

Validity of ultrasound examination in the diagnosis of acute appendicitis compared with surgical results

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ABSTRACT:

Objective: To assess the validity of ultrasound examination in the diagnosis of acute appendicitis.

Methods: This case series study included 750 patients. From January 2003 to March 2007, patients with suspected acute appendicitis were sent to the radiological section in the AL-Jamhory teaching hospital and my private clinic for sonography.

A distended appendix with a lumen more than 6mm, aperistaltic appendix with appendicolith in its lumen are all signs and criteria for the diagnosis of acute appendicitis.

Result: Of the 750 patients suspected to have acute appendicitis who were examined by sonography, 527 were males and 223 females. 468 patients had true acute appendicitis, and 220 patients were negative for this disease.

Thirty patients showed false positive diagnosis, while 32 patients proved to have false negative results. The overall sensitivity of ultrasound examination to diagnose acute appendicitis was 94%, specificity 88%, accuracy 92%, positive predictive value 93% and negative predictive value was 88%.

Conclusion: sonography must be used as first modality to assess suspected acute appendicitis. It is easy, non invasive, simple and rapid.

الخلاصة:

الهدف: لتقييم أهمية فحص الموجات فوق الصوتية في تشخيص حالات اشتباه التهاب الزائدة الدودية الحاد. تقييم البحث: دراسة وصفية لحالات مرضية.

المشاركون: ٧٥٠ مريضاً مصابون باشتباه التهاب الزائدة الدودية الحاد. مكان إجراء البحث والإطار الزمني: أجريت الدراسة في شعبة الأشعة في م. الجمهوري التعليمي والعيادة الخاصة في الموصل منذ كانون الثاني ٢٠٠٣ وحتى آذار ٢٠٠٧.

طرق الدراسة: تم فحص الزائدة الدودية للمرضى وتم اعتماد الصفات التالية كأدلة على الالتهاب الحاد وشملت انتفاخ الزائدة الدودية بحيث يصبح قطر تجويفها أكثر من ٦ ملم، فقدان الحركة النبضية للزائدة، وجود جسم غريب داخل التجويف للزائدة مسبباً لانسدادها.

النتائج:

تم دراسة (٧٥٠) مريضاً مصابين باشتباه التهاب الزائدة الدودية. ٥٢٧ من الذكور و ٢٢٣ من الإناث تبين إصابة ٤٦٨ مريضاً بالتهاب الزائدة الدودية الحاد المثبت بإجراء التداخل الجراحي، بينما كان ٢٢٠ مريضاً سليماً من هذا المرض.

تم اكتشاف ٣٠ مريضاً من الذين شخصهم فحص الموجات فوق صوتية بان لديهم التهاب الزائدة الدودية بينما الفحص بعد إجراء العملية تبين خطأ ذلك (موجب خاطئ) وكان هناك ٣٢ مريضاً لم يتم تشخيصهم من قبل فحص الموجات فوق صوتية ولديهم المرض (سالب خاطئ).

بلغت حساسية فحص الموجات فوق الصوتية لتشخيص حالات التهاب الزائدة الدودية الحاد ٩٤% والخصوصية ٨٨% ودقة الفحص ٩٢%.

الاستنتاج: فحص الموجات فوق الصوتية هو من الفحوصات السهلة الإجراء والسريعة، وغير تداخلية ولهذا يجب إجراءه كفحص أولي في حالات الاشتباه بالتهاب الزائدة الدودية.

Acute appendicitis is still the most common cause of emergency surgery of the abdomen⁽¹⁾. Most of the investigators agree that 20-25% of appendices removed by surgery are normal⁽²⁾. It remains one of the most difficult diagnoses to be made clinically⁽³⁾. Much of these difficulties stem from the variability in its clinical presentation because the classical presentation including peri-umbilical pain localizing to the right iliac fossa, vomiting, leucocytosis are generally seen in less than 50% of patients⁽³⁾. In acute appendicitis, the preoperative diagnosis is uncertain in 30% and despite the improvement in surgical techniques, the negative appendectomy rate continues to be as high as 25%⁽⁴⁾. Acute appendicitis can occur at any age but is more prevalent in young adults and it is the most common surgical problem reported in children and pregnant women^(5,6).

The complications of acute appendicitis include peritonitis, localized periappendicular abscess, thrombosis of portal vein drainage, liver abscess and septicemia⁽⁷⁾. The rate of complications including death is directly related to the delay of diagnosis and delay in surgical treatment⁽⁸⁾. Mortality rate of simple appendicitis is 0.1% but it increases to 20-60 fold with perforation, and the rate of wound infection increases 35% with perforation⁽⁸⁾.

Prospective studies have shown the overall accuracy of the clinical diagnosis to be not more than 70-78% in suspected appendicitis with correspondingly high rate of 20-25% unnecessary laparotomies⁽⁹⁾. Up to as many as 30% of patients with proven appendicitis are misdiagnosed and discharged by the physician before being correctly identified⁽¹⁰⁾. The negative laparotomies remain in the 20-25% range⁽¹¹⁾, and this rate is higher in elderly women and children.

No laboratory test can establish the diagnosis of acute appendicitis with 100% accuracy. The usefulness of white blood cells count for diagnosis of acute appendicitis is controversial. Plain radiograph, supine and upright films have long been used in the work-up of patients with suspected appendicitis. The findings include indistinctness of right psoas muscle margin, scoliosis of the spine, obliteration of peritoneal fat lines, soft tissue mass effect in the right lower quadrant, colonic cutoff

sign (due to colonic spasm), localized small bowel ileus, calcified appendicoliths and free air in the peritoneal cavity⁽¹²⁾. Barium enema was used to diagnose acute appendicitis depending on visualizing the appendix⁽¹³⁾.

Helical computerized tomography had a good role in the diagnosis of acute appendicitis but ionizing radiation and the use of intravenous contrast made it a relatively invasive test⁽¹⁴⁾.

The ultrasound finding associated with acute appendicitis had been investigated in the past⁽¹⁵⁾. It has several advantages over the other techniques mentioned. These are:

- 1-The structure being evaluated –the appendix- is close to the surface of the abdomen.
- 2-The bowel can be displaced or compressed eliminating the disturbing gas artifacts.
- 3-The area of maximum tenderness indicated by the patient can be directly examined⁽¹⁶⁻³⁶⁾.

Ultrasound evaluation of patients with abdominal pain in suspected appendicitis includes visualization of non-compressible appendix more than 6-7mm in diameter (from outer wall to outer wall diameter). One expert team has identified three criteria for diagnosis of appendicitis by ultrasound examination which include; tender non-compressible appendix, no peristalsis of the appendix and the over all diameter of the appendicular lumen is greater than 6mm⁽¹⁷⁾.

The advantage of ultrasound examination to diagnose appendicitis is well known, the study is quick, readily available in most cases, non-invasive, has low complication risks and has been known to be accurate. High resolution ultrasound enables visualization of the inflamed appendix and can assess a variety of relevant disease. Bed-side ultrasound in evaluation of patients with suspected appendicitis is used nowadays as preliminary test⁽¹⁸⁻³⁷⁻⁴⁰⁾. The ultrasound diagnosis of acute appendicitis may be difficult if the appendix is not visualized, and this is especially common in obese patients. The ultrasound examination may be problematic if the patient suffers from acute pain which doesn't allow him to tolerate the pressure that must be applied with the probe on the right iliac fossa to permit visualization of the appendix⁽¹⁹⁾. The overall accuracy of ultrasound examination in the diagnosis of acute appendicitis in most

of the studies was about 85%, so that it appears to be most useful in the early stage of the disease and it can be easily repeated to reach final diagnosis⁽²⁰⁾.

The study aims to assess the validity of ultrasound examination in the diagnosis of acute appendicitis.

Patients and methods:

A total of (750) patients referred to the radiology section in AL-Jamhory Hospital from January 2003 to March 2007 with clinical suspicion of acute appendicitis were examined by ultrasound using "Aloka SSD 500 equipment". Some of these patients were examined in my private clinic on afternoon using Shimadzu C-32 equipment. A linear array transducer usually 5MHZ is used in examination.

The patient is examined in supine position and is initially asked to point the area of maximum tenderness. Scanning of the patient should be initiated in the region of maximal pain indicated by the patient to expedite the sonographic evaluation and this is called self-localizing technique⁽²¹⁾. If no abnormality is found, then transverse and longitudinal images are obtained of the abdomen, including the right lower quadrant and the right lateral abdomen extending from subhepatic location to the pelvis.

In all areas examined, the anterior abdominal wall is compressed slowly but firmly with the ultrasound transducer to displace normal bowel loops in an effort to locate the inflamed appendix. This procedure is called graded compression ultrasonography. If an apparently normal appendix is identified, a careful survey of the entire length of the appendix should be performed to avoid false negative examination when the inflammation is confined to the tip of the appendix^(22, 38). Sometimes I use posterior manual compression of the abdominal wall to help to visualize the appendix.

In the transverse plane of the appendix, alternating echogenic and hypoechoic concentric layers should be sought, corresponding to the visualization of various layers of the bowel wall. An inner-most hyperechoic layer corresponds to the interface between the mucosa and intraluminal contents. Hypoechoic layer corresponds to muscularis mucosae. A middle hyperechoic layer corresponds to the submucosa. An outer hypoechoic, layer corresponds to the muscularis propria. And

peripheral hyperechoic layer corresponds to the serosa⁽²³⁾. The fluid within the appendiceal lumen appears as an inner hypoechoic central sonolucency. A positive examination consists of visualization of the appendix. Fig. (1)

The diagnostic findings of examined patients were documented and such patients were followed to assess the type of treatment. Patients who underwent surgical operation were recorded and the post-operative results were compared with the ultrasound findings.

The sensitivity, specificity and accuracy with other statistical values are concluded using 2×2 table.

Results:

The sample included 750 patients. Their ages ranged from (6) years to (70) years forming (7) age groups according to decades of age including their liver spans, which are measured Fig.(2). Of these patients there are 527(70%) male and 223(30%) females with a sex ratio of 2.3:1.

Distribution of patients according to final diagnosis is shown on Fig. (3).

Thus 468(67%) patients who are diagnosed as acute appendicitis proved by surgery to have this diagnosis. The ultrasonographic criteria for acute appendicitis are shown in Table (1).

Other findings in association with perforated appendix include thickening of the adjacent bowel wall, atonic bowel loops, interloop fluid pockets, periappendicular fluid and abscess are encountered in 20 patients with acute appendicitis and perforation. Fig. (4).

The 30 patients in whom ultrasound showed positive signs of acute appendicitis and after surgery proved to be normal appendices are considered false positive diagnosis, and the surgical result shows the real cause of these cases ranging between ruptured ovarian cyst, cecal diverticulae, psoas muscle hematoma, inspissated stool mimicking an appendicolith and mesenteric adenitis.

In the 252 (33%) patients where the ultrasound finding showed negative signs of acute appendicitis, they were followed after sonographic examination and 220 patients of them showed no any aggravation of their clinical symptoms and their final diagnosis on discharge was not acute appendicitis. Hence, they were considered true negative cases on statistical bases. In these cases

normal appendix is visualized in 198(90%) cases only and the rest were not visualized, and in all these patients no sonographic signs of acute appendicitis were encountered. So these 220 patients are considered true negative cases on statistical bases.

In the remaining 32 patients where initial sonographic results showed negative sign for acute appendicitis actually were exposed to surgical laparotomies because they continued to have clinical symptoms that were suggestive of acute appendicitis

and this diagnosis was actually proved later by surgery and histopathology of the appendix. Therefore these 32 patients were considered false negative cases on statistical analysis.

The final statistical analysis are shown as follows: The overall sensitivity of ultrasound examination in diagnosis of acute appendicitis in this study is 94%; specificity 88%. The positive predictive value PPV=93% while negative predictive value NPV= 88% and the overall accuracy is 92%.

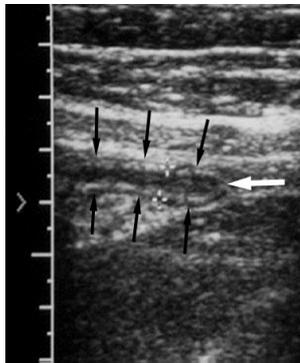


Fig. (1): Sonographic appearance of normal appendix.

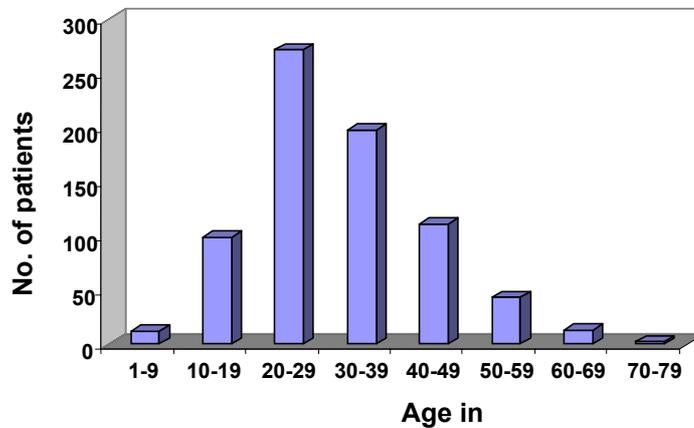


Fig. (2): Histogram demonstrates the age distribution of patients.

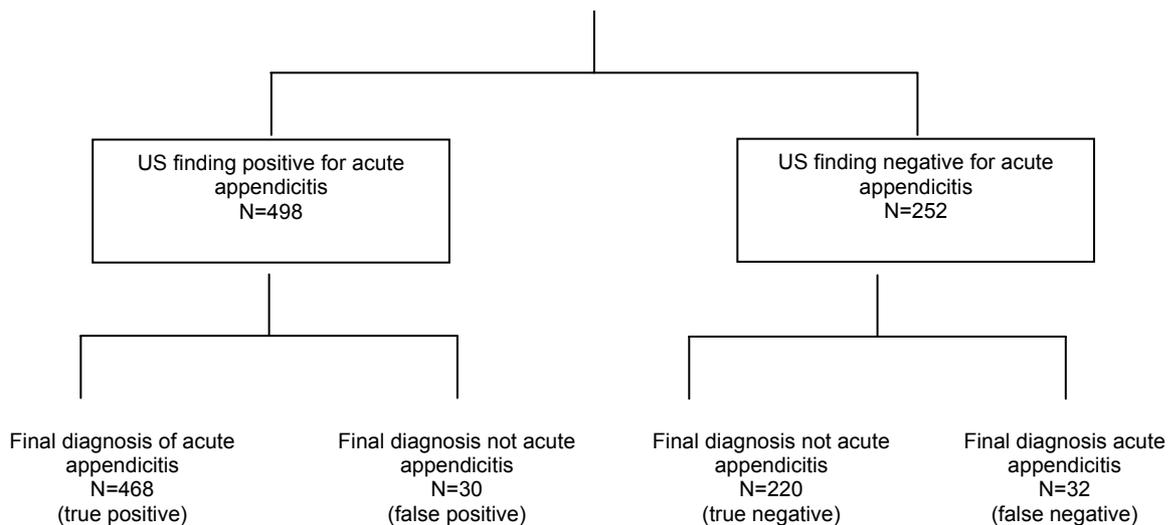


Fig. (3): Distribution of the patients according to the final diagnosis.

Table (1): Sonographic findings of acute appendicitis in 468 patients.

Sonographic sign	%
Diameter of the appendicular lumen more than (6) mm.	100%
Blind ending tubular structure filled with fluid, aperistaltic.	90%
Non-compressible appendix	88%
Echogenic submucosa	65%
Presence of appendicolith	40%
Free intra peritoneal fluid	15%

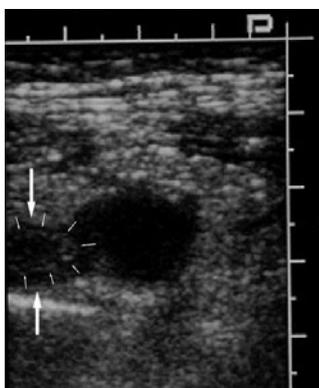


Fig. (4): Sonographic appearance of perforated appendix.

Table (2): validity of sonographic assessment in acute appendicitis.

%	D.S Wade et al. (28)	Toe et al.(29)	Sodak et al. (30)	Schwerk et al. (31)	Present study
Sensitivity	85.5	92	86.7	75-92	94
Specificity	84.4	96.9	90	92-100	88
Positive predictive value (PPV)	88.3	89.7	94.5	89	93
Negative predictive value (NPV)	80.1	97.9	79.9	96	88
Accuracy	85	96	88	87	92

Discussion:

This study utilizes the role of ultrasonography for the assessment of cases with suspected acute appendicitis and its influence upon patient management and outcome. We evaluate the usefulness of graded compression sonography with the adjuvant use of posterior manual compression technique to detect the appendix^(38, 39, 41).

Diagnostic ultrasound imaging of the appendix has improved steadily over the past decade and has been used traditionally as a primary modality in children with suspected acute appendicitis⁽²⁴⁾. It is very safe, fast, needs no ionizing radiation, non-invasive and considered most beneficial for paediatric age and pregnant patients⁽¹⁵⁾.

Regarding this study, the peak age of patients suffering from acute appendicitis

was between 20-30 years. This can be explained on the amount of lymphoid tissue present inside the appendix which is very little at birth and increases with age to reach the peak at 20-35 years and then starts to regress. Obstruction of the lumen of the appendix is thought to be due to lymphoid tissue hyperplasia beside the presence of fecolith⁽²⁵⁾.

Most of the studies which were done by expert teams had identified three main criteria for the diagnosis of acute appendicitis which include^(17, 33).

- 1- The overall diameter of the appendicular lumen is more than (6)mm.
- 2- tender non-compressible appendix.
- 3- Aperistaltic appendix.

The dilated lumen of the appendix was very important index for diagnosis of acute

appendicitis in our study and it was shown in 100% of our patients.

This is similar to Quillin et al. and Hayden et al. (1992); both showed the significance of this sign in their patients as 100%, and 98% respectively.^(19, 32)

The normal appendix was not always depicted in our study. It was seen only in 198 patients (90%) of the 252 true negative cases and was not visualized in the remaining 54 patients. Therefore, non-visualization of the appendix with the absence of any other inflammatory sign was interpreted as negative of appendicitis in accordance with other studies by Balthazar and Kamel et al.^(26, 27)

In this study there were 32 patients who had acute appendicitis proved after appendicectomies, but the preoperative sonographic diagnosis failed to label that (false negative). The causes of failure include retrocecal inflamed appendix when the dilated atonic caecum prevents the visualization of the appendix, moderate bowel ileus, small bowel obstruction, obesity and severe right iliac fossa tenderness which prevents proper graded compression examination^(18, 34).

On the other hand we came across 30 patients who were diagnosed to have acute appendicitis by ultrasound and post-operatively the appendices proved to be normal (false positive). This was due to other causes like hydrosalpinx, tubovarian abscesses, Crohn's disease, psoas muscle haematoma, inspissated stool mimicking an appendicolith. These diseases give features that simulate a dilated inflamed appendix. Most of the studies mentioned that the factors which decrease the reliability of sonographic evaluation of appendicitis include obesity, overlying bowels gas, nature of sonographic modality beside the ultrasound examination is being operator dependent and needs good experience in this field.^(28, 35)

The validity of sonographic assessment in acute appendicitis involved in our study as compared to other studies is shown in table(2).

Besides the known criteria of acute appendicitis mentioned in table (1), we conclude an associated sign in almost all the cases of acute appendicitis and this is an increased echogenicity of the portal veins radicle through the liver; in other words, there are periportal veins increased

echogenicity. This is mostly due to thrombophlebitis of these vein radicles due to portal blood drainage from the inflamed appendix. It was a good index of acute appendicitis.

Conclusion:

- 1- Ultrasonography is an accurate modality in the diagnosis of acute appendicitis and it is most useful in patients with acute equivocal clinical findings, so it should be the first modality used in this aspect.
- 2- The efficacy of sonographic assessment for acute appendicitis was superior to that of surgeon's initial clinical impression ($P < 0.001$) which is highly significant.
- 3- The early and accurate diagnosis of appendicitis can decrease the morbidity and hospital cost by reducing the delay in diagnosis of appendicitis and its associated complications, as well as by avoiding inpatient observation prior to surgery in patient who presents with typical symptoms. Furthermore ultrasound may provide alternative diagnosis which could be treated on out patient basis.
- 4- Being easy, fast, non-invasive, ultrasonography has advantages over other imaging modalities in diagnosis of acute appendicitis, and besides sonography can be available in every casualty department ready for this job.

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