, different techniques are introduced like computer aided programs, different scoring systems, gastrointestinal (GIT) contrast studies, ultrasonography (USG), computed tomography (CT scan), Magnetic Resonance Imaging (MRI scan) and Laparoscopy.³ Among these modalities USG is simple, easily available, non-invasive, convenient and cost effective.⁴ Recently with the availability of high frequency transducers, resolution is considerably improved enabling visualization and diagnosis of appendicular pathologies. In experienced hands, graded compression sonography is particularly useful in cases of suspected uncomplicated acute appendicitis. Obvious advantages of ultrasound are 1) It does not employ any ionizing radiation, non-invasive, 2) There is minimal discomfort to the patient, 3) easy availability, portability and repeatability 4) No specific patient preparation is required. The significance of this study is that USG will definitely improve general surgeon’s confidence in diagnosis of acute appendicitis and reduce the negative
appendicectomy rate; thus reducing workload of hospitals and postoperative complications.\textsuperscript{5} Hence the aim of this study was to find out the role of USG in the diagnosis of acute appendicitis in clinically equivocal cases and to correlate USG findings with histopathological findings.

\textbf{MATERIALS AND METHODS:} The study was approved by Institutional Ethical Committee of Al-Ameen Medical College, Bijapur. Detailed and signed informed consent was obtained from the subjects in the presence of witness, after oral reading of the protocol in verbatim and explaining it in the subject’s own language. All the patients referred for this study were included irrespective of age, sex, pregnancy, or otherwise. Present study is a non-randomized, prospective study comprises of 56 patients. We selected patients with the history of abdominal pain in whom the clinical signs were equivocal for acute appendicitis at the Department of Radio-diagnosis in Al-Ameen Medical College Hospital, Bijapur. This study was performed during the period from November 2012 to March 2014.

\textbf{Inclusion Criteria:}
1. Patients clinically suspected to be having acute appendicitis.
2. All individuals irrespective of age and sex.
3. Cases with history of recurrent appendicitis presenting with acute symptoms.

\textbf{Exclusion Criteria:}
1. All other causes of acute abdomen.
2. Cases with recurrent appendicitis not presenting with acute symptoms.
3. Cases of acute appendicitis diagnosed clinically and sonologically but not willing for further management were excluded from the study.

\textbf{USG (Ultrasonographic) Evaluation Criteria:} All USG studies were performed with the 7.5-10 MHz linear array transducer. In women, an ultrasound study of the pelvis was acquired with 3.5MHz-7.0 MHz curvilinear transducer with the patients bladder partially filled. By using a linear array transducer, the sonographic plane was perpendicular to the table; the special flat T-shape enabled the examiner to exert gentle compression with the transducer using both hands in the same way as when palpating the abdomen. The method of examination in this study was similar to that used in the graded compression described by Puylaert.\textsuperscript{6}

\textbf{USG Examination:} All patients were asked to point to the site of maximal pain in the right lower quadrant (RLQ) with a single finger before the study. The examination was initiated by scanning in the transverse plane in the lateral right mid abdomen just above the level of umbilicus. The examination was continued caudally in the RLQ with gradually increasing compression until all bowel gas and fluid could be expressed from the ascending colon and caecum. An attempt was made to image caecal tip in the transverse plane by scanning caudal to the approximate insertion of the terminal ileum.

Gently reducing and then increasing the pressure of the transducer allowed assessment of compressibility of the normal bowel, normal caecum and terminal ileum. Care was taken so that pressure on the transducer was gradually reduced so as not to elicit pain because of rebound tenderness. The inflamed appendix was most often visualized at the base of caecal tip during maximal
graded compression. The examination was continued caudally with identification of the psoas and external iliac artery and vein. Longitudinal and oblique scans were then obtained of the lower quadrant with graded compression.

**USG Diagnostic Accuracy:** The examination was considered diagnostic if all the bowel gas and fluid could be manually expressed with the transducer from the caecum and terminal ileum. A study was taken as non-diagnostic if the caecum could not be adequately compressed. Measuring the distance from one point on the serosal layer to opposite point on serosa assessed outer diameter.

Sonographic visualization of inflamed appendix or identification of peri-appendicealabcess was considered positive for the diagnosis of appendicitis. Visualization of appendix less than 6mm or non-visualization was recorded as a negative result.

To determine and compare the diagnostic accuracy of initial physical examination and USG in acute appendicitis, the following criteria were considered:

- **Sensitivity** = \( TP / (TP + FN) \)
- **Specificity** = \( TN / (TN + FP) \)
- **Positive Predictive value** = \( TP / (TP + FP) \)
- **Negative Predictive value** = \( TN / (TN + FN) \)

**Histopathological Criteria:** A histopathological examination was performed on all surgically removed appendices, which formed the basis for definitive judgment. Patients not undergoing surgery were excluded for calculating sensitive and specificity as there was no histopathological reports (HPR) for those cases.

**Statistical Analysis:** The diagnostic accuracy of sonography was examined using the NPV, positive predictive value (PPV), negative and positive likelihood ratios, sensitivity, specificity, and their respective 95% confidence intervals (CIs). Frequency tables were generated using SAS version 9.1.3 software (SAS Inc, Cary, NC), and the 95% CIs were calculated using VassarStats. The CIs were calculated using the efficient-score method (corrected for continuity). Inter-reader reliability was verified using Cohen weighted \( \kappa \) and Kendall tau \( \beta \) coefficients. Values between 0.61 and 0.80 were considered good agreement. Values are reported as estimated values and 95% CIs.

**RESULTS:** In our study, 38 cases (67.86%) of our patients showed sonological findings suggestive of acute appendicitis i.e. non compressible appendix with a mean diameter > 6 mm (Table 1). Among those USG positive cases, 1 case (2.6%) showed appendicolith, 2 cases (5.2%) showed appendicular mass, 2 cases (5.2%) showed appendicular abscess and 2 cases (5.2%) showed features s/o perforating appendicitis. In cases of appendicular abscess and one case of perforating appendicitis, inflamed appendix was not visualized.
Table 2 depicts out of 56 cases, appendix was visualized in 39 cases. In 35 cases appendix was non-compressible with a diameter of >6mm which was considered as a feature of acute appendicitis (Figure 1). In remaining 4 cases, appendix was compressible with a diameter <6mm which is considered as a feature of normal appendix (Figure 2). In two cases of appendicular abscesses and in one case of perforating appendicitis, appendix was not visualized. They were identified in USG by other features like loculated fluid collection, prominent pericaecal fat and loss of submucosal integrity. Taking all this in to consideration, USG was positive for appendicitis in 38 cases. Out of these 38 cases, probe tenderness was present in 33 cases (86.84%).

| USG findings     | No. of patients | Percentage |
|------------------|-----------------|------------|
| Non-compressible | 35              | 92.11      |
| Compressible     | 4               | 10.53      |
| Tender           | 33              | 86.84      |
| Diameter >6mm    | 35              | 92.11      |

Table 2: Frequency distribution of patients positive for acute appendicitis

Figure 1: Ultrasonography of acute appendicitis
In Table 3, among 56 cases, USG was negative for appendicitis in 18 cases (32.14%). Out of this, 7 cases (38.89%) had alternative diagnosis which included right renal calculi in 3 cases, right hemorrhagic ovarian cyst in 1 case, right hydroureteronephrosis in 2 cases and right tubo ovarian mass in 1 case. Appendix was not visualized in 7 cases (38.89%) in whom no pathology was detected accounting for abdominal pain. In 4 cases we could directly visualize normal appendix, which were compressible with a mean diameter of less than or equal to 6 mm.

| USG findings                  | No. of patients | Percentage |
|-------------------------------|----------------|------------|
| Alternative diagnosis         | 07             | 38.89      |
| Non visualized appendix       | 07             | 38.89      |
| Visualized normal Appendix    | 04             | 22.22      |
| **Total**                     | **18**         | **100.0**  |

Table 3: Frequency distribution of patients negative for acute appendicitis

Only those cases that had undergone appendectomy were included for calculating the sensitivity, specificity, accuracy, positive predictive value and negative predictive value of our study which included a total of 47 cases (83.93%). Remaining 9 cases had been omitted as they did not have histopathological confirmation. In Table 1, out of 56 cases recruited for the study purpose, 38 cases (67.85%) were positive for acute appendicitis sonologically. Table 4 depicts, out of these 38 patients, 36 cases underwent appendectomy and 2 cases of appendicular mass had conservative management and hence not included for analyzing the result. Out of this, 34 cases were true positives and 2 cases were false positives. Out of 18 patients (32.14%) who were negative for acute appendicitis sonologically, 7 patients who had alternative diagnosis were given conservative management and
hence were excluded for final result analysis as they do not have histopathological confirmation i.e., 11 patients out of 18 patients were included. Among these 11 patients, 4 cases were diagnosed as false negatives and 7 cases were diagnosed as true negatives. By ultrasound examination we were able to give alternative diagnosis in 7 cases thus explaining the symptoms of patients. Normal appendix was visualized in 4 cases. In this study it was observed that the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of ultrasound scanning with reference to histopathological confirmation were found to be 89.74%, 77.78%, 94.44%, 63.64% & 87.23% respectively.

| USG | HPR                  | Total |
|-----|----------------------|-------|
|     | Positive | Negative |       |
| Positive | 34      | 02      | 36    |
| Negative | 04      | 07      | 11    |
| Total   | 38      | 09      | 47    |

Table 4: USG diagnosis compared with HPR reports in acute appendicitis patients

| Sensitivity | Specificity | Positive Predictive Value | Negative Predictive Value |
|-------------|-------------|---------------------------|---------------------------|
| 89.74 (95% CI, 75-96) | 77.78 (95% CI, 40-96) | 94.44 (95% CI, 81-91) | 63.64 (95% CI, 30-88) |

**DISCUSSION:** In our study we could identify normal appendix in 4 cases (10.53%). The normal appendix was compressible, less than 6mm in diameter and ovoid in cross-section. In these cases we confidently excluded the diagnosis of acute appendicitis. This is in conformity with the study of Thomas Rettenbacher et al. In the remaining 14 cases, ultrasound was unable to detect either normal or abnormal appendix. In 35 cases (62.5%) of the total number of cases where we could see an inflamed appendix, it was non-compressible and spherical in shape in all the cases. The outer diameter of the appendix was greater than 6mm in all the 35 cases. This finding is consistent with the criteria laid down by Jeffrey et al. and reinforced by the study of Thomas Rettenbacher et al.

Ultrasound not only diagnosed acute appendicitis but also diagnosed other conditions mimicking appendicitis. In our study, 18 cases were negative for appendicitis accounting for 32.14% of total cases. Out of these 18 cases, we could give an alternative diagnosis in 7 cases (38.89%) like right renal calculus in 3 cases, right hemorrhagic ovarian cyst in 1 case, right hydroureronephrosis in 2 cases and right tuboovarian mass in 1 case. All those cases were managed conservatively based on our report. Thus we could prevent negative laparotomy in these cases. This is consistent with the studies of Gaensler et al. and Faet al. In our study, 47 (83.93%) of patients had surgical management and the remaining 9 cases (16.14%) had conservative management. The commonest position of the appendix was retrocecal (63.84%) of the total cases who had appendectomy.

This was in accordance with the literature. The ultimate proof for the diagnosis of acute appendicitis was histopathological examinations. The accuracy of sonography in the diagnosis of acute appendicitis in our study was 87.23%. In this study, the observed sensitivity, specificity, positive predictive value and negative predictive value of ultrasound scanning with reference to histopathological confirmation was 89.74%, 77.78%, 94.44%, 63.64%, respectively. The comparative results of different studies were given by Joshi et al. summarizes the results of the present study.
As operator gains experience, false negativity also decreases, which is in accord with Wade et al.\textsuperscript{15} who stated that the results would not be so impressive if the operator did not have enough experience.

But Cheshbrough et al.\textsuperscript{16} in his study included radiology residents and observed that the accuracy did not diminish and reported an accuracy of 86% for ultrasonography, comparable with the present study. Other factors which are responsible for false negative diagnosis in acute appendicitis is retrocecal position of appendix and when caecum is filled with gas and faeces which is consistent with the study conducted by Yacoe and Jeffrey.\textsuperscript{17} In such cases, adequate compression is not possible. In our study out of 4 false negative cases, 2 cases had appendix in retrocecal position and 2 cases had gas distended caecum.

**CONCLUSION:** Ultrasound is a non-invasive highly diagnostic investigation that has improved our ability to detect appendicitis and its complications with improved results and reduced rate of unnecessary surgeries. Tissue harmonic ultrasound therefore is an imaging modality of preference in cases of acute appendicitis. Diameter of larger than 6mm is the most sensitive USG finding for appendicitis, with high positive predictive value and negative predictive value, followed by non-compressibility of the infamed appendix. These two USG findings together provide the most accurate diagnosis in suspected cases of acute appendicitis. Surgery followed by histopathological examination was the ultimate proof of acute appendicitis.

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