

## Ultrasonography in acute appendicitis

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### ABSTRACT

**Background & Objectives:** This study was undertaken to establish the Ultrasonographic (USG) findings in acute appendicitis and to establish the accuracy of USG in the diagnosis of acute appendicitis. **Materials & Methods:** One hundred patients who presented to the emergency department with a clinical diagnosis of acute appendicitis were subjected to USG. USG findings of those patients suggestive of acute appendicitis were noted. The decision to operate for appendicitis was made on the surgeon's final clinical impression after correlating with USG findings. Histopathological examination of the appendicectomy specimen was taken as the gold standard for the diagnosis of acute appendicitis. **Results:** USG diagnosis of acute appendicitis is based on a combination of sonographic features. The findings of an aperistaltic tubular structure arising from the caecum with a target appearance on cross section, outer diameter of  $> 6$  mm, mural wall thickness  $> 3$  mm, and probe tenderness over the visualized appendix should prompt the diagnosis in the appropriate clinical settings. The visualization of appendicolith is associated with higher rate of perforation and the visualization of fluid with internal echoes in acute appendicitis could suggest abscess formation. **Conclusion:** USG is a very useful and essential modality in the diagnosis of acute appendicitis with a sensitivity of 93.93%, specificity of 100%, PPV of 100%, NPV of 89.47% and an overall accuracy of 96% in the diagnosis of acute appendicitis.

**Key words:** Acute appendicitis; appendicectomy; ultrasonography

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### INTRODUCTION

In 1554, French physician Jean Fernel first described the term acute typhlitis (derived from the Greek typhlon for caecum) and perityphlitis. Later in 1711, Lorenzo Heister, professor of surgery at Helmstedt, was the first to suggest the appendix as the likely site of primary inflammation. Reginald Fitz, professor of pathology, published a landmark manuscript describing the appendix as the source of inflammation in acute typhilitis. It is Fitz who first coined the term appendicitis.<sup>1</sup>

The vermiform appendix is a blind muscular tube with mucosal, submucosal, muscular and serosal layer. Acute appendicitis is the most common abdominal surgical emergency.<sup>2</sup> Between five and 10% of the population develop this condition at sometime in life. The peak incidence is in the second and third decade of life, but can occur at any

age.<sup>3</sup>

USG came as a specific tool for preoperative diagnosis of acute appendicitis in 1981 when Deutsch and Leopold reported the visualization of an inflamed appendix for the first time in a young leukemic patient.<sup>4</sup> Puylaert in 1986 first introduced the graded compression technique for the diagnosis of acute appendicitis.<sup>5</sup> In this technique, the probe is applied with gradually increasing pressure over the right iliac fossa to displace the bowel loops and visualize the appendix.

### MATERIALS AND METHODS

All patients who presented to the emergency department with a clinical diagnosis of acute appendicitis were subjected to USG. USG examination was done initially using a 3.5 MHz convex probe. Abdominal organs were scanned

followed by examination of the right iliac fossa using the graded compression technique. The examination was then performed with a 7.5MHz linear-array transducer. The ascending colon was first identified and traced caudally to locate the caecum. The appendix was then identified as blind-ending, peristaltic tubular structure arising from the tip of the caecum with a gut signature.

The diagnosis of acute appendicitis was suggested by the presence of an aperistaltic, non-compressible tubular structure in right iliac fossa arising from the caecum with target appearance on transverse section. The maximum outer to outer wall diameter and wall thickness (hypoechoic muscular wall) were measured. Probe tenderness over the enlarged appendix was also noted. USG was considered negative for appendicitis when the appendix could not be visualized or if other pathology was discovered for the cause of pain in the right iliac fossa.

Patients underwent appendicectomy on the basis of the surgeon's final clinical impression after correlating with USG findings. Histopathological examination of the appendectomy specimen was done using routine hematoxylin and eosin staining. The histopathological diagnosis was considered as the gold standard for the diagnosis of acute appendicitis.

## RESULTS

Out of the 100 clinically suspected cases, 74 patients underwent appendicectomy. Histopathological examinations showed acute appendicitis in 44, gangrenous appendicitis in five, gangrenous appendicitis with perforation in 17 and normal appendix in eight. Thus acute appendicitis was confirmed in 66 patients.

Out of the 66 patients with histopathologically proven acute appendicitis, 62 (93.93%) were diagnosed on preoperative USG. In the remaining 4 (6.06%) patients USG failed to visualize the inflamed appendix. Of these four patients, two had perforated appendix, while one was an obese patient and the appendix could not be located, and the other had a malrotated gut with undescended caecum.

USG showed either a normal scan or an alternative diagnosis for the cause of pain in right iliac fossa in 26 of the 100 patients and hence these patients were not operated and were later discharged. Therefore, USG had a sensitivity of 93.93%, specificity of 100%, PPV of 100%, NPV of 89.47%, and an

overall accuracy of 96% in the diagnosis of acute appendicitis.

The USG findings of an aperistaltic, non-compressible tubular appendix with a target sign on cross section and probe tenderness over the inflamed appendix were demonstrated in all the cases with histopathologically confirmed appendicitis thus having 100% sensitivity and specificity.

The observed maximum outer diameter of the inflamed appendix ranged from 6.1 to 15.8 mm, with an average of 10.0 mm. The observed mural wall thickness of an inflamed appendix ranged from 2.2 to 5.8 mm, with an average of 3.36 mm. However in two cases with histopathologically confirmed appendicitis the wall thickness was less than 3 mm. A grossly distended fluid-filled appendix was seen in these two patients. USG diagnosis of acute appendicitis was however made in these two patients based on the other sonographic findings.

An appendicolith was visualized on USG in nine (13.63%) of the 66 patients with appendicitis, which was later confirmed during surgery. Five had perforated appendix and the remaining four had uncomplicated appendicitis. In other words, five (29.41%) of the 17 patients with perforation had an appendicolith compared to 4 (9.09%) of 44 patients with uncomplicated appendicitis. An appendicolith was thus visualized more frequently in patients with perforation.

Minimal clear fluid collection in right iliac fossa was noted in 10 (22.72%) of the 44 patients with non-perforated appendicitis, while significant collection with internal echoes were noted in all the 17 patients with perforated appendix and pyoperitoneum.

## DISCUSSION

In his original description of the graded compression technique, Puylaert JB<sup>5</sup> emphasized that visualization of the appendix alone was the sole criterion for the diagnosis of acute appendicitis by means of USG, as normal appendix was not visualized. Lehmann D et al.<sup>6</sup> noted normal appendix in 13 (12%) of their 109 patients, with an average outer diameter of 5.5 mm. Rioux M<sup>7</sup> however, reported visualization of normal appendix in 102 (82%) of 125 normal patients. In this present study normal appendix was not visualized.

The average diameter of the inflamed appendix in the present study was 10.0 mm (range 6.1 to 15.8

mm) and increased diameter as a USG sign of appendicitis was demonstrated in all patients with acute appendicitis (sensitivity and specificity of 100%). The present study is in agreement with that of Jeffrey RB et al<sup>8</sup> who had concluded that a diagnosis of appendicitis can be made in patients with persistent right iliac fossa pain and an appendicular diameter of > 6 mm. Rettenbacher T et al<sup>9</sup> however, noted appendicular diameter in control subjects (who did not have appendicitis) ranged between two to 13 mm and in 23% of these patients the diameter were > 6 mm. Diameter of acutely inflamed appendix ranged from 6 to 30 mm. They concluded that diameter of > 6 mm can diagnose acute appendicitis with a sensitivity of 100%, but with a poor specificity of 68%, PPV and NPV of 63% and 100% respectively, and 79% accuracy. This diagnostic criterion in their study was more useful in excluding acute appendicitis than in confirming it.

In a study by Jeffery RB et al,<sup>10</sup> the range of mural thickness of an acutely inflamed appendix varied from three to eight mm, with an average of 3.6 mm. The ranged obtained in the present study was from 2.2 to 5.8 mm, with an average of 3.36 mm. In two cases with confirmed appendicitis the wall thickness measured 2.2 mm. Distended fluid-filled appendixes were seen in these two patients during surgery. Hayden CK<sup>11</sup> reported wall thickness in acute appendicitis ranged from two to seven mm, the majority being only two to three mm. Though an exact cut-off value for appendicular wall thickness in acute appendicitis has not been determined, an acutely inflamed appendix, especially when distended by fluid, can have a wall thickness less than 3 mm.<sup>11</sup>

Probe tenderness over the visualized appendix on USG was very useful in the diagnosis of acute appendicitis and was present in all the patients with acute appendicitis in the present study. Soda K et al<sup>12</sup> using this criterion alone achieved a sensitivity of 86.7%, specificity of 89.7%, a PPV of 94.5%, a NPV of 76.5%, and an overall accuracy of 87.6%. This criterion itself was superior to that of the surgeon's initial clinical impression in the author's study.

An appendicolith was visualized on USG in nine (13.63%) of the 66 patients with appendicitis in this present study. These patients were diagnosed as having appendicitis by USG based on the increased outer diameter and mural thickness. Appendicolith was just an additional finding. Jeffrey RB et al.<sup>8</sup>

however, noted two patients with surgically confirmed appendicitis having multiple appendicoliths but with an outer appendiceal diameter of less than 6 mm. Thus he concluded that a diagnosis of acute appendicitis can be made even if the maximal outer diameter is 6 mm or less, when appendicolith is also visualized in patients with right iliac fossa pain. Forel F et al<sup>13</sup> reported three cases with atypical clinical findings and in whom the detection of an appendicolith by USG made the diagnosis of acute appendicitis possible. They were the first to report the sonographic demonstration of an appendicolith in 1983.

In this present study, an appendicolith was seen in 5 (29.41%) of the 17 patients with perforation, in contrast to four (9.09%) of the 44 patients with uncomplicated appendicitis. An appendicolith was thus demonstrated more frequently in patients with complicated appendicitis. Faegenburg D<sup>14</sup> studied 17 patients with acute appendicitis and who had appendicolith on abdominal radiography. All had acute appendicitis and 12 were complicated by gangrene or perforation. Thus the demonstration of an appendicolith is not only a strong evidence for acute appendicitis in patients with right iliac fossa pain, even if the outer diameter is less than 6 mm, but also indicates the possibility of perforation.

Though a diagnosis of acute appendicitis was made on USG, gangrenous appendicitis without perforation could not be made on pre-operative USG. Thus, sonographic prediction of a gangrenous appendicitis was poor in the present study. In the 17 patients with gangrenous appendicitis and perforation, the most significant finding to suggest perforation was the demonstration of pericaecal fluid collection containing internal echoes. In a similar study Borushok KF et al<sup>15</sup> noted three sonographic findings that were statistically significant in appendicular perforation: loculated pericaecal fluid, circumferential loss of the echogenic submucosal layer of the appendix, and prominent adjacent pericaecal fat more than 10 mm thick. The best single sonographic feature in their study was loculated pericaecal fluid indicating an abscess (specificity 100%). This finding indeed was the only feature to suggest perforation in this present study.

## CONCLUSION

Ultrasonography is a very useful and essential modality in the diagnosis of acute appendicitis with a sensitivity of 93.93%, specificity of 100%, PPV

of 100%, NPV of 89.47% and an overall accuracy of 96% in the diagnosis of acute appendicitis.

Diagnosis is based on a combination of sonographic features. The findings of an aperistaltic tubular structure arising from the caecum with a target appearance on cross section, outer diameter of >6 mm, mural wall thickness >3 mm, and probe tenderness over the visualized appendix should prompt the diagnosis in the appropriate clinical settings. The visualization of appendicolith is associated with higher rate of perforation and the visualization of fluid with internal echoes in acute appendicitis could suggest abscess formation.

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