Original Article

Sonographic evaluation of acute appendicitis and its complications

Soniya Daga, Sushil Kachewar, Dilip L Lakhkar, Kalyani Jethlia, Abhijeet Itai

Department of Radiodiagnosis and Imaging, Dr. Vitthalrao Vikhe Patil Memorial Hospital and Medical College, Ahmednagar, Maharashtra, India

Abstract

Objectives: The objectives of the study were to evaluate various sonographic findings in patients with clinically suspected acute appendicitis and its complications; to follow up and confirm sonographic findings by histopathological examination following surgery; and to determine the role of color Doppler sonography in acute appendicitis.

Materials and Methods: One hundred patients clinically suspected to have acute appendicitis underwent ultrasound examination using high-resolution transducers; linear array transducers of 7.5–10 MHz and curvilinear transducer of 3.5–5 MHz. The presence of aperistaltic, noncompressible, blind-ended tubular structure with a diameter ≥6 mm in the right iliac fossa was the primary criterion for the diagnosis of acute appendicitis. Other findings such as the presence of appendicoliths, gas within the lumen of appendix, loculated collections, and appendicular phlegmon were also considered.

Results: Out of 100 cases recruited for the study, 95 cases underwent surgical intervention in the form of immediate appendicectomy (89 patients), interval appendicectomy (four patients), or drainage of abscess (two patients). On histopathological/surgical correlation, true positive was 85, false positive – 1, true negative – 6, and false negative – 3. The observed sensitivity, specificity, positive predictive value, and negative predictive value of ultrasonography (US) in the diagnosis of acute appendicitis were 96.5%, 85.7%, 98.8%, and 66.7%, respectively, with an overall accuracy of 95.7%. In our study, 75% patients of appendicitis showed hyperemic color Doppler flow. Furthermore, the use of color and power Doppler sonography was more helpful in those patients where it was difficult technically to visualize the entire appendix.

Conclusion: Grayscale US should be the first primary evaluation for patient suspicious of acute appendicitis, and color Doppler is an additional modality to increase sensitivity and more accuracy.

Keywords: Acute appendicitis, color Doppler, graded compression, McBurney's point, ultrasonography

Address for correspondence: Dr. Soniya Daga, Department of Radiodiagnosis and Imaging, Dr. Vitthalrao Vikhe Patil Memorial Hospital and Medical College, Opposite Government Milk Dairy, Vilad Ghat, Ahmednagar - 414 111, Maharashtra, India.
E-mail: dagasoniya@gmail.com

INTRODUCTION

Appendicitis is the most common cause of acute abdomen, presenting as a triad of pain in the right iliac fossa, fever, and vomiting that requires surgical intervention. Patients with the condition may present with a wide variety of clinical manifestations, and diagnosis may elude even the most experienced clinicians. Prompt diagnosis is essential to minimize morbidity, which remains substantial if complications occur. The radiologist's role lies not only in diagnosing appendicitis but also to rule out other conditions which may mimic symptoms of appendicitis.

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High-resolution graded compression color Doppler ultrasonography (US) and computed tomography (CT) are the imaging modalities of choice in cases of appendicitis. Although CT is highly sensitive and specific for the diagnosis of acute appendicitis, high-resolution US is the primary modality of choice.[1]

The appendix on ultrasound is visualized as a small, easily compressible, ovoid,[2] concentrically layered, mobile, blind-ended, aperistaltic tubular structure arising from the posteromedial aspect of the cecum near the ileocecal transition.[3] The sonographic landmark is the base of cecum. The normal diameter of appendix is <6 mm. Usually, the normal appendiceal lumen contains gas, and its absence may suggest inflamed appendix in the presence of other findings.[4,5] The normal appendix has a thin central echogenic line corresponding to the submucosa surrounded by a hypoechoic outer zone representing the muscularis mucosa with a collapsed lumen.

Sonographic findings in acute appendicitis include:[6-9]

- Noncompressible, blind-ended, aperistaltic tubular structure in right lower quadrant arising from the base of cecum
- Target lesion or Bull's-eye appearance of appendix
- Appendiceal diameter >6 mm
- Lumen distended with anechoic and hypoechoic material
- Appendicolith
- Circumferential loss of submucosal layer of appendix
- Loculated and prominent pericecal fluid
- Prominent pericecal fat.

Color Doppler US plays an important role in differentiating normal from inflamed appendix when the US findings are equivocal, especially when the diameter of the appendix is in the 6–7 mm range. Diastolic flow is high and likely reflects arteriolar vasodilatation that accompanies the inflammation. In patients with a clearly positive acute appendicitis diagnosis by US, color Doppler plays an important role in identifying patients with ischemic/gangrenous changes.[10,11]

Aims and objectives

- To evaluate various sonographic findings in patients with clinically suspected acute appendicitis and its complications
- To follow up and confirm sonographic findings by histopathological examination following surgery
- To determine the role of color Doppler sonography in acute appendicitis.

MATERIALS AND METHODS

The study was performed at the Department of Radiodiagnosis and Imaging in Dr. Vitthalrao Vikhe Patil Medical College and Hospital, Ahmednagar, Maharashtra, India, after ethical clearance from the Institutional Ethical Committee with informed patient consent on patients who reported to the surgical outpatient or emergency department with a history of abdominal pain, in whom clinical signs were strongly suggestive of acute appendicitis were referred to our department for US evaluation. One hundred patients with clinical signs of appendicitis underwent sonographic examination using Mindray Grayscale, color and power Doppler US machine (Model No. 51220HL DC-7) with a 3.5–5.0 MHz curvilinear or 7.5–10 MHz linear array transducer showing noncompressible, blind-ended, aperistaltic tubular structure in right lower quadrant arising from the base of cecum with a diameter >6 mm and raised vascularity on color Doppler study, and the results were compared with operative and histopathological findings or with follow-up. Patients of all ages having strong clinical signs of appendicitis or its complications were included in the study. Those who cannot be followed up or had undergone appendicectomy were excluded from the study.

All the observations during the study were recorded containing information regarding name, age, clinical examination findings, ultrasound examination findings, operative findings, and histopathological report.

RESULTS

Overall, out of 100 patients, 90 patients were diagnosed appendicitis on US examination.

Various age groups were considered in the study, and the peak incidence of appendicitis was found to be in the age group of 21–30 years. The youngest patient diagnosed was 8 years old and oldest patient was 62 years old.

Majority of patients in the study presented with pain in abdomen, more localized to the right iliac region.

In the study, various US appearances of appendicitis [Figures 1-3] were observed as described in Table 1.

Appendiceal diameter of >6 mm (83/85 or 97.6% of patients with appendicitis) was the most consistent finding suggestive of acute appendicitis. Noncompressibility (77/85 or 90.6%), target appearance (72/85 or 84.7%), and probe tenderness at McBurney's point (78/85 or 91.8%) were next common findings of the patients' positive for appendicitis [Graph 1].

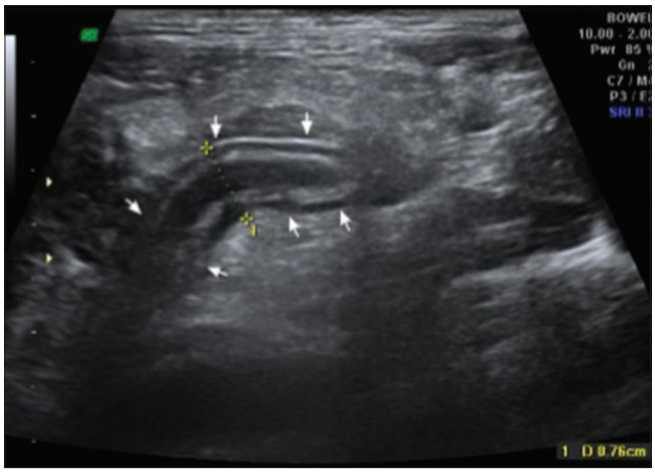


Figure 1: High-frequency (7.5–10 MHz linear transducer) ultrasonographic appearance in right iliac fossa in a patient diagnosed clinically as acute appendicitis showing a blind-ended, tubular, hypoechoic, aperistaltic, noncompressible structure originating from cecum having gut signature with a diameter of 7.6 mm with surrounding fat stranding and no associated lymphadenopathy

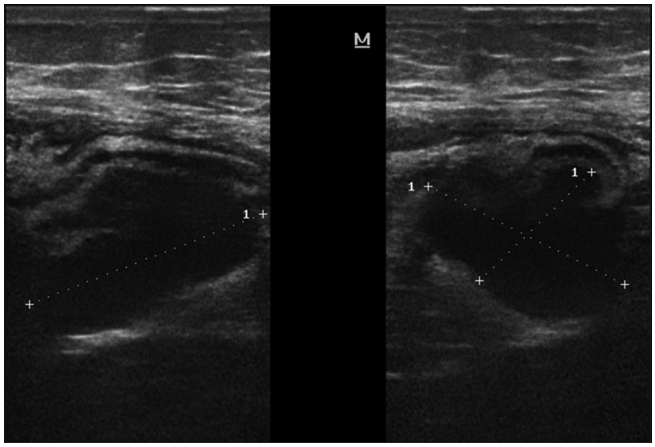


Figure 3: Longitudinal and transverse ultrasound scan at the tip of inflamed appendix showing discontinuity in the wall of appendix with surrounding hypoechoic collection and adjacent fat stranding suggestive of appendicular perforation with periappendicular abscess formation

Table 1: Ultrasonographic appearance of appendicitis

Sonographic diagnosis	Number of cases	Percentage of cases*
Normal appendix	6	6.60
Positive for appendicitis	85	93.4
Uncomplicated acute appendicitis	76	76 (83.5)
Perforated acute appendicitis	3	3 (3.3)
Appendicular abscess	2	2 (2.2)
Appendicular mass	4	4 (4.4)

*Values within parentheses indicate the percentage among cases positive for appendicitis sonography

Color Doppler assessment revealed normal color flow signals in 17.6% (15/85), hyperemic appendiceal wall in 75.2% (64/85), and absent flow signals in 7.05% (6/85) of the patients. Of the 15 appendices with normal color flow signals, eight had sonologically demonstrable normal appendices, whereas remaining seven were inflamed. Of 64 appendices with hyperemic flow signals, all cases had appendicitis. Single case out of six cases having absent flow signals showed gangrenous changes of appendix.

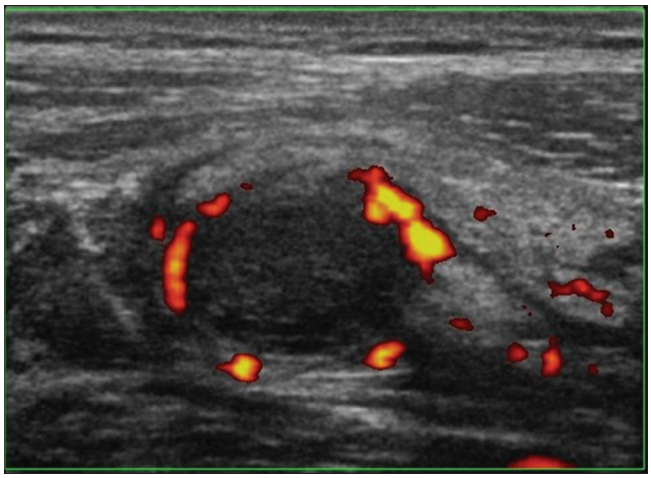
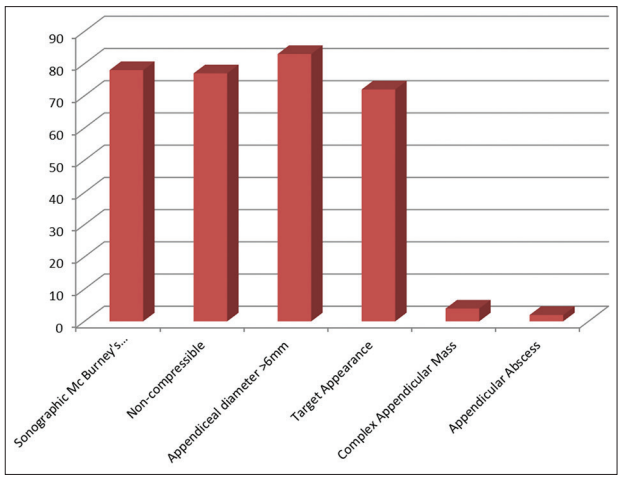


Figure 2: Transverse ultrasound image of appendix which appears enlarged, hypoechoic with surrounding fat stranding showing increased peripheral vascularity on power Doppler study suggestive of hyperemic blood flow around the inflamed appendix



Graph 1: Ultrasonographic findings in appendicitis

Out of 100 cases recruited for the study, 95 cases underwent surgical intervention in the form of immediate appendicectomy (89 patients), interval appendicectomy in cases of appendicular mass (four patients), or drainage of abscess (two patients). Of 89 patients who underwent immediate appendicectomy, 85 cases were found to have acute appendicitis and four were normal (negative appendicectomy) by histopathological examinations. Among 100 cases, US was positive in 89 cases and one case was diagnosed as false positive and three cases were diagnosed as false negative. US successfully diagnosed six true-negative cases.

The overall accuracy of sonography in the diagnosis of acute appendicitis in the present study was 95.7%. The observed sensitivity, specificity, predictive value of positive test, and predictive value of negative test of ultrasound scanning were 96.5%, 85.7%, 98.8%, and 66.7%, respectively.

DISCUSSION

The present study included patients with clinically suspected appendicitis. After a detailed history and clinical examination, the patients were subjected to ultrasound examination using graded compression technique with high-resolution probes (high-frequency linear array: 7.5–10 MHz and low-frequency curvilinear array: 3.5–5.0 MHz).

Appendicitis is one of the most common causes of acute abdominal pain that requires surgical intervention. Timely and accurate diagnosis reduces the morbidity. The incidence of appendicitis was most common in the third decade followed by the second decade having a male preponderance.

An outer diameter of appendix >6 mm was the most consistent finding in cases of acute appendicitis. The other findings observed in appendicitis were noncompressibility, target appearance, probe tenderness at McBurney's point, visualization of appendicolith, and the absence of gas within the lumen of appendix. Increased intra-abdominal fat echoes in right iliac fossa, hypoperistaltic loops in right iliac fossa, mesenteric (peri-ileal/periappendiceal) lymph nodes, and periappendiceal fluid collection were the ancillary findings appreciated on sonography.

The terminal ileum, resolving appendicitis, inspissated stool causing increased diameter of appendix, and periappendicitis from surrounding inflammation are the most common causes for false-positive diagnosis on US. In our study, one case had a false-positive diagnosis of appendicitis which was due to fecal-impacted appendix which caused increase in the outer diameter of appendix.

Quillin *et al.* showed that color Doppler sonography is an important tool in diagnosing appendicitis in patients having equivocal findings on grayscale ultrasound.[11] According to the study conducted by Quillin *et al.*, the sensitivity and specificity of color Doppler sonography was 87% and 97% in diagnosing acute appendicitis, respectively.

In our study, 75% patients of appendicitis showed hyperemic color Doppler flow. Furthermore, the use of color and power Doppler sonography was more helpful in those patients where it was difficult technically to visualize the entire appendix. Power Doppler was useful in those patients when color Doppler was equivocal.

Color Doppler ultrasound also proved helpful in diagnosing appendiceal abscess by showing hyperemic blood flow around the abscess.

CONCLUSION

Grayscale US should be the first primary evaluation for patient suspicious of acute appendicitis, and color Doppler is an additional modality to increase sensitivity and more accuracy. US is not only helpful in diagnosing appendicitis and its complications but also in excluding other causes which may mimic the disease.

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Conflicts of interest

There are no conflicts of interest.

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