

Original Article

Evaluation of Ultrasonography in the Diagnosis of Suspected Acute Appendicitis

Mohamed Nabil YM Riyad¹, George K Ouzounov²,
Ibrahim K Wafaie¹, Majed A Gamal¹, Vinod K Grover¹
Departments of ¹Surgery and ²Radiology, Al-Jahra Hospital, Kuwait

Kuwait Medical Journal 2001, 33 (2): 148-152

ABSTRACT

Objective: To assess the efficacy of ultrasound (US) as a diagnostic modality to establish the indications for surgery in patients suspected for acute appendicitis with equivocal clinical pictures.

Design: Prospective randomized study.

Setting: Departments of Surgery and Radiology, Al-Jahra Hospital, Al-Jahra, Kuwait.

Subjects: A total of 148 patients suspected to have acute appendicitis admitted with equivocal clinical findings in the period from October 1997 to November 1999.

Methods: Abdominal US using the graded compression technique. A positive US was defined as a tender non-compressible appendix with an outer wall to outer wall diameter of >6mm. The sonographic data

were correlated with clinical, operative and pathological findings.

Results: Graded compression US results were analyzed and showed 97.4% specificity, 88.2% sensitivity, 95.3% accuracy, 90.9% positive predictive value, and 96.5% negative predictive value. The results are discussed and compared to previous reports.

Conclusion: US was found to be a useful tool in the diagnosis of suspected cases of acute appendicitis with equivocal clinical findings. US helped to minimize negative laparotomies and avoid unnecessary appendectomies. US is, however, an operator-dependent investigative tool.

KEYWORDS: acute abdominal pain, acute appendicitis, ultrasound

INTRODUCTION

Acute appendicitis is one of the most common abdominal emergencies requiring surgery^[1,2]. The accuracy of acute appendicitis diagnosis has been reported to be between 71% and 85%^[1-5]. Preoperative diagnosis of acute appendicitis remains challenging despite improvements in history taking and clinical examination, new computer-aided decision support systems, clinical diagnostic scoring and new imaging techniques, such as ultrasonography (US) and computed tomography^[6-12]. In recent years, US has been widely performed during the examination of patients with clinically suspected acute appendicitis because of its safety and high diagnostic accuracy^[10-16]. Abdominal US was first performed in 1981^[3] to demonstrate an inflamed appendix. Since then, many studies have found promising value in abdominal US for the diagnosis of acute appendicitis^[4,5,7]. These studies show a sensitivity of 75% to 98% and accuracy of 76% to 96%^[4-7,10-20].

Clinicians remain aware that a normal sonographic examination does not completely rule out appendicitis and they still face the same dilemma in about 50% of their patients, regardless

the sonographer's conclusion^[5]. US examination for the diagnosis of acute appendicitis is, however, operator-dependent and has many potential pitfalls to overcome^[4,5].

The aim of this study was to assess the efficacy of graded compression US of the appendix in order to establish the indication for surgery in patients suspected for acute appendicitis with equivocal clinical picture.

PATIENTS AND METHODS

A total of 148 patients suspected to have acute appendicitis admitted to the Department of Surgery, Al-Jahra Hospital, with equivocal clinical findings from October 1997 to November 1999 were prospectively enrolled in this study. Al-Jahra Hospital is a central hospital of the Ministry of Health of Kuwait and serves the approximately 300,000 residence of the Al-Jahra area. It is the only hospital in this area with 24-hour full capacity emergency service.

The attending physician examined all patients upon presentation to the emergency room. The patient's clinical picture together with their leucocyte count, urine analysis and plain

Address correspondence to:

Dr. M Nabil Y. M. Riyad, Registrar of Surgery, Al-Jahra Hospital, Al-Jahra, Kuwait. Tel: (965) 458-1703; fax: (965) 458-2048
e-mail: Shahed1@USA.Net

radiographs of the abdomen were assessed. Patients with right lower quadrant pain and the indication "rule out appendicitis" were seen by the senior surgical registrar and the attending physician in the emergency room.

If a diagnosis of acute appendicitis was made on clinical grounds, the patient was operated immediately (587 patients were operated during the same period of our study without having a sonographic examination for the appendix). If the diagnosis was equivocal, the patient had an ultrasonogram of the appendix as soon as possible. The decision on whether to operate was made after taking into consideration the history, repeated clinical examination and all test results.

Clinical details included initial location of pain, duration of symptoms, fever (temperature > 38 °C) nausea or vomiting, diarrhea (liquid feces more than three times a day), right lower quadrant guarding (presence of voluntary or involuntary contracture of the abdominal muscles), signs of peritoneal irritability (rebound tenderness, Rovsing's and psoas's sign), increased peristalsis, leucocytosis (more than $10.5 \times 10^9/l$) and left shift (presence of more than 75% neutrophils). Signs suggestive of appendicitis on plain abdominal radiography were the presence of fecoliths, disappearance of the psoas line, focal ileus or increased density in the right lower quadrant.

The ultrasonographic examination was done using high graded-compression ultrasonography with 5 MHz variable focus linear array transducer. An abnormal dilated tender, non-compressible appendix > 6 mm in diameter was considered a positive test for acute appendicitis.

Other sonographic signs for acute appendicitis included edema and asymmetry of the appendicular wall. US was considered negative when the appendix could not be found, it was normal, or if non-appendicular pathology was discovered.

During examination, the caecum and the terminal ileum can be adequately compressed with the transducer to evaluate the peri-appendiceal and retrocaecal region. The psoas muscle and iliac vessels should be identified. The normal appendix may be identified in a high percentage of cases. Sonographic features of a normal appendix include the following:

1. Maximum outer diameter of 6mm
2. Maximum thickness of the wall of the appendix of 2mm
3. Demonstration that the appendix originates from the base of the caecum
4. Demonstration of the inner echogenic submucosal ring and the outer hypoechoic ring (Fig.1)

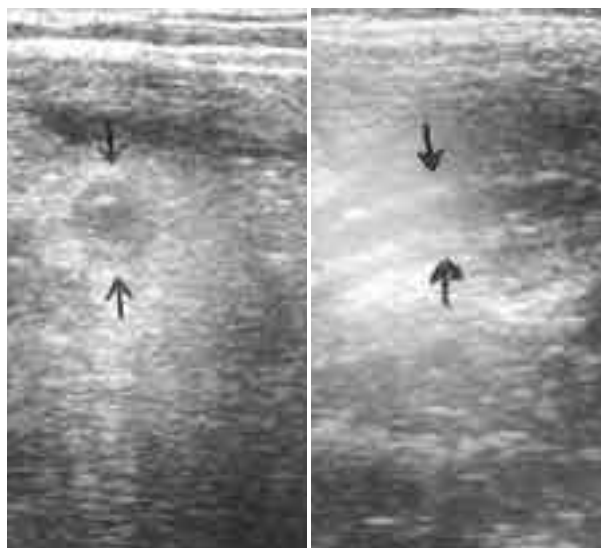


Fig. 1: Transverse and longitudinal planes in a patient with acute appendicitis. The diameter of the appendix was 8.8 mm showing inner echogenic ring and outer hypoechoic ring i.e. the typical three-ringed (target pattern). This was a true positive case.

Table 1

Results of graded compression US examination in 148 patients

Diagnosis	No. of Patients	Remarks
True positive	30	Confirmed by pathological examination
True negative	111	Three had surgery with normal appendices
False negative	4	Surgery done with acute appendicitis confirmed by pathological exam
False positive	3	Two patients had surgery and proved to have acute appendicitis by pathological exam One improved without surgery (may be acute catarrhal appendicitis)

N.B: - 39 patients had surgery; 18 of them were done laparoscopically.
- 5 of the appendices were histologically normal.
- 34 showed acutely inflamed appendix.

Table 2

Overall results of graded compression US

Overall Results	Percentage
Sensitivity	88.2
Specificity	97.4
Accuracy	95.3
Positive predictive value	90.9
Negative predictive value	96.5

5. No peristalsis observation in this tubular structure
 6. Termination of this tubular structure in a blind pouch
- The measurement between 5 and 7mm is

Table 3

Diagnoses of patients who tested true negative on diagnostic US for acute appendicitis.

Diagnoses	No. of patients
Urinary tract disease	38
Gynecological causes	30
- pelvic inflammatory (13)	
- pregnancy related (9)	
(Broad ligament stretch)	
- Mittelschmerz (7)	
- ovarian cyst rupture (1)	
Large bowel disease	15
- Constipation (10)	
- irritable bowel disease (5)	
Mesenteric lymph adenitis	10
Unknown etiology	18
Total	111

N.B.: These patients were followed up in the out-patient department, fully investigated as their conditions warranted and treated accordingly

Table 4

Value of compression US in the diagnosis of acute appendicitis

Author	No. of patients	Specificity %	Sensitivity %	Accuracy
Present study	148	97.4	88.2	95.3
Puylaert ⁴	60	100	89	*
Jeffrey et al ¹¹	250	96.2	89.9	93.9
Zeidan et al ⁶	94	93.7	74.2	87.2
Rubin ^{**} et al ¹⁴	134	92	89	*
Fa et al ¹⁵	84	90.6	66.7	86.8
Abu- Yousef et al ¹²	68	95	80	90
Adams et al ¹³	44	86	89	87
Overall (Average)	882	93.86	83.25	90.03

* Not reported by the author

** Limited to childhood

inconclusive and warrants close clinical scrutiny. Patients with normal screening were discharged from the hospital and were re-evaluated two weeks and one month later in the surgical outpatient department.

The diagnosis of appendicitis was confirmed by pathologic reports. Pathologic findings were divided into acute cattarrhal appendicitis, acute suppurative appendicitis, acute gangrenous appendicitis, perforated appendicitis or normal appendix. Those with other diseases were treated as their condition warranted.

RESULTS

From October 1997 to November 1999, 148 patients fulfilled the study criteria. There were 59 males and 89 females whose ages ranged from 5 to 55 years (mean age: 23.7 years). Diagnostic results of graded compression US are shown in Tables 1 and 2. There were 115 patients with negative US. Of these, four were falsely negative (false negative rate

= 3.5%). All four patients had surgery because of persistent localized pain and tenderness and acute appendicitis was confirmed on pathological examination. The clinical diagnoses for the 111 patients who tested true negative on diagnostic US is shown in Table 3. The 108 patients improved and were discharged for follow up after 2 weeks and one month in the outpatient department. The other three patients continued to have persistent right lower quadrant pain and localized tenderness. They were subsequently taken to surgery where pathology showed normal appendix. One had mesenteric adenitis and two had unknown etiologies.

There were 33 patients who had positive US studies and subsequently had surgery. Of these, 30 patients had pathological confirmation of acute appendicitis and three were falsely positive. Of the latter, one improved without surgery (possibly an acute cattarrhal appendicitis) and the other two had a normal appendix on pathological examination. One of these had a ruptured ovarian cyst. In these patients, the appendix was 6 mm and tender and was diagnosed as borderline. Appendicitis and surgery was done because of the persistent pain and localized tenderness in the right iliac fossa in addition to the borderline results of US (false positive rate 9.1%). Of the 39 patients who had appendectomies, 18 were performed laparoscopically. Five were histologically normal and the remaining showed acutely inflamed appendix.

During the same period, 587 patients underwent appendectomy depending on the clinical findings without doing US for the appendix. Of these, 107 patients had pathologically normal appendices accounting for 18.23% negative exploration.

DISCUSSION

Acute appendicitis is one the most common and challenging diagnosis in surgical practice^[1,2]. It's well known that the most important discriminative and diagnostic tools for acute appendicitis are detailed history taking and physical examination performed by an experienced physician. Even so, the clinical diagnosis of acute appendicitis is variable, (approximately 70% to 80% accurate, with negative appendectomy rates of 20% to 30%)^[4-7,15,16,22,23]. Strategies to decrease both the negative appendectomy rate and the morbidity and mortality of appendicitis are warranted^[22]. There are many modalities to aid the diagnosis of acute appendicitis such as leukocyte count, C-reactive protein assay, plain abdominal film and scoring system^[2,4,21-23]. These examinations are non-specific and cannot be used as the definitive diagnostic test^[4,11,16]. Computed tomography and barium

enema have been used to diagnose appendicitis. The former is time consuming, complicated, expensive, not always available and entails the use of I.V. contrast material^[8,9]. The latter has limitations of unprepared bowel, causes patient discomfort and was found unreliable because of its high false positive and false negative results^[9]. Laparoscopy is invasive and has limited use in patients who have had surgery or patients with retrocoecal appendicitis^[7]. Graded compression US is a rapid, safe, non-invasive, inexpensive and easily accessible examination^[3-5,11-16]. US can also be safely used in pregnant patients and children^[14,15]. It has been reported that the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of US for the diagnosis of appendicitis are superior to that of the surgeon's clinical impression^[23]. Obesity and overlying loops of gas-filled bowel may give sonography a lower sensitivity in some cases^[5]. US was first performed by Deutsch in 1981 to demonstrate the inflamed appendix^[3] and in 1986, Puylaert described the graded compression US technique for the diagnosis of acute appendicitis^[4]. Several studies have proven its efficiency^[12-16,20-23]. Puylaert recommended using routine US in patients presenting with right lower quadrant pain in order to rule out diseases mimicking acute appendicitis, such as Crohn's disease, bacterial enteritis cholecystitis, perforated duodenal ulcer and gynecological disorders^[4]. Wells recommended using US only in equivocal cases^[17]. Nickel expressed doubt in its accuracy and advised against using this modality on a large scale^[18]. A meta-analysis including 17 previous studies (3358 patients) showed a 84.7% sensitivity and a 92.1% specificity^[16] for US. Takada reported the ability of US to differentiate between cases with catterhal appendicitis from phlegmonous and gangrenous^[19]. Abu-Yousef was able to visualize a normal appendix with a hypoechoic wall of 2 mm thick in two out of 68 patients^[12]. Jeffrey et al confirmed that a normal appendix can be visualized and recommended observation for patients with a visualized appendix of 6mm or less in diameter^[11]. The most frequent sonographic findings in acute appendicitis are the non-compressibility of the appendix with a wall diameter greater than 6 mm with persistent right lower quadrant pain^[5](Table 4).

Our data confirm the value of US in the diagnosis of acute appendicitis and has produced comparable results to the current literature. Of the 39 appendectomies performed, five had a pathologically normal appendices (2.8%). In the group of 587 patients who did not have US for the appendix, 107 patients had normal appendices (18.23%). This is similar to previous publication documenting a 15-25% error in diagnosis rate^[4,10].

However, in pregnant women and children, the error rate is reported to be much higher (35-45%)^[6]. This series of 148 patients included 18 children under the age of 12 years, nine pregnant women and 21 women with gynecological problems. Therefore, a higher error rate may well have been expected if US had not been utilized. In the study of 206 patients reported by Larson et al., the value of diagnostic US was most evident in the group of patients in whom the diagnosis of appendicitis was in question. In this group, they noted a specificity of 94%^[20]. Our false negative rate of 3.5% compared favorably with other authors who reported a false negative result of high resolution US in diagnosing acute appendicitis from 3-25%^[4,11-16].

The sensitivity reported of US is less than the specificity because of the number of false negatives, some of which cannot be controlled (poor tolerance by the patient, obesity, presence of gas and unusual location of the appendix). These difficulties can be reduced by employing high-resolution real-time imaging and by the graded compression technique^[12].

More experience in using US to diagnose acute appendicitis should improve the false positive results. If surgeons are trained to perform sonography, the accuracy of perceptive diagnosis of appendicitis may improve. In our study, all sonograms were performed by an experienced consultant radiologist with good communication and cooperation with the surgeons with whom they discussed the cases. Patients with normal screening were followed up in the outpatient department at two weeks and one month. We agree with Zeidan^[6] and Pearson^[10] that US with graded compression has its limitation in diagnosing acute appendicitis, but it is as good or better than other methods and avoids radiation. It provides a relatively accurate and specific test for acute appendicitis but has variable sensitivity.

CONCLUSION

Graded compression US is a good modality in diagnosing patients suspected to have acute appendicitis with equivocal clinical findings. The reliability and non-invasive nature of US argue that it should be taken into account in the computer-aided decision support systems to be designed in the future.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. Ali Nur, Chairman of Surgery Dept and Dr. Sameer Humad, Chairman of Radiology Dept. Dr. Alaa El-Faragy, Mrs. Evelyn Fortich; Quality Assurance & Infection Control Office, Al-Jahra Hospital, Kuwait, for their assistance in the preparation of this manuscript.

REFERENCES

1. Hawthorn IE. Abdominal pain as a cause of acute admission to hospital. *J R Coll Surg Edinb* 1992; 37:389-339.
2. Doherty GM, Lewis FR Jr. Appendicitis: continuing diagnostic challenge. *Emerg Med Clin North Am* 1989; 7:537-553.
3. Deutch A, Leopold RG. Ultrasonic demonstration of the inflamed appendix. *Radiology* 1981; 140:163.
4. Puylaert JBCM. Acute appendicitis: US evaluation using graded compression. *Radiology* 1986; 158:355-360.
5. Rioux M. Sonographic detection of the normal and abnormal appendix. *AJR* 1992; 158:773-778.
6. Zeidan BS, Wasser T, Nicholas GG. Ultrasonography in the diagnosis of acute appendicitis. *J R Coll Surg Edinb* 1997; 42:24-26.
7. Gallego MG, Fadrique B, Nieto MA, Calleja S. Evaluation of ultrasonography and clinical diagnostic scoring in suspected appendicitis. *Br J Surg* 1998; 85:37-40.
8. Malone AJ Jr, Wolf CR, Malmed AS, Melliore BF. Diagnosis of acute appendicitis: value of unenhanced CT. *Am J Roentgenol* 1993; 160:763-766.
9. Rajagopalan AE, Manson JH, Kennedy M, Pawlikowski J. The value of the barium enema in the diagnosis of acute appendicitis. *Arch Surg* 1977; 112:531-533.
10. Pearson RH. Ultrasonography for diagnosing appendicitis. *Br Med J* 1988; 297:309-310.
11. Jeffrey RB Jr, Laing FC, Townsend RR. Acute appendicitis: sonographic criteria based on 250 cases. *Radiology* 1988; 167:327-329.
12. Abu-Yousef RB, Bleicher JJ, Maher TW, Urdaneta LF, Franken EAJr, Metcalf AM. High-resolution sonography of acute appendicitis. *Am J Roentgenol* 1987; 149:53-58.
13. Adams DH, Fine C, Brooks PC. High-resolution real-time ultrasonography: A new tool in the diagnosis of acute appendicitis. *Am J Surg* 1988; 155:93-97.
14. Rubin SZ, Martin SJ. Ultrasonography in the management of possible appendicitis in childhood. *J Pediatr Surg* 1990; 25:737-740.
15. Fa EM, Cronan JJ. Compression ultrasonography as an aid in the differential diagnosis of appendicitis. *Surg Gynecol Obstet* 1989; 169:290-298.
16. Orr Rk, Porter D, Hartman D. Ultrasonography to evaluate adults for appendicitis; decision making based on meta-analysis and probabilistic reasoning. *Acad Emerg Med* 1995; 2:644-650.
17. Wells PN. The prudent use of diagnostic ultrasound. British Institute of Radiology presidential address 1986. *Br J Radiol* 1986; 59:1143-1151.
18. Niekel RA, Lampmann LE. Graded compression sonography in acute appendicitis. *Fortschritte Auf Dem Gebiete Der Rontgenstrahlem Und Der Nuklearmedizin* 1986; 145:441-445.
19. Takada T, Yasuda H, Uchiyama K, Hasegawa H, Shikatata J. Ultrasonographic diagnosis of acute appendicitis in surgical indication. *Int Surg* 1986; 71:9-13.
20. Larson JM, Pierce JC, Ellinger DM, Parish GH, Hammond DC, Ferguson CF, Verde FJ, Vander Kolk HL. The validity and utility of sonography in the diagnosis of appendicitis in the community setting. *Am J Roentgenol* 1989; 153:687-691.
21. Zielke A, Hasse C, Sitter H, Rothmund M. Influence of ultrasound on clinical decision making in acute appendicitis: A prospective study. *Eur J Surg* 1998; 164:201-209.
22. Chen SC, Chen KM, Wang SM, Chang KJ. Abdominal sonography screening of clinically diagnosed or suspected appendicitis before surgery. *World J Surg* 1998; 22:419-425.
23. Pohl D, Golub R, Schwartz GE, Stein HD. Appendiceal ultrasonography performed by non radiologist: Does it help in the diagnostic process? *J Ultrasound Med* 1998; 17:217-221.