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Research Article

DETERMINATION OF SENSITIVITY AND SPECIFICITY OF ULTRASONOGRAPHY IN ACUTE APPENDICITIS: COMPARISON WITH PER-OPERATIVE FINDINGS AND HISTOPATHOLOGICAL REPORT

SASMITA PARIDA, BIBEKANANDA NAYAK, JAYASHREE MOHANTY

Department of Radio Diagnosis, SCB Medical College, Cuttack, Orissa, India. Email: drparidasasmita@gmail.com

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ABSTRACT

Objective: This study was under taken to compare the ultrasonographic findings with pre-operative findings and histo-pathological report and to evaluate the sensitivity, specificity, positive and negative predictive values and accuracy of ultrasonography in the diagnosis of acute appendicitis.

Methods: It was a prospective study done in the department of radio-diagnosis, SCBMCH, Cuttack. Patients with provisional diagnosis of acute appendicitis were subjected to ultrasound of abdomen and pelvis. Patients with positive USG findings were followed up for pre-operative findings and histo-pathological results. All the obtained data were tabulated and subjected to statistical analysis.

Results: Among the 100 cases studied, 77 cases were proved as acute appendicitis based on surgical and histopathological results. Male to female ratio was 1.5:1. The disease was found to be more prevalent in second and third decade of life. Location of affected appendix was most commonly retro caecal. Mean diameter of the appendix was 8.56 mm. Target sign and non-compressible bowel loop was the most commonly detected ultrasonographic sign and the ultrasonographic sensitivity was 96.1% and specificity was 95.65% in our study.

Conclusion: High resolution sonography with graded compression is a very useful diagnostic tool for diagnosis of appendicitis in problematic cases and in women in their reproductive period. It is also helpful in detecting complications of appendicitis and other abdominal diseases that mimic acute appendicitis.

Keywords: Acute appendicitis, Appendicolith, Ultrasonography, Appendectomy.

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INTRODUCTION

Acute appendicitis is one of the most common surgical abdominal emergencies in India. Any delay in the diagnosis increases the morbidity period, undue complications, and mortality rate. As this disease is amenable for treatment by surgery, early diagnosis plays an important role in the early treatment and in preventing undue complications [1].

Acute appendicitis is one of the most common causes of acute abdomen in young adults. Acute appendicitis is relatively rare in infants, becoming increasingly common in childhood and early adult life, reaching a peak incidence in teens and early 20's. In about 30% of patients, the signs, symptoms, and laboratory findings of acute appendicitis are atypical often leading to delay in diagnosis and surgical intervention with consequent increase in rate of perforation and complication.

In addition, other diseases produce clinical and laboratory findings similar to that of acute appendicitis leading to negative appendectomy rate of 20-25%. This rate is as high as 30-35% in case of female patients in their reproductive years because of various gynecological diseases.

Grades compression ultrasound using high-frequency linear array transducers in supine position for diagnosing acute appendicitis was advocated by Puylaert *et al.* [2].

Ultrasound can diagnose a number of conditions that mimic appendicitis clinically. If appendicitis can be excluded sonologically and an alternative diagnosis can be made, two benefits will occur. Unnecessary appendectomy can be avoided and appropriate treatment can be instituted. Ultrasound can be recommend in children when there is diagnostic doubt, in young women (due to high incidence of tubal disease), and in patients who are pregnant [3].

Women, in particular, benefit most from preoperative imaging, with a statistically significant lower negative appendectomy rate than that in women who undergo no preoperative imaging.

The use of high-frequency probes gives better lateral and axial resolution. Higher-frequencies are absorbed more strongly so depth resolution is less. Therefore, both probes are needed to examine the patients. In conjunction with pre-operative findings and histopathological (HP) results, it provides useful information for accurate diagnosis and treatment for the patient.

The aim of this present study was to find out the sensitivity and specificity of ultrasonography **(**USG) in acute appendicitis, to study the positive and negative predictive values and accuracy of ultrasound in the diagnosis of acute appendicitis and also to compare the USG findings with pre-operative findings and HP reports.

METHODS

This is a prospective study done in the Department of Radiodiagnosis in SCB Medical College Hospital (MCH), Cuttack during September 2013 to September 2015.

A total number of 100 cases referred to the Department of Radiodiagnosis, SCB MCH, Cuttack with the clinical diagnosis of acute appendicitis were taken for the study. Institutional ethical clearance and informed consent from patients were obtained before the study after recording the proper history, clinical examination, and relevant laboratory investigation; patients were subjected to USG examination. Patients were followed up for pre-operative and HP findings. Obtained data were tabulated and percentages were taken. From these data sensitivity, specificity, positive and negative values

of ultrasound, and accuracy of ultrasound in acute appendicitis were calculated.

Inclusion criteria

All the patients with clinical and laboratory diagnosis of acute appendicitis were included in the study.

Exclusion criteria

Patients who were unfit for the surgery, cases with appendicular lump, cases with peritonitis, and recurrent appendicitis were excluded from the study. Patients more than 75 years of age and uncooperative patients were also excluded from the study.

Ultrasound protocol

First, general survey of the patient's abdomen was performed with 2-5 MHz curvilinear probe; then, the examination of the right lower quadrant by graded compression technique with 3-12 MHz linear probe was done.

Scanning was done in the supine position while applying gradual compression, which displaces the shadowing gas contents in the caecum and ascending colon allowing visualization of the retrocaecal area. It also brings the intra-abdominal structures closer to the transducer and its focal zone. Scanning was performed in a routine fashion in the transverse plane starting from the point below the tip of the caecum and moving cephalad to the middle of the transverse colon. Examination in the longitudinal plane was used to confirm the findings.

The inflamed appendix was usually located just near medial and inferior to the caecum and anterior and lateral to the iliac vessels, occasionally posterior to the caecum. If the appendix was not located, scanning the area where the patient shows maximum tenderness by fingertip was usually the site of appendix. After visualization of the appendix (non-compressible bowel loop), the diameter of the appendix was measured and appendicolith, collection of fluid in the right iliac fossa, echogenic and thickened mesentry, and caecal wall thickening were looked for.

RESULTS

The study was done in 100 clinically diagnosed patients with acute appendicitis (Fig. 1). In our study, age of the patient varied from 2 to 67 years and maximum number of patients were in the age group of 11-20 years (41.7%) (Table 1). The male to female ratio was 1.5:1. In present study, 98.7% cases were having pain in the abdomen followed by tenderness (93.5%), nausea and vomiting in 66%, and fever in 66% of cases (Table 2).

Among the 100 cases studied, 77 cases were proved surgically and histopathologically as acute appendicitis (Table 3) (in USG 75 cases were diagnosed as acute appendicitis), 4 cases were appendicular mass, 4 cases were pelvic inflammatory disease, 3 cases were right ureteric calculus, 2 cases were ileocaecal tuberoculosis, 2 cases were right acute pyelonephritis, 1 case was twisted ovarian cyst, 1 case was ileitis, 1 case was carcinoma caecum, and no abnormality was detected in 5 cases (Table 4, Figs. 1 and 2).

Table 1: Age incidence of acute appendicitis and appendicular mass in ultrasound diagnosis

Age (years)	No. of patients (%)
0-10	12 (15.18)
11-20	33 (41.77)
21-30	17 (21.51)
31-40	5 (6.32)
41-50	7 (8.86)
51-60	3 (3.78)
61-70	2 (2.53)
Total	79 (100)

Retrocaecal appendix was observed in 59 cases (76.62%) of total cases, pelvic in 13 cases (16.88%), subcaecal in 2 cases (2.59%), and per illeal in 1 case (1.29%) (Table 5).

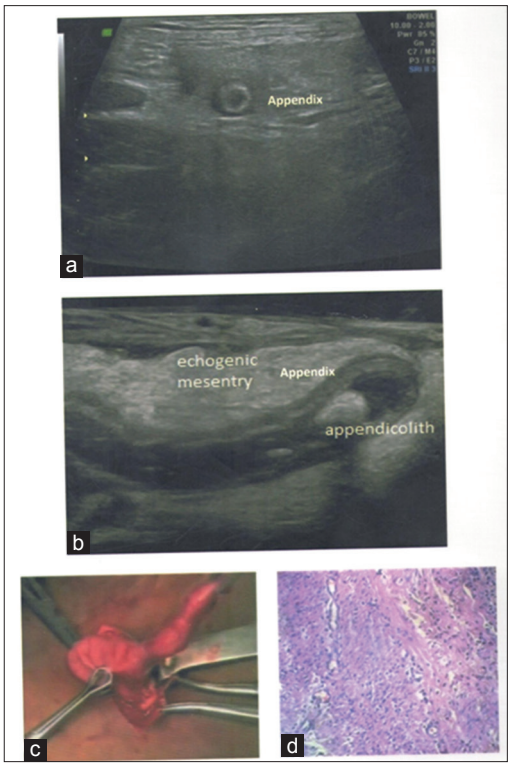

Fig. 1: Acute appendicitis with appendicolith. (a) Transverse, (b) longitudinal, (c) per-operarive, (d) histopatholical

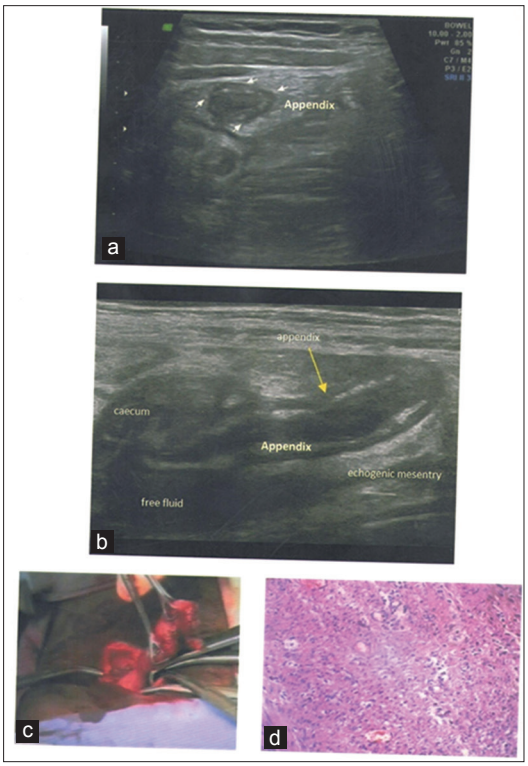

Fig. 2: Acute and chronic appendicitis with caecal wall thickening and free fluid in right iliac fossa. (a) Transverse, (b) longitudinal, (c) per-operarive, (d) histopatholical

In our study, 98.7% cases were found with target sign. 93.5% cases showed probe tenderness, 35% cases showed fluid in right illaec fossa, 12.9% cases showed appendicolith, and 83% cases with echogenic mesentry in cases of acute appendicitis, 100% cases showed diameter more than 6 mm, 25.9% cases showed caecal wall thickening and 96.1% cases showed non-compressible bowel loop (Tables 6 and 7).

DISCUSSION

USG examination of acute appendicitis is the most commonly used imaging technique. The medical ultrasound is in use since middle 1950's, there is an increase in the clinical value in diagnosis of acute appendicitis due to evolution of graded compression technique by Puylaert in 1986 [2].

Table 2: Clinical findings in cases of acute appendicitis

Clinical findings (signs and symptoms)	No. of cases (%)
Pain abdomen	76 (98.7)
Tenderness	72 (93.5)
Fever	51 (66)
Nausea and vomiting	51 (66)

Table 3: Acute appendicitis in USG/per-OP/HP study

No. of case diagnosed acute appendicitis in USG	75
No. of cases diagnosed in per-operative study	77
No. of cases diagnosed in HP study	77

USG: Ultrasonography, HP: Histopathological

Table 4: The spectrum of disease which mimics acute appendicitis in ultrasound in our cases

Disease	Male	Female	Total
Acute appendicitis	45	30	75
Appendicular mass	3	1	4
Right acute pyelonephritis	-	2	2
Right ureteric calculus	3	-	3
Pelvic inflammatory disease	-	4	4
Twisted ovarian cyst	-	1	1
Ileitis	0	-	0
Ileocaecal tuberculosis	1	1	2
Carcinoma caecum	1	-	1
No abnormality detected	4	4	8
Total	57	43	100

Table 5: Position of appendix in our series

Appendix position	No. of cases (%)
Retro caecal	59 (76.62)
Pelvic	13 (16.88)
Subcaecal	2 (2.59)
Pre-ileal	1 (1.29)
Post-ileal	1 (1.29)
Subhepatic	1 (1.29)
Total	77 (100)

Table 6: Sonographic findings in case of acute appendicitis and percentage

Findings	No. of cases (%)
Target sign	76 (98.7)
Probe tenderness	72 (93.5)
Free fluid	27 (35)
Thickened or echogenic mesentery	64 (83)
Non-compressible bowel loop	74 (96.1)
Caecal wall thickening	20 (25.9)
Appendicolith	10 (12.9)

For patients with right left quadrant (RLQ) pain, the question has to be answered whether the pain is really due to acute appendicitis or other diseases which mimic acute appendicitis.

The clinical presentation of acute appendicitis is typical in than 70% of patients. About 30% of patients have an uncertain preoperative diagnosis.

Consequently, the rate of unnecessary laparotomy for acute appendicitis is as high as 20-25%. The rate is even higher 35-45% in women of child-bearing age group because of pelvic inflammatory disease and complicated pregnancies. Hence, USG examination of the right left quadrant is necessary for these patients [4].

According to a study done by Jeffery Jr. *et al.* the mean age group for the occurrence of appendicitis was 26 years and according to Galindo Lallego the mean age group was 21.8 years [5]. Among 100 cases studied 41.7% of cases were in the age group of 11-20 years followed by age group of 20-30 years.

In our study, of 75 cases of acute appendicitis, 45 patients were male and 30 patients were female. The male to female ratio was 1.5:1. According to Bailey and Love textbook of surgery, males were more commonly affected than females.

In our study, it was found that 98.7% of cases were having pain in abdomen, 93.5% cases showed tenderness, 66% cases were with nausea and vomiting, and 66% cases were with fever.

According to Jeffery *et al.*, abdominal pain was found in 99-100% of cases, tenderness in right lower quadrant was found in 96% of cases, nausea and vomiting in 60-90% of cases, low-grade fever in 67-69% of cases, which is correlating with the study [5].

In the present study, 98.7% cases were found with target sign, 93.5% cases showed probe tenderness, 35% cases showed fluid in right illaec fossa, 2.9% cases showed appendicolith, and 83% cases were with echogenic mesentery in cases of acute appendicitis.

According to Subash *et al.*, percentage of target sign was 98.7%, probe tenderness was 100%, fluid in right illaec fossa was 35%, appendicolith in 9% cases, and echogenic mesentery was 80.9% which was correlating with this study [6].

In our study, 96.1% cases showed appendix diameter more than 6 mm, 25.9% cases showed caecal wail thickening, 96.1% cases showed non-compressible bowel loop, and 83% cases showed echogenic fat.

According to Hussain *et al*. the diameter of appendix on ultrasound was more than 6 mm in 96.7% cases. Non-compressible bowel loop was found in 93.3% cases, echogenic fat in 86.7% cases, and caecal thickening in 20% cases. This finding was highly correlating with our study [7].

In our study, we observed retrocaecal appendix in 59 cases (76.62%) of total cases, pelvic in 13 cases (16.88%), subcaecal in 2 cases (2.59%),

Table 7: Calculation of sensitivity, specificity, positive, and negative predictive value

Sonographic diagnosis disease	Patients with disease	Patients without
Positive	74(a)	1(b)
Negative	3(c)	22(d)
Sensitivity	a/a+c × 100	96.1%
Specificity	d/d+c × 100	95.65%
Positive predictive value	a/a+b × 100	98.66%
Negative predictive value	d/d+c × 100	88%

preileal in I case (1.29%), postileal in I case (1.29%), and subhepatic in 1 case (1.29%).

According to Walker *et al*., the appendix was retrocaecal and retrocolic in 65.28%, pelvic in 31.01%, subcaecal in 2.26%, preileal in 1%, and postileal in 0.4% [8].

In our study, we had taken the maximum outer diameter of the normal appendix 6 mm as a sonographic criterion. Mean diameter of appendix in our study was 8.56 mm.

Abu-Yousef *et al*. in their study had taken the maximum outer diameter of normal appendix was 6 mm as a sonographic criterion [9]. Furthermore, Jeffrey Jr *et al.* in their study took maximum outer diameter of 6 mm as a sonographic criterion for acute appendicitis while mean diameter of their study was 8.7 mm [5].

In our study, role of USG in diagnosis of acute appendicitis the sensitivity was 96.1%. According to Jeffrey Jr. *et al*. study sensitivity was 89.9%. According to Joshi *et al.*, the sensitivity was 96%. In our study, the sensitivity was correlating with the above-reported series [10].

We found the role of USG in diagnosis of acute appendicitis specificity was 95.65%.

Jeffrey Jr. *et al.* reported the specificity to be 96.2%, Joshi *et al.* reported specificity to be 93%, and Puylaert *et al.* reported 100% specificity. The specificity in our series was correlating with the above-reported series [10,2].

In our study, false negativity of 3 % was noted. These patients were obese with thick abdominal wall, so we could not locate the appendix. These were proved to be retrocaecal and subhepatic appendix at surgery. In a study by Joshi *et al.*, false negativity of 4% was reported [10].

In our study, false positivity of 1% was noted. Ileitis of terminal ileum was mistaken as an inflamed appendix. Josi *et al.* also reported a false positivity of 2%. An inflamed Meckel's diverticulum was mistaken as an inflamed appendix in their patients [10].

In our study, role of USG in the diagnosis of acute appendicitis predictive value of positive test was 98.66% which was similar to the findings of Jeffrey Jr *et al.* as 93% and Joshi *et al.* as 98% [5,10].

In our study, role of USG in the diagnosis of acute appendicitis predictive value of negative test was 88%. In a study by Jeffrey Jr. *et al.*, it was reported as 94.3% [5]. Joshi *et al.* reported it was 88% which was similar to our study [10].

Role of USG in diagnosis of diseases mimicking acute appendicitis

In a review by Gaensler *et al.*, [11] USG was found to be 70%. An accurate in detecting non-appendiceal disease in a group of patients without appendicitis in whom a specific diagnosis was made; however, half of their patients without appendicitis had a nonspecific diagnosis of abdominal pain of known origin. USG was helpful in the diagnosis of various gynecologic and visceral diseases but was less accurate in the diagnosis of urinary tract disease.

Early and accurate diagnosis of appendicitis is important, both to lower the negative appendectomy rate and to avoid increased risk of perforation associated with operative delay. If perforation occurs operative morbidity increases 15-fold, and mortality increases 50-fold.

Many diseases mimic acute appendicitis in their clinical presentation, including those seen only in women of child-bearing age, such as pelvic inflammatory disease, torsion of ovarian cysts or tumors, endometriosis, hemorrhagic corpus luteal cysts, and hemorrhagic or necrotic uterine fibroids.

In pregnant women, conditions such as ectopic pregnancy, placental abruption, and uterine wall rupture can clinically resemble acute appendicitis. Conditions such as acute cholecystitis, diverticulitis, intestinal obstruction, renal stones and perforated gastric, or duodenal ulcers can pose diagnostic problems in both sexes. USG is also helpful in the diagnosis of *Campylobacter* ileocolitis and other forms of ileocolitis that can mimic acute appendicitis in their presentation.

USG shows mural thickening of the terminal ileum and proximal colon as well as moderately enlarged mesenteric lymph nodes [12]. Surgical intervention is not indicated in this disease.

In immunocompromised patients, neutropenictyphlitis can present with RLQ pain and fever without leukocytosis. USG can be helpful in differentiating this condition from acute appendicitis as hypoechoic or echogenic thickening of the wall of the caecum and ascending colon is seen [13].

"USG is also helpful in the diagnosis of mesenteric adenitis, another condition that can have a similar presentation to that of acute appendicitis." The inflammatory process is self-limiting, and laparotomy is not indicated [14,15].

RECOMMENDATIONS

Patients with suspected acute appendicitis can be divided into four groups. Patients with typical clinical and laboratory findings of acute appendicitis constituting the first group should undergo laparotomy without delay. USG will not increase the accuracy of clinical diagnosis, in these cases and may cause false sense of security with detrimental results because of false negative results.

Patients with atypical clinical diagnosis and most ovulating women should have high-resolution USG evaluation of the RLQ. Those with a sonographic diagnosis of acute appendicitis, constituting the second group, should be considered for surgery regardless of their clinical symptoms, as a false positive rate of sonography is low. With this approach, the diagnosis of acute appendicitis may be made promptly, thus preventing or decreasing the risk of perforation and hence the morbidity and mortality of acute appendicitis.

The third group consists of those with atypical clinical symptoms and adequate negative sonographic examinations. The negative examination is conclusive if the intraperitoneal structures, such as caecum, terminal ileum, psoas muscles, and ileal vessels are visualized, and if gas can be displaced from the colon so that the retrocaecal area may be adequately demonstrated. If the sonographic examination of the pelvis and abdomen is not revealing, this third group can be observed clinically until there is resolution of symptoms and signs and return of laboratory findings to normal values.

The fourth group consists of those with negative, but technically inadequate, USG examinations. Depending on the degree of clinical suspicion, these patients should be operated on, evaluated by other imaging studies such as computed tomography (CT), or followed clinically.

In both third and fourth groups, the pelvic or abdominal USG may reveal other diseases, and the clinician is then directed to a different course of treatment.

CONCLUSION

We suggest patients with acute appendicitis can be divided into three groups.

1. Patients with typical clinical, laboratory, and ultrasound findings should undergo laparotomy without any delay.
2. Patients with atypical clinical diagnosis but positive sonographic diagnosis should also be considered for surgery regardless of their clinical symptoms as false positive rate of sonography is low.

3. Patients with atypical clinical symptoms but adequate negative sonographic examination should be observed clinically or evaluated but other imaging modalities such as CT. In these cases, appendicitis mimics may play a role in diagnosis.

Hence, high-resolution sonography with graded compression is a very promising examination for the diagnosis of appendicitis in complicated cases and women in their reproductive period. It is fast and easy to perform. Because of its high accuracy, sonography should be the primary imaging procedure for patients suspected to have acute appendicitis. Ultrasound is also helpful in detecting complications of appendicitis and for other abdominal diseases that mimic appendicitis.

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