

Sonographic Accuracy in Determining Acute Appendicitis in the Children in a Tertiary Care Hospital

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Objective: The purpose of this study was to determine the accuracy of sonographic diagnosis in patients with suspected acute appendicitis in a tertiary care hospital, utilizing commercially available 3.75 MHz curved array probe. Most of the studies on this subject have used high frequency probes and therefore report very high sensitivities and specificities.

Material and Methods: 220 paediatric patients (range 3-14 years, mean age 11.3 years) attending the Emergency Department Of Lahore General Hospital Lahore with clinical suspicion of acute appendicitis were evaluated by the author. Children with vague abdominal pain or without suspicion of acute appendicitis were not included in the study. Four criteria i.e. enlarged appendix (diameter more than 6 mm), lack of compressibility, a blind ending loop without peristalsis and localized fluid collection were taken into consideration before declaring a patient to be having acute appendicitis.

Results: Sonography confirmed the diagnosis in 39 out of 54 patients whereas 15 patients, falsely reported to be normal on sonography, were found to be having acute appendicitis on surgery. False positive diagnosis was made in 6 patients, all of whom underwent appendectomy. 160 patients declared normal on sonography proved to be normal on observations during hospital stay and follow up. Sensitivity of 72% achieved in this study was lower than reported in current literature employing high frequency probes. Specificity 96%, accuracy 91%, negative and positive predictive values of 92 and 87% respectively fall within described range of quoted results.

Conclusion: Though sensitivity achievable with the medium frequency ultrasound probe is a little lower than that declared in recent similar studies, author believes that given the availability of this probe and considering the cost effectiveness, use of standard commercially available 3.75 MHz probe is quite effective in making a diagnosis of acute appendicitis and should be encouraged so that a sizeable portion of unnecessary appendectomies can be avoided.

Key words: Acute appendicitis, sonography, children, tissue harmonic imaging.

Introduction

Transabdominal sonography has been performed as an imaging technique in patients with suspected appendicitis because sonography can rapidly help distinguish patients with appendicitis requiring CT or surgery from those with a normal appendix.¹ Ultrasonography is rapid, noninvasive, inexpensive, and requires no patient preparation or contrast material administration. Because ultrasonography involves no ionizing radiation and excels in the depiction of acute gynaecologic conditions, it is recommended as the initial imaging study in children, in young women, and during pregnancy.

Appendicitis is the most common cause of acute abdominal pain that necessitates surgical intervention in Western world.² Clinical diagnosis is based primarily on symptoms and physical findings, however the diagnosis is often difficult and upto 50% of patients hospitalized for possible appendicitis do not actually have this disorder. Authors of large prospective studies report a 22-30% removal rate of normal appendices at surgery.³⁻⁶ To reduce the frequency of unnecessary appendectomy, use of ultrasonography as a diagnostic tool for appendicitis has been widely evaluated.⁷⁻⁹

Several large trials have reported sensitivities of 77-

89% and specificities of 94-96% using high frequency (7-12 MHz) linear probes. The primary aim in this study was to evaluate the diagnostic accuracy, sensitivity and specificity of sonography in the evaluation of acute appendicitis in a community hospital like ours where we have standard 3.75 MHz curved array probe available. Thus these results are a guide as to how effective an ultrasound diagnosis of acute appendicitis may be in a community hospital in the expert hands utilizing the said probe.

Materials and Methods

Lahore General Hospital is a tertiary care hospital, serving a large segment of the local population. Its new Emergency Block started in 2006 and it is where this study has been carried out. All the patients referred to the sonography section of Emergency Radiology Department for suspected diagnosis of acute appendicitis were included in this study. We did not include patients with vague or generalized abdominal pain in our study as surgeon had no doubt of acute appendicitis on clinical grounds. Most of the patients in this study were having pain in right iliac fossa mimicking acute appendicitis. CT was not employed in any of the cases for primary workup, as in our department it is used only as a problem solving tool.

Technique

From May 2007 to July 2008, 220 consecutive paediatric patients (range 3-14 years, mean age 11.3 years) suspected at clinical evaluation of having appendicitis at Emergency Department of Lahore General Hospital, underwent ultrasonography using conventional popularly available curved array 3.75 MHz probe (Toshiba Famio 5, Toshiba Medical Equipment, Japan) by the author having experience of more than 15 years. Four criteria were utilized to make the diagnosis of acute appendicitis i.e. enlarged appendix (diameter more than 6 mm), lack of compressibility, aperistaltic blind ending gut loop and localized fluid collection. Curved array 3.75 MHz transducer was used in all these cases. The author used the graded compression technique described by Puy-laert^{10,11} and, in a large number of patients, also used operator dependent techniques e.g. examination in lateral decubitus position and manual compression of posterior abdominal wall to bring the pathological area in the focal zone of ultrasound beam for better visualization of pathology. Special attention was given to sonographic finding of periappendiceal hyperechoic structure when acute appendicitis was suspected strongly on clinical grounds but it fell short of fulfilling sonographic criteria of acute appendicitis. A diagnosis of acute appendicitis was made when outer diameter of visualized appendix exceeded 6 mm under compression or when the enlarged appendix remained non-compressible on gentle pressure by ultrasound probe. Tenderness elicited over enlarged appendix was additional feature for ensuring diagnosis in the presence of sonographic criteria.

Results

During the period of 14 months, 220 patients were scanned to find out inflamed appendix. Out of these referred patients, 54 had acute appendicitis and remaining 166 did not. Positive sonographic findings had been reported in 39 of those 54 patients. 2 of the 39 patients with true positive findings had a ruptured appendix at the time of surgery whereas remaining 37 of 39 had all features of acute appendicitis in surgeon's opinion during surgery. Of the 15 patients with false negative finding on ultrasonography, presence of pelvic inflammatory disease (4 patients), right ureteric/ renal calculus (6 patients), mesenteric adenitis (1 patient) and psoas abscess (1 patient) diverted the radiologist's attention from inflamed appendix. Appendix could not be visualized in the remaining 3 patients as it was noted to be in retrocecal (2 patients) and pelvic (1 patient) locations, which are appendiceal positions difficult to be assessed sonographically. One patient had equivocal findings and was declared normal on ultrasonography but had to be operated on strong clinical suspicion. All of the 54 patients with acute appendicitis had the diagnoses confirmed by surgery and in 10 patients surgical impression was also confirmed by histopathology.

All 15 patients with false negative diagnoses were operated on strong clinical suspicion and laboratory findings. The author made false positive diagnoses in 6 patients, all of whom underwent appendectomies as referring surgeon him-

self was in doubt and could not rule out possibility of acute appendicitis on clinical grounds alone. The 160 patients with true negative sonographic findings and doubtful diagnosis in the surgeon's assessment were followed up either during their stay in Emergency Department when their symptoms regressed markedly or by calling them in the Out patient Department or Emergency Department next day when all of them reported either disappearance or marked improvement in their symptoms since first reporting.

Discussion

Sonography now plays a vital role in non-invasive evaluation of patients with right lower quadrant pain. Acute appendicitis is a common clinical problem.¹² Graded compression sonography was reported by Puy-laert in 1986 for diagnosing acute appendicitis in adults. However, a normal appendix was difficult to visualize because of technical limitations of ultrasound machines at that time.¹³ Ultrasonography machines in general and their resolution in particular have markedly improved since then, therefore several additional criteria for appendicitis were established such as increased wall thickness of appendix, non-compressibility of inflamed appendix, shape of appendix (ovoid or linear structure), presence of localized fluid in right iliac fossa, demonstration of soft tissue hyperechogenicity in right lower quadrant due to inflamed pericecal/ perienteric fat and absence of gas in appendiceal lumen.¹⁴⁻¹⁶ Recent introduction of tissue harmonic imaging (THI) could resolve problem in technically difficult patients by increasing depth of penetration and markedly improving image quality.¹⁷



Fig. 1: A case of acute appendicitis. Sonography reveals an outer appendiceal diameter of 9 mm (between calipers placed outside the muscular coat). Appendix is assuming an ovoid shape, a feature suggestive but not diagnostic of the acute appendicitis.

The outer appendicular diameter of 6 mm or more as a sign of acute appendicitis provides high sensitivity but limited specificity. Many recent studies have shown the range of normal appendicular diameter to vary from 4 to 11 mm the-

reliance on this parameter alone is not recommended. Visualization of an enlarged appendix on sonography needs to be clinically correlated. This sonographic diagnostic criterion is more useful in excluding acute appendicitis than in confirming it¹⁵ (Figure 1).

Rioux M described sensitivity in detecting appendicitis was 93%, specificity was 94% and accuracy was 94%. He concluded that sonography was helpful in detecting acute appendicitis.¹⁸ The normal appendix is seen infrequently at ultrasonography, although it may be seen, particularly in thin patients; with excellent quality examinations. He described the visualization of the normal appendix in an amazing 102 of 125 (82%) patients without acute appendicitis. In the experience of others,^{19,10,23} this number usually is substantially lower, 0%–4%, in the adult population, regardless of technique. The threshold diameter of 6 mm, above which inflammation is present, is invaluable in distinguishing the normal appendix from the inflamed appendix, as the diameter of the normal compressed appendix is invariably less than this.

Frequently normal appendix is moveable with its location changing even during sonographic examination. Usual downward sweeping of high frequency linear transducer in starting graded compression sonography may cause low lying or false pelvic-located appendix to move down wards where it becomes even more difficult to be visualized. Therefore the author used upward sweeping of the probe as it can displace upwards the low lying cecum with its attached appendix. Lateral decubitus position can also serve the same purpose by upward displacement of low lying cecum along with appendix.²⁰

At ultrasonography, appendix appears round or ovoid on the transverse section when slight pressure is applied over it. Shape of the appendix in transverse section is a useful ultrasound criterion, since avoid shape over entire appendiceal length rules out acute appendicitis. The appendiceal wall thickening seen in acute appendicitis causes an increase in outer appendiceal diameter therefore most of the acutely inflamed appendices are round on transverse section.

A confident diagnosis of acute appendicitis can be made on the appearance of non-compressible appendix measuring 6 mm or more in antero-posterior diameter.^{12,21} A diameter of 6 mm or more confirms acute appendicitis with a sensitivity of 100%; a specificity of 68%; positive and negative predictive values of 63% and 100% respectively and an accuracy of 79%.¹⁵

The presence of edematous thickening of the cecal wall, pericecal lymphadenopathy or right lower quadrant abscess or ascites is suggestive of but not specific for appendicitis. Although the criteria for the diagnosis of appendicitis are focused on the appendix itself, inflammatory change in peri-enteric fat is often the first and most obvious finding at ultrasound examination. Inflamed fat appears as hyper-echoic periappendiceal soft tissue with indistinct margins²² (Figure 2).

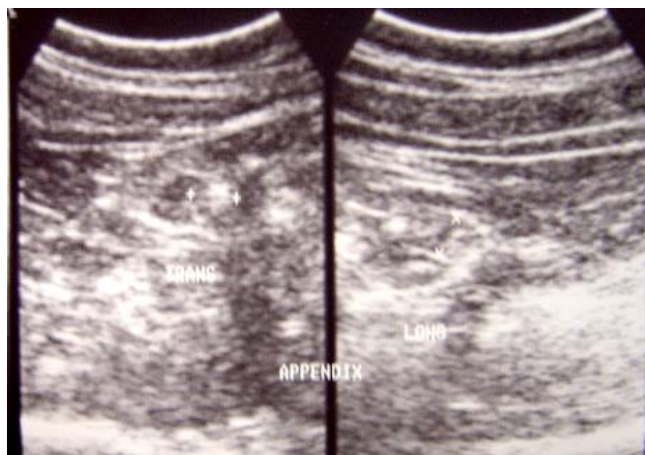


Fig. 2: *Sonographic images of mildly inflamed appendix having 7 mm diameter, appendix was non compressible, slightly increased echogenicity in the periappendiceal region reflects inflammation of the adjacent fat.*

In an exhaustive and detailed study by Terasawa et al. whereby all literature relating to sonographic and CT depiction of acute appendicitis from 1966 to Dec 2003 was analysed, ultrasonography had an overall sensitivity of 0.86, a specificity of 0.81, a positive likelihood ratio of 5.8, and a negative likelihood ratio of 0.19.²⁴ In another study by Kessler N. et al., the prevalence of appendicitis was 46%. The appendix was identified with ultrasonography in 86% of the patients, which included 96% of patients with and 72% of patients without appendicitis. The most accurate appendiceal finding for appendicitis was a diameter of 6 mm or larger, with a sensitivity, specificity, NPV, and PPV of 98%. The lack of visualization of the appendix with ultrasonography had an NPV of 90%. The most accurate periappendiceal finding of appendicitis was the presence of inflammatory fat changes, with an NPV of 91% and a PPV of 76%, whereas other findings had both NPV and PPV less than 65%.²⁵

Sensitivity of 72% achieved in the present study was lower than reported in current literature where high frequency probes have been employed. Specificity 96%, an accuracy of 91%, negative and positive predictive values of 92 and 87% respectively fall within described range of quoted results.

Pitfalls

The most common source of error in the over diagnosis of appendicitis with ultrasonography include misinterpretation of the terminal ileum as the appendix and misinterpretation of a normal appendix as an inflamed appendix. The terminal ileum, in contrast to appendix, does not attach to the base of the cecum, is not blind ended and shows frequent peristaltic activity. In all cases, terminal ileum appears as a tubular fluid filled structure which is easily compressible and shows reduction in antero-posterior dimensions upon compression

by ultrasound probe.²³

If inflammation is localized to only the tip of the appendix, an incomplete examination also could lead to an erroneous impression that the appendix is normal. The requirement of visualizing the entire length of the appendix is emphasized to avoid a false-negative diagnosis. Other problems in the visualization of the inflamed appendix may be its pelvic or retrocecal locations where it can be missed easily.

Conclusion

The sensitivity of diagnosing acute appendicitis in our study is considerably below (72% versus 77-89%) than that documented in current literature despite the fact that all these examinations were performed by an experienced radiologist. However specificity, accuracy, positive and negative predictive values are falling within acceptable range. The author believes that this is primarily due to absence of high frequency linear transducer and non-availability of THI. He also believes that because of easy approach, most of the cases with proven acute appendicitis came to this hospital in very early phases, i.e. within two hours of onset of symptoms and hence many of proven acute appendicitis cases on surgery were missed due to inconclusive ultrasonographic imaging findings. Overcrowded department is another reason of low sensitivity owing to the unavailability of sufficient time for detailed evaluation of each patient. A high false negative percentage can be reduced if sufficient time is allowed for adequate bladder filling for optimal pelvic assessment as in all these 15 cases, concurrent genito-urinary pathology (renal or ureteric calculus, pelvic inflammatory disease, ovarian cyst etc.) diverted radiologist's attention from inflamed appendix.

It was also noted that surgeon's reliance on ultrasonography is not as high as is expected in this era. Most of the surgeons solely rely on clinical judgment. This approach in gradually changing and unless emergency appendectomy has to be performed without delay, most of the surgeons prefer to get ultrasonography report to confirm or rule out their provisional diagnosis of acute appendicitis. This is more frequent in female cases where pelvic pathology closely mimics appendicular pain and needs to be clearly ruled in or out before surgery is carried out.

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