

Diagnostic Accuracy of Ultrasonography in Cases of Acute Appendicitis

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ABSTRACT

Aims and objectives: To evaluate the accuracy of ultrasonography in the diagnosis of various pathologies of the appendix and to compare the findings of ultrasonography with surgical outcome.

Materials and methods: All the patients suspected of appendicitis clinically were referred for ultrasonography. The accuracy of ultrasonography in the diagnosis of appendicitis was compared with surgical outcome.

Results: Out of 50 cases who underwent ultrasonography, 37 cases were sonographically positive for appendicitis and 13 cases were appendicular masses. Right iliac fossa tenderness, rebound tenderness, and Rovsing's sign were the cardinal signs. The overall specificity and sensitivity were 95% in the diagnosis of acute appendicitis.

Conclusion: Ultrasound is the first-line method in patients referred with clinically suspected acute appendicitis and is cost-effective and reduces the cost of treatment of expensive procedures like exploratory laparoscopy and computed tomography abdomen.

Keywords: Accuracy, Acute appendicitis, Diagnosis, Ultrasonography.

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INTRODUCTION

Acute appendicitis is the most common cause for acute abdominal emergency surgery. The vermiform appendix, though a vestigial organ, poses a great diagnostic challenge to both surgeons and radiologists. The decision for surgical intervention is still primarily based on precise

clinical criteria. Acute appendicitis is a common cause of abdominal pain for which prompt diagnosis is rewarded by a marked decrease in morbidity and mortality. It is generally accepted that in men the negative appendectomy rate should be below 20% and rates of 10 to 15% are commonly reported.^{1,2} On the contrary, young women commonly present with acute gynecological illnesses that closely mimic acute appendicitis. Reported negative appendectomy rates in ovulating women thus remain disturbingly high and range from 34 to 46%.^{3,4} Accurate diagnosis in a patient with an acute abdomen is essential for the following reasons:

- In total population, there is at least 7% lifetime chance of suffering from acute appendicitis.⁵
- Appendiceal and other rupture incidents account for 17 to 40% morbidity, perforation rate being higher in the elderly and the very young.⁶
- Lack of early diagnosis results in perforation and complications, such as abdominal abscess, wound infection, and death.⁷

Despite technological advances, diagnosis of acute appendicitis is still based primarily on history and clinical examination. The routine laboratory examination of blood and urine is mandatory. Leukocytosis with a "shift to the left" is useful but nonspecific. Plain abdominal radiographs have an overall accuracy of only 8%. The radiographic signs are nonspecific. Though the accuracy of barium enema examination is between 50 and 84%,^{8,9} the findings are often negative even when there is appendiceal perforation or formation of an abscess. It is time consuming, uncomfortable for patients, and entails ionizing radiation.

Helical computed tomography (CT) has reported a sensitivity of 90 to 100%, specificity of 91 to 99%, accuracy of 94 to 98%, positive predictive value (PPV) of 92 to 98%, and negative predictive value of 95 to 100% for the diagnosis of acute appendicitis. These results are comparable with those achieved by experienced investigators, who have used thin section conventional and contrast-enhanced CT, and is superior to the recently reported clinical accuracy.^{10,11} However, the radiation hazard, lack of easy availability, and cost are still major problems in its routine use for investigating appendicular pathology.

There have been numerous publications on the use of ultrasound (US) as a diagnostic tool. These studies

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demonstrate a sensitivity of 75 to 94% and specificity of 87 to 96%.^{8,9} Several prospective studies have been conducted where the results of ultrasonography (USG) were used as an aid for surgeons in making an operative decision. Ultrasound is the most important bedside tool for investigating appendicular pathologies because of its easy availability, relatively low cost, and no radiation hazard. It is very important to exclude the nonappendicular pathology and give an accurate diagnosis since it helps in management decision and planning the surgery when needed.

AIMS AND OBJECTIVES

This study was conducted to evaluate the diagnostic accuracy of US in pathologies of the appendix. The study was based on the presumption that an accurate diagnosis helps to reduce high negative appendectomy rates, unnecessary delay in the surgery and hence, the chances of complications, and thereby benefit affected patients.

MATERIALS AND METHODS

The study was conducted on 50 patients, referred from surgical services for suspected appendicular pathology.

Ultrasonography was performed with high-frequency linear array transducer and low-frequency curvilinear transducer, wherever needed. The examination was commenced from right upper quadrant in the region of the hepatic flexure followed by the ascending colon and ended in the right lower quadrant in the region of the cecum. Graded compression was applied until the iliac vessels and psoas muscles were clearly visible.

Scanning at the point of maximum tenderness was found to be more useful in localizing appendix and has been reported to decrease the average time of examination by one third. When the patient can localize one point of maximum tenderness, US has been reported to yield a correct diagnosis in 94% of the cases, whether the diagnosis is that of appendicitis or not. This also applies to cases where the portion of the appendix adjacent to the cecum is normal and only the tip or the distal portion of the appendix is inflamed. Ultrasonography has also been found to be useful in elucidating alternative diagnoses.

In patients with significant abdominal guarding or extreme discomfort, gradual application and release of transducer pressure was useful in ensuring the adequacy of examination. Asking the patient to flex their lower extremities at hips and knees facilitated the examination by decreasing the abdominal tension. Analgesics were found to be useful in accomplishing a successful and a painless examination by Larson et al.¹²

Since appendix has a variable position, it may not always be visible from an anterior approach; lateral or posterolateral scanning is thus useful and recommended

in all examinations. This technique demonstrates an otherwise nonvisible retrocecal appendix. Scanning both with full and empty urinary bladder may allow easier visualization of an otherwise hidden appendix.

Apart from right iliac fossa, the entire abdomen is examined to exclude disease of the gallbladder, pancreas, kidney, aorta, stomach, small and large bowel, uterus, and ovaries.

The presence of free air is excluded by turning the patient in the left decubitus position, which allows air to accumulate between the liver and lateral abdominal wall.

In women, a full bladder allows a better survey of the uterus and ovaries. Transvaginal US is helpful in diagnosing gynecological disease.

Interpretation

Our prospective real-time US assessment of the appendix and of inflammatory changes in the right lower abdominal quadrant was based on a set of criteria derived from reports in the literature.^{13,14} Enlarged appendix, lack of compressibility of the appendix, inflammatory changes in perienteric fat in the right lower quadrant, cecal wall thickening, right lower quadrant lymph nodes, and peritoneal fluid. The appendix was considered enlarged when its outer anteroposterior diameter under compression, measured in the transverse plane, was 6 mm or larger. Inflammatory changes were defined as the presence of an area of regionally increased echogenicity (hyperechoic halo) adjacent to or surrounding the distal ileum wall, cecum, or appendix that possibly contained ill-defined hypoechoic zones. A lymph node in the right lower quadrant was considered clinically important when it measured 5 mm or larger at its smallest diameter.¹⁵ Cecal wall thickness from the outer wall to luminal surface was measured on transverse sections under compression,¹⁶ and thickening were defined as when the cecal wall measured 5 mm or larger.

If the appendix is not visualized or if a nonappendicular pathology is discovered, the scan was considered as normal, for diagnosis of appendicular pathology for this study.

OBSERVATION AND RESULTS

The maximum incidence of appendicular pathologies was noted in the age group of 21 to 30 years. The youngest patients was 7 years and the eldest was 85 years. Addis et al¹⁰ reported similar findings. The most common appendicular pathology detected was acute appendicitis. Complications of acute appendicitis like perforation, appendicular mass, or abscess were noted in 13 (26%) patients (Table 1). The most common position of the appendix was found to be retrocecal, followed by pelvic. The minimum diameter noted was 5.5 mm and maximum was 17 mm, the average being 11.5 mm.

Table 1: Pathologies found on USG

Ultrasonography Diagnosis	No. of cases	Percentage
Acute appendicitis	27	54.00
Appendicular perforation	7	14.00
Appendicular abscess	4	8.00
Appendicular lump	2	4.00
Reactive inflammation of appendix	2	4.00
No abnormality detected	8	16.00
Total	50	100.00

Jeffrey et al¹⁷ and Rao et al¹⁸ reported similar findings and concluded that diameter of appendix >6 mm is the most important criteria in diagnosing acute appendicitis. The layered architecture of the appendix was preserved in all cases of acute nonperforated appendicitis (Figs 1 and 2). However, in cases of perforated appendicitis and appendicular abscess, focal loss of the layered architecture was noted in 11.90% patients. Similar findings were noted by

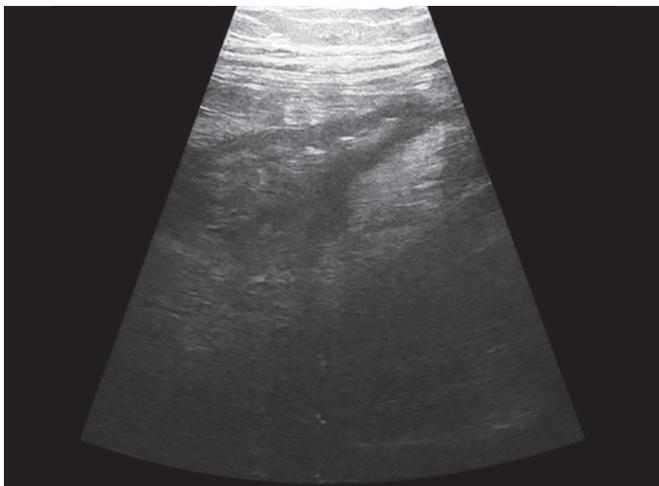


Fig. 1: Ultrasonography revealed inflamed appendix with blind-ended loop



Fig. 2: Ultrasonography revealed appendix giving target sign

Borushok et al.¹⁹ In cases of nonperforated acute appendicitis, the appendix was found to be noncompressible in all cases. This has been postulated as an important criteria in diagnosing acute appendicitis by Rioux.²⁰ In cases of reactive inflammation of appendix, compressibility was seen in 50% patients. Fecoliths were noted in 25.92% cases of acute nonperforated appendicitis and in 28.57% cases of appendicular perforation. Similar findings were reported by Horrow and White.²¹ They reported that appendicolith occurred in 36% patients, more often in perforated appendicitis (49%) than in nonperforated appendicitis (27%). The inflammation of cecum and/or terminal ileum was seen more in cases of complicated acute appendicitis (61.53%) than in nonperforated acute appendicitis (14.81%). Horrow and White²¹ reported cecal thickening in 41% of perforated appendicitis and 24% of nonperforated appendicitis.

Mesenteric inflammation was noted in 37.03% of cases of acute nonperforated appendicitis and in 84.61% of cases of complicated appendicitis. Broushok et al¹⁹ also concluded that inflammatory changes in periappendiceal fat tend to be more severe in the perforated group.

In the nonperforated acute appendicitis, small fluid collections were noted in 37.03% cases (Fig. 3). In cases of appendicular perforation and abscess, free fluid was seen in all the cases and larger in amount. In appendicular lump, free fluid was noted in 50% cases. Borushok et al¹⁹ have also noted similar findings.

Enlarged regional lymph nodes were noted in 14.81% of cases, slightly more in complicated appendicitis than in nonperforated appendicitis.

DISCUSSION

A set of 50 patients with clinically suspected appendicular pathology were studied with abdominal USG. Sonographic findings were correlated with the intraoperative findings.



Fig. 3: Ultrasonography revealed inflamed appendix with periappendix collection

Out of the 50 patients, age of the young patient was 7 years and age of the oldest patient was 85 years. Maximum number of patients suffering from some pathology of the appendix belonged to 21 to 30 years age group. Out of 50 patients, 30 were male and 20 patients were female, male to female ratio being 1.5:1. The most common pathology detected was acute nonperforated appendicitis (27 cases), followed by appendicular perforation (7 cases), recurrent appendicitis (8 cases), appendicular abscess (4 cases), appendicular lump (2 cases), and reactive inflammation of appendix (2 cases). Out of 50 patients who have one of the appendicular pathologies, USG was detected correctly in 42 patients (sensitivity 86.86%, PPV 98.85%). These findings are almost similar to the results from the study done by Puylaert et al²² Abu Yousef et al.⁸ Out of 30 surgically proven cases of acute appendicitis (without complications), USG diagnosed it correctly in 27 patients (sensitivity 95%, PPV 100%). The diagnosis was missed in three cases. Out of seven cases of appendicular perforation, US gave a correct diagnosis in six cases (sensitivity and PPV 92.85%). The USG missed the perforation in one case. Out of four cases of appendicular abscess, USG diagnosed correctly in all four cases (sensitivity and PPV 100%). Out of two cases of appendicular lump, USG gave a correct diagnosis in both cases. Reactive inflammation of appendix was correctly diagnosed by USG in one case. Out of 42 cases of appendicitis, complications like perforation, abscess, or lump were detected in 15 cases. The overall incidence of complicated appendicitis was thus 35.71%. Of these 15 cases, USG gave a correct diagnosis in 13 (PPV 96.15%). Körner et al²³ reported perforation rate of 19 to 35% in cases of acute appendicitis. In all the eight cases of recurrent appendicitis, patients underwent US examination in the relatively symptom-free period, and USG could not give the diagnosis in any case. The diagnosis was confirmed on interval appendicectomy. The most important factor for diagnosing appendicular pathology was found to be the direct visualization of the appendix. The appendix was visualized in 42 patients. The two most accurate appendiceal findings for acute appendicitis were a diameter of 6 mm or larger and a lack of compressibility. These two criteria show 100% sensitivity and 100% PPV for acute nonperforated appendicitis. Jeffrey et al¹⁷ and Rao et al¹⁸ reported similar findings and concluded that diameter of appendix >6 mm is the most important criteria in diagnosing acute appendicitis. Noncompressibility has been postulated as an important criteria in diagnosing acute appendicitis by Rioux²⁰ and Jeffrey et al.¹⁷ However, for acute appendicitis with complications, the diameter criteria revealed sensitivity varying from 57.14 to 93.75% and PPV varying from 66.6 to 100%. Noncompressibility showed sensitivity from 50 to 81.25% in complicated appendicitis.

The round shape of the inflamed appendix with layered structure constitutes the so-called target sign. It showed 100% sensitivity and PPV. In cases of appendicular perforation, focal loss of this layered structure is an important sign with a high PPV (100%); however, it is not very sensitive (43.75% in appendicular abscess). Similar findings were noted by Borushok et al.¹⁹ Presence of appendicolith is an important criterion; however, it is not very sensitive. Fecoliths were noted in 25.92% cases of acute nonperforated appendicitis and in 28.57% cases of appendicular perforation. Similar findings were reported by Horrow and White.²¹ They reported that appendicolith occurred in 36% patients, more often in perforated appendicitis (49% than in nonperforated appendicitis [27%]). Periappendiceal fat inflammation has high PPV of 84.61%; however, the sensitivity was low (37.31%) in acute nonperforated appendicitis. In complicated appendicitis, the sensitivity was higher (87.5 to 100%). Borushok et al¹⁹ also concluded that inflammatory changes in periappendiceal fat tended to be more severe in the perforated group. Inflammatory thickening of the cecum and/or terminal ileum also revealed similar results. It has low sensitivity for acute nonperforated appendicitis (14.81%) and higher sensitivity (61.53%) noted for complicated appendicitis. Horrow and White²¹ reported cecal thickening in 41% of perforated appendicitis and 24% of nonperforated appendicitis. The presence of free/loculated intraperitoneal fluid revealed very high sensitivity for appendicular perforation and abscess (100%). Sensitivity was 50% for appendicular lump and 37.03% for acute nonperforated appendicitis. Puylaert et al²² and Borushok et al¹⁹ have also noted similar findings. The presence of enlarged mesenteric lymph nodes showed low sensitivity (14.81%) for acute nonperforated appendicitis. Variable sensitivity (43.75 to 100%) was noted for complicated appendicitis. Kessler et al²⁴ have reported lymphadenopathy in 32% cases of appendicitis.

In reactive inflammation of the appendix, all these criteria are neither sensitive nor specific. When present, they do help in diagnosis. Usually, the primary pathology is obvious and the visualized appendix does not fulfill the criteria for acute appendicitis. Appendicolith was not visualized in all of these cases.

CONCLUSION

Ultrasonography has high sensitivity and specificity in the detection of various appendicular pathologies. The overall accuracy of US in diagnosing appendicular pathology was found to be 95%. Direct visualization of the appendix is the most important criteria in diagnosing any appendicular pathology. In acute nonperforated appendicitis, a diameter of 6 mm or larger and lack of

compressibility were the most sensitive and accurate criteria. However, the periappendiceal findings like mesenteric and cecal inflammation, the presence of free intraperitoneal fluid, and regional lymphadenopathy have low sensitivity. When present, these findings increase the confidence in diagnosis.

In appendicular perforation, focal loss of the layered structure of the appendix is very specific, but it is not very sensitive. Instead, the presence of free fluid has both high sensitivity and PPV. The periappendiceal findings like mesenteric and cecal inflammation and regional lymphadenopathy were also seen more commonly in complicated appendicitis.

In recurrent appendicitis USG is highly sensitive in the acute phase; however, in the symptom-free period, it loses sensitivity.

In conclusion, this study showed that USG has a high degree of accuracy in diagnosing various pathologies of the appendix. It is thus recommended that US should be considered as an important modality in patient evaluation in all clinically diagnosed cases of acute appendicitis and in doubtful cases for a better management decision and patient care.

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