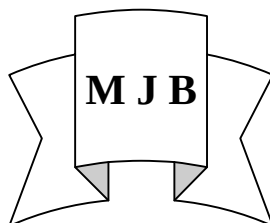


Sensitivity , Specificity and predictive values of ultrasonography in the diagnosis of acute appendicitis

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Abstract

objective: To evaluate the sensitivity and specificity, negative predictive value (NPV), and positive predictive value (PPV) of ultrasonography (US) in the diagnosis of acute appendicitis.

PATIENTS AND METHODS

A cross sectional study of 125 patients with suspected appendicitis was performed .. The appendiceal diameter (normal, less than 6 mm), compressibility of the appendix ,intraluminal fluid and echogenicity of surrounding fat were the primary criteria used to determine the status of the appendix by ultrasound and compare with histopathological examination as confirmative test

RESULTS:

The prevalence of real confirmed appendicitis by histopathology examination is 46% .while the sensitivity of sonographic examination in detecting appendicitis is 85%, the specificity is 53% , . The positive predictive value of sonography is 60 %; while the negative predictive value is 81%.The most accurate appendiceal finding for appendicitis was a diameter of 6 mm or larger 95% while 81% of confirmed cases have lack compressibility while only 28% of confirmed cases of true appendicitis have intraluminal fluid .

CONCLUSION:

Sonography is useful in detecting acute appendicitis and can clearly show the abnormal appendix more frequently .with high sensitivity and low specificity

حساسية ونوعية والقيم التنبؤية للسونار في تشخيص التهاب الزائدة الدودية الحاد

الخلاصة :

تقيم حساسية التشخيص والنوعية والقيم التنبؤية الموجبة والسالبة لفحص السونار لالتهاب الزائدة الدودية الحاد .

المرضى وطرائق البحث:

أجريت دراسة مقطعية لـ ١٢٥ مريض يشتبه باصابتهم بالتهاب الزائدة الدودية الحاد وتم فحصهم بالسونار حيث اعتبرت المعايير التالية أساساً لتشخيص التهاب الزائدة الحاد بالسونار زيادة قطر الزائدة الدودية (أكثر من ٦ مل)، وقابليتها على الضغط حيث لا تنضغط في حالة التهابها إضافة إلى تجمع السوائل داخل الزائدة مع إضافة إلى زياده العتمة في الانسجة المحيطة بها .

النتائج:

أظهرت هذه الدراسة ان معدل انتشار التهاب الزائدة الدودية الحاد ٤٦ % فقط ، في حين كانت حساسية التشخيص بالسونار ٨٥ %، والنوعية لهذا الفحص ٥٣ %، كانت القيمة التنبؤية الموجبة للفحص بالسونار ٦٠ %، والقيمة التنبؤية السالبة للفحص ٨١ % .أوضحت هذه الدراسة ان قطر الزائدة الدودية (أكبر من ٦ مل هي الأكثر في نتائج الفحص بالسونار ٩٥ % قياساً بانعدام قابلية الزائدة الدودية على الضغط ٨١ %، في حين كان تجمع السوائل داخل الزائدة هو الأقل في معايير التشخيص الثلاثة ونسبة ٢٨ % فقط .

أستنتاج:

نستنتج من هذه الدراسة ان الفحص بالسونار يساعد على تشخيص التهاب الزائدة الدودية الحاد وبحساسه عاليه ٨٥%،وقدره تنبويه موجب ٦٠% في حين انخفضت نوعية هذا الفحص وارتفعت قيمته التنبويه السالبه.

INTRODUCTION :

Appendicitis is the most common cause of acute abdominal pain that necessitates surgical intervention in the Western world (1). Clinical diagnosis of acute appendicitis is based primarily on symptoms and physical findings. However, this diagnosis is often difficult, and up to 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 (2–5). To reduce the frequency of unnecessary appendectomy, the importance of laboratory findings that include both white blood cell (WBC) counts and C-reactive protein (CRP) values has been stressed (6–8), and the use of ultrasonography (US) as a diagnostic tool for appendicitis has been widely evaluated (9–13). Reported Ultrasound signs of appendicitis can be grouped into the two categories of (a) appendiceal findings and (b) periappendiceal findings, which mainly include inflammatory changes in the right lower abdominal quadrant. Many Ultrasound signs are present in most suspected cases of appendicitis (6–14). Some of these signs, however, are also present in alternative conditions that can clinically mimic appendicitis. To our knowledge, the frequencies of laboratory and US findings in both appendicitis and alternative conditions have not been compared. The purpose of this investigation was to evaluate the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the individual Ultrasound findings in the diagnosis of appendicitis.

Aim of study

To assess the value of sonography in detecting the normal and abnormal appendix

PATIENTS AND METHODS

From September 2007 to June 2008, 125 consecutive patients suspected at clinical evaluation of having appendicitis underwent cross sectional evaluations, which included Ultrasound of the right side of the abdomen. All patients were selected by the senior surgeon in the emergency department of Hilla teaching hospital, appendicitis was diagnosed in the first three of the differential diagnoses. Ultrasound are part of the routine assessment in patients with right-side abdominal pain at our institution at our hospital in addition to laboratory investigation . through communication with a group of the managing surgeon and physician, the follow up, diagnosis and fate of these cases were obtained.

US Technique

In each patient, the abdomen was initially examined at Ultrasound (Elegra; Siemens, Germany) by using a broadband 4–7-MHz convex-array transducer. This evaluation was supplemented with Ultrasound assessment of the appendix and the surrounding region by using a broadband 5–10-MHz linear-array transducer and the graded-compression technique Our cross sectional study Ultrasound assessment of the appendix and of inflammatory changes in the right lower abdominal quadrant was based on a set of seven criteria derived from reports in the

literature (9,15,16): enlarged appendix, fluid in the appendiceal lumen, 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 (17). Cecal wall thickness from outer wall to luminal surface was measured on transverse sections under compression (18), and thickening was defined as when the cecal wall measured 5 mm or larger.

Statistical Analysis

The sensitivity, specificity, ,positive predictive value (PPV), and negative predictive value (NPV) of each US, , . In addition, we attempted to identify combinations of biologic findings and combinations of Ultrasound findings that provided the best NPV or PPV. The Chi square test was used to test hypothesis were considered to be statistically significant when *P* values were less than 0.05

RESULTS

This study included 125 patients clinically suspected of having appendicitis Their age range 6 –63 years (mean age, 29.5 years) .They consisted of 67female and 58 male

patients ,their mean age are 29.5 years and 30.4 years respectively .The 57 patients of 125 suspected appendicitis case have been proved by histopathology to have acute appendicitis (prevalence, 46%). In all 125 patients the diagnosis was confirmed with surgery and histological evaluation which included 57 patients have acute appendicitis and 68 patients have normal appendix . In the appendicitis group, the surgical and histologic findings showed perforation of the appendix in 8 patients. The appendix was identified at Ultrasound assessment in 49 of 57patients with appendicitis (table 1)has true positive 49 patient and false negative 8 patient, as result ultrasound has sensitivity 85 % in diagnosis acute appendicitis .

Whereas it was identified in 36 of 68 patients without appendicitis (table 2)(fig 2) and in remaining 32 of 68 patients ultrasound diagnosis as acute appendicitis while by histopathological study proved normal appendix .as result ultrasound has specificity 53% ,and positive predictive value 60 %,negative predictive value 81 % ..

The patients in whom the appendix was visualized constituted a group in which appendiceal Ultrasound findings could be tested. Table 3 shows the frequency with which each appendiceal finding was interpreted as positive or negative,. The two most accurate appendiceal findings for appendicitis were a diameter of 6 mm or larger and a lack of compressibility. In the patient with appendicitis and an outer appendiceal diameter less than 6 mm, surgical and pathologic examination revealed distal appendicitis, but, although the distal appendix was dilated in comparison with the proximal one, both the proximal and distal appendix measured less than 6 mm at

Ultrasound (Fig 3). Fluid in the appendiceal lumen (Fig 4) also specific findings for appendicitis, with found in 28% of real confirmed appendicitis however, these findings were not sensitive since they were encountered in only half of the patients with appendicitis.

The periappendiceal Ultrasound findings were tested in the entire group, Fat changes in the right lower abdominal quadrant were present in 91% of the appendicitis group but also in 24% of the nonappendicitis group, which included 8 patients with ileocolitis , 10 patients with mesenteric adenitis, was detected at Ultrasound in only 25% of patients with appendicitis and in more than 10% of patients without appendicitis. Peritoneal fluid was noted in 51% of patients with appendicitis but also in almost 30% of patients without appendicitis. Right lower abdominal quadrant adenopathy was present in 32% of patients with appendicitis and in 38% of patients without appendicitis. Combining the nonappendiceal findings with appendiceal findings did not increase the NPV or PPV of individual appendiceal findings, such as an appendix 6 mm or larger in diameter or noncompressibility of the appendix

DISCUSSION

The inability to visualize the normal appendix is classically considered a major weakness of using Ultrasound (US) in the assessment of patients suspected of having appendicitis, because it represents a serious limitation to confidently excluding the diagnosis of appendicitis (5). In their state-of-the-art article, Birnbaum and Wilson (9) claimed that in their experience and in that of others (11,15), a normal appendix is visualized in only 0%–4% of cases in

the adult population, regardless of the US technique used, and they stated that the results of Rioux (12), who visualized a normal appendix in 82% of patients without acute appendicitis, were "amazing."

In contrast with this classic viewpoint, it was visualized a normal appendix in 53% of the patients without appendicitis, which is a rate close to the 64% appendix visualization rate obtained by Rettenbacher et al (19) in a population of healthy subjects. The notion that the normal appendix is seldom visualized at Ultrasound is based on reports published more than 10 years ago (10,14) or on data obtained by sonographers who are not radiologists with experience in Ultrasound assessment of the gastrointestinal tract (20).

In this study the sensitivity is high this finding goes with finding of Puylaert (11) while the specificity is low which consisted with Puylaert (11) finding who found high specificity .

Technologic advances combined with in-depth radiologic experience have dramatically improved the use of Ultrasound in the visualization of a normal appendix. The same improvement has been reported with use of computed tomography (CT); the normal appendix was visualized in more than 95% of cases published in 1997 (21), which is in contrast with the visualization in 51% of cases reported in 1991 (22).

It was found that identification of an appendix measuring less than 6 mm in diameter was a very accurate indication to exclude appendicitis, . Concerning the nonvisualization of the appendix, was obtained a NPV 81% for appendicitis ; the same results were reported in the studies with a high normal appendix visualization rate

(12). As a result, nonvisualization of the appendix can only be valid as an accurate finding to exclude appendicitis for sonographers who can usually identify a normal appendix.

Ultrasound evaluation of the appendix ideally includes evaluation of the appendiceal wall and appendiceal content. It was decided to measure the outer appendiceal diameter rather than appendiceal wall thickness for two reasons. First, as shown by Rioux (12), inflammation of the appendiceal wall may be indistinguishable from hypoechoic intraluminal pus, thus making measurement of the appendiceal wall inaccurate.

Second, the mucosal surface may be difficult to identify within the appendix. The threshold diameter of 6 mm, which is the most commonly reported threshold, in this study 95% of confirmed acute appendicitis cases show more than 6 mm in diameter sensitivity . The high sensitivity is out of line with the data obtained by Rettenbacher et al (19), who reported an appendiceal diameter of 6 mm or larger in 32% of symptomatic patients without appendicitis in whom the appendix was identified. Rioux (12) obtained intermediate results with an appendiceal diameter of more than 6 mm in 6% of patients without appendicitis. It was assume that this discrepancy is due to differences in measurement of appendiceal diameter. thus performed measurements under maximal compression to standardize the measurement because the relevant anteroposterior diameter of a compressible appendix may vary according to the graded compression applied to the abdominal wall, and it was hypothesize that was may have compressed some loose feces or air out of the normal patent lumen.

The evaluation of the content of the appendiceal lumen focused on

the presence of intraluminal fluid as a sign of appendicitis, whereas Rettenbacher et al (24) considered the absence of gas in the appendiceal lumen as a criterion for appendicitis. The same mechanism might explain both the presence of fluid and the absence of gas in an inflamed appendix. Obstruction, which is the most common cause of appendicitis, could lead to retention of pus or appendiceal secretion with resorption of intraluminal gas (24). It was did not evaluate the presence or absence of gas in the appendix because we considered that the Ultrasound appearance of a tiny appendicolith or a small amount of feces could resemble gas. The clinical importance of appendiceal air is under debate (25), but was believe that its evaluation is easier at CT(computed tomography) than at Ultrasound. By contrast, appendiceal fluid, which is a finding that has never been evaluated to our knowledge, is easier to identify, and its presence could be a useful ancillary sign.

Among right lower abdominal quadrant changes, inflamed fat has been concluded to be 100% sensitive but not a specific sign of appendicitis at CT (21). It is well known that inflamed fat in the right lower quadrant may be present in a broad spectrum of alternative diagnoses to appendicitis (26), and it was found inflamed fat in 24% of the patients without appendicitis. It was did not detect inflamed fat in every patient with appendicitis, which is contrary to known data from CT studies. However, it was hypothesize that some subtle inflammatory changes may have been missed in our Ultrasound assessment, especially because was did not prospectively analyze the noncompressibility of the fat, which could be an interesting finding for diagnosing inflamed fat.

Right lower abdominal quadrant adenopathy is a common reaction to ileal, cecal, or appendiceal inflammatory disease that is encountered in both patients with appendicitis and those without it. We agree with previous conclusions (17,21,27) that the only definitive way to differentiate an appendicitis adenopathy from mesenteric adenitis is to identify either an enlarged inflamed appendix or a normal appendix. Cecal wall changes have been extensively analyzed by using CT, which enables identification of focal cecal apical thickening and arrowhead and cecal bar signs suggestive of appendicitis, whereas circumferential diffuse wall thickening is present in colitis (28,29). However, such evaluations require adequate cecal distention as is obtained by using the CT technique described by Rao et al (21). Therefore, was limited our evaluation with Ultrasound to the identification of cecal wall thickening but did not obtain sufficient predictive values to

differentiate appendicitis from nonappendicitis.

A limitations of this study must be considered. The study design was based on a cross sectional evaluation of several Ultrasound and biologic criteria. It was aware that some additional criteria not included in our protocol may have been interesting to evaluate, especially the thickness of the appendiceal wall, the presence of air in the appendiceal lumen, and the noncompressibility of the periappendiceal fat. .

In conclusion, ultrasound examination is helpful to diagnosis a real acute appendicitis when it is positive in a high proportion ,an appendix with a threshold anterior to posterior diameter of 6 mm under compression is the most indicative US finding for appendicitis, with high sensitivity . When the appendix is identified, the evaluation of periappendiceal findings does not improve the usefulness of Ultrasound .

Table 1: Validity ,positive and negative predictive value for diagnosis acute appendicitis by sonography study.

	Appndicitis	Normal appendix	Total
ultrasound positive	TP 49	FP 32	81
Ultrasound Negative	FN 8	TN 36	44
Total	57	68	125

Sensitivity : $TP/TP+FN = 49/49+8 \times 100 = 85\%$

Specificity : $TN/TN+FP = 36/36+32 \times 100 = 53\%$

Positive predictive value $TP/FA+TP = 49/49+32 \times 100 = 60\%$

Negative predictive value : $TN/TN+FN = 36/36+8 \times 100 = 81\%$

False negative rate : $FN/TOTAL \text{ APPENDICITIS} = 8/57 \times 100 = 15\%$

False positive rate : $FP/TOTAL \text{ NORMAL APPENDIX} = 32/68 \times 100 = 47\%$

- TP:true positive
- TN:true negative
- FP:false positive
- FN:false negative

Table 2: symptomatology of 68 patients proved by histopathological to have normal appendix

Final diagnosis	no.of patient N0.68%
Non specific abdominal pain	22 (33 %)
Gynecological disease	20 (30 %)
Mesenteric adenitis	10 (16 %)
Ileitis and iliocolitis	8 (12 %)
Gastroenteritis	5 (0.073 %)
Pain colic	2 (0.029 %)
Cystitis	1 (0.014 %)

Table 3. Appendiceal Ultrasound Signs for the Diagnosis of 49 patients proved by histopathology to have Appendicitis .

Finding and Value	diameter > 6 mm	lack of compressibility	intraluminal fluid
Finding at US			
Positive	47 (95%)	40(81%)	14(28%)
Negative	2 (5%)	9 (19%)	35(72%)
Total	49	49	49



Figure 1a. (a) Transverse and (b) longitudinal US images obtained in a 27-year-old man with appendicitis (arrows). The appendix has an anteroposterior diameter of 8 mm.

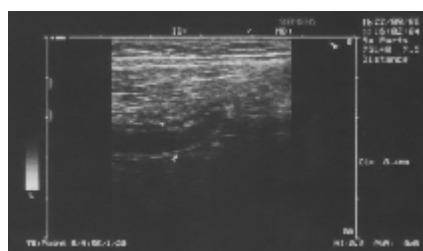


Figure 1b. (a) Transverse and (b) longitudinal US images obtained in a 27-year-old man with appendicitis (arrows). The appendix has an anteroposterior diameter of 8 mm

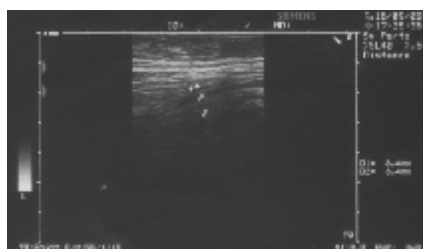
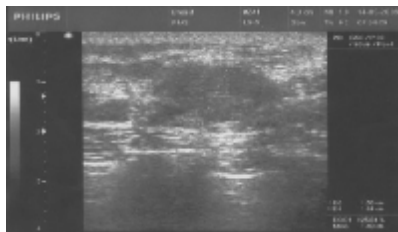
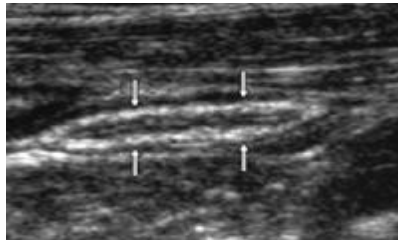
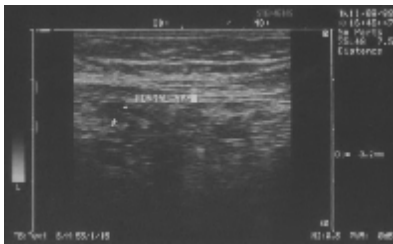


Figure 2a. (a-c) Longitudinal US images show a normal appendix (arrows) in three different patients.



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