

The Diagnostic Role of US in Patients with Right Lower Quadrant Abdominal Pain¹

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Purpose: To determine the frequency with which ultrasonography (US) provides a correct diagnosis and suggests appropriate guidance for the treatment of patients with right lower quadrant abdominal pain.

Materials and Methods: During an 11-month period, US was consecutively performed in 84 patients who were presented with right lower quadrant abdominal pain. In the 76 [M ; F = 16 ; 60, age range 14 - 87 (mean, 41) years] who formed the study population, final diagnoses were made surgically or clinically. For US, a 5 - 7-MHz convex-array, 4-MHz vector-array, and/or 7-MHz linear-array transducer was used, according to the patient's body habitus. To determine how often our US reports had provided a correct diagnosis and suggested appropriate guidance for surgical or medical treatment, and to calculate their diagnostic value, the reports were retrospectively compared with final diagnoses.

Results: US diagnoses were acute appendicitis in 40 patients (53%), diseases other than this in 25 patients (33%), and no abnormality in 11 (14%). In 38 of the 40 patients (95%), the diagnosis of acute appendicitis was surgically confirmed as correct, and for other diseases, diagnoses based on the findings of US proved to be correct in 21 of 25 patients (84%). Overall, diagnosis was correct in 67 (88%). As regards appropriate guidance for treatment, 46 (61%) and 30 (39%) patients were diagnosed by US to have surgical and medical diseases, respectively. In 44 of the 46 (96%), it was confirmed guidance was appropriate, and for the 30 with medical disease, this was so in all but one case (97%). Overall, the treatment plan was appropriate in 72 patients (95%).

Conclusion: Our study revealed that US was able to provide a correct diagnosis in 88% of patients with right lower quadrant abdominal pain, and in 95% of these, the treatment plan suggested was appropriate. US is, therefore, a valuable screening tool in the diagnosis and therapeutic guidance of such patients.

Index words : Abdomen, US
Appendix, US
Ultrasound (US), utilization

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Received December 28, 1999; Accepted September 19, 2000

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It is widely accepted that ultrasonography (US) has played an essential role in the initial investigation of patients presenting with acute abdominal pain. Significant improvement in the image quality of state-of-the-art US has helped clarify the normal and pathologic features of gastrointestinal tract (1), and over the past ten years, the modality has thus gained acceptance for the examination of patients with abdominal pain, even in the right lower quadrant (2). Previous studies have reported that US is very useful for the diagnosis of acute appendicitis with a sensitivity of 80 - 89% (3 - 7), even in evaluating clinically equivocal cases (8). In addition, some studies have claimed that US is useful for establishing alternative diagnoses in patients with suspected acute appendicitis, and has an accuracy of 70% (8). In patients with right lower quadrant abdominal pain, US is, therefore, thought to be a good screening tool for differentiating acute appendicitis from other diseases that occur in this region.

Needless to say, the US findings in cases involving intestinal and genitourinary diseases occurring in the right lower quadrant of the abdomen have been extensively described in a large number of US publications (1 - 14). Few studies, however, have investigated the frequency with which US can provide useful guidance in the diagnosis and management of patients presenting with right lower quadrant abdominal pain. The purpose of this study was to determine how often US is able to provide correct diagnosis and proper guidance for the treatment of such patients.

Materials and Methods

During an 11-month period (September 1998 to July 1999), transabdominal US was consecutively performed in 84 patients referred to our US department due to abdominal pain localized or predominant in the right lower quadrant. Eight were excluded from our study after being discharged without definite diagnosis or further follow-up, and the study population thus consisted 76 patients [60 women and 16 men aged 14 - 87 (mean, 41) years].

For US, a 5 - 7-MHz convex-array, 4-MHz vector-array, and/or 7-MHz linear-array transducer (model 128XP/10; Acuson, Mountain View, U.S.A.) was used, according to the patient's body habitus. Patients were asked to point out the site of maximal tenderness, and US was performed initially at this site, and then around it. The graded compression technique was used, as de-

scribed previously (4), especially for the detection of an inflamed appendix. Patients with no US evidence of appendicitis underwent routine US examination of the upper abdomen and pelvis.

All US examinations were performed within 12 hours of a patient's arrival at our hospital, either by an experienced abdominal radiologist or by senior residents under his or her supervision. In order to support the US diagnosis and differentiation of surgical and medical diseases, all personnel involved were informed of all clinical data prior to the examination, and in every case, a formal report of US diagnosis was delivered to the clinician. Here, 'surgical' disease was defined as one in which surgical intervention was required, while 'medical' disease was as one for which medical treatment was sufficient.

All medical records of the 76 patients were reviewed. Forty-five underwent surgery (appendectomy, $n = 40$; other operations, $n = 5$), and their pathologic diagnoses were reviewed. For the remaining 31 patients, final diagnoses were substantiated by a combination of clinical findings, laboratory results, and radiologic follow-up. To determine how often our US reports had suggested correct diagnosis and appropriate guidance for treatment (surgical vs. medical), and to calculate their diagnostic values, the reports were retrospectively compared with final diagnoses.

Results

US diagnoses were acute appendicitis in 40 patients (53%), diseases other than this in 25 (33%), and no abnormality in 11 (14%) (Table 1).

Among the 40 patients in whom acute appendicitis was diagnosed following US, the condition was confirmed by surgery in 38 (95%). One of the remaining two cases was confirmed by colonoscopic biopsy as tuberculous enterocolitis, and the other, on the basis of the surgical findings, as a fecalith-impacted appendix, without inflammation.

The alternative diagnoses in the 25 patients in whom US indicated the absence of acute appendicitis comprised ten gynecologic diseases (13%), eight intestinal (11%), three urologic (4%), and four other diseases (5%). US diagnoses of gynecologic disease included ovarian or paratubal cysts ($n = 6$), pelvic inflammatory disease ($n = 3$), and uterine myoma ($n = 1$). The diagnoses of intestinal diseases were enterocolitis ($n = 5$), diverticulitis ($n = 2$), and inflammatory cecal mass ($n = 1$), while the

Table 1. Number of US in Correct Diagnosis and Proper Guidance for Treatment Plan

US Diagnosis	Final Diagnosis		US Suggestion		Final Treatment	
	Correct	Incorrect	Surgical	Medical	Surgical	Medical
Appendicitis (n = 40)	38	2	40	0	39	1
Gynecologic diseases (n = 10)	9	1	4	6	4	6
Intestinal diseases (n = 8)	8	0	1	7	1	7
Urologic diseases (n = 3)	3	0	0	3	0	3
Other diseases (n = 4)	4	0	1	3	1	3
No abnormality (n = 11)	8	3	0	11	0	11

Note. - US = ultrasound.

urologic diseases diagnosed comprised hydronephrosis of the right kidney due to gravid uterus (n = 2), and hydronephrosis of both kidneys due to urethral obstruction (n = 1). The four other diseases were diagnosed as mesenteric lymphadenitis (n = 2), cholecystitis (n = 1), and gallstone (n = 1). These US diagnoses turned out to be correct in 21 of the 25 patients (84%). Among the remaining four who were misdiagnosed, one in whom the US diagnosis was cystic degeneration of uterine myoma was found on surgery to have acute appendicitis accompanied by endometriosis. In the second patient, a cystic and solid neoplasm in the right ovary had been diagnosed by the initial US, but follow up US revealed that this had disappeared, indicating a normal ovary. In the third patient, in whom US had demonstrated a mucinous cyst in the left ovary, torsion of a tubal cyst had occurred, accompanied by endometriosis in the right adnexa. In the last patient, US revealed the presence of a mucinous cyst with hemorrhage, but torsion of an ovarian mass was confirmed surgically.

Of the 11 patients in whom US showed no abnormality (14%), eight were shown during follow-up to have no further abnormalities, and the final diagnosis was therefore abdominal pain of unknown origin. The remaining three patients had diseases that were neither related to their symptoms nor detected by US, but were included in the group whose condition was misdiagnosed. In one, surgery revealed an about 2 cm-sized endometrioma, in

Table 2. Values of US for Diagnosing Acute Appendicitis and Guiding Surgical and Medical Diseases

Diagnosis	Diagnostic Value				
	Accuracy	Sensitivity	Specificity	PPV	NPV
Acute appendicitis (n = 39)	73/76 (96)	38/39 (97)	35/37 (95)	38/40 (95)	35/36 (97)
Surgical disease (n = 45)	72/76 (95)	43/44 (98)	29/32 (90)	43/46 (93)	29/30 (97)
Medical disease (n = 31)	72/76 (95)	29/32 (90)	43/44 (98)	29/30 (97)	43/46 (93)

Note. - US = ultrasound, PPV = positive predictive value, NPV = negative predictive value. Numbers in parentheses are percentages.

the right ovary, but because it was small, it appeared clinically insignificant. The second had a submucosal tumor in the distal rectum revealed by barium enema, and in the last, colitis, diagnosed by colonoscopy, was present. Overall, US diagnoses were correct in 67 of the total of 76 patients (88%).

With regards to the treatment plan, 46 (61%) and 30 (39%) patients were diagnosed by US to be suffering from surgical and medical diseases, respectively. In the first of these two groups, 44 (96%) underwent surgery, including appendectomy (n = 39), paratubal cyst excision (n = 1), salpingo-oophorectomy (n = 2), cholecystectomy (n = 1), and right hemicolectomy (n = 1). Of the 30 who were diagnosed as suffering from medical disease, all except one, who underwent appendectomy, were treated conservatively (97%). The overall treatment plan, including both surgical treatment (n = 45) and medical treatment (n = 31), was, therefore, properly guided in 72 of the total of 76 patients (95%). Three medical diseases misdiagnosed as surgical diseases were pseudomass of the right ovary, tuberculous enteritis, and fecalith-impacted appendix without inflammation. One surgical disease misdiagnosed as a medical disease was acute appendicitis with endometriosis. In this patient, acute appendicitis was missed, and US appeared to indicate cystic degeneration of uterine myoma. The values obtained for diagnosing acute appendicitis, as well as for guiding medical or surgical treatment, are shown in Table 2.

Discussion

The diagnostic ability of US in cases in which solid organs of the upper abdomen are involved is well established, and US has, therefore, been popular as a screening tool for the evaluation of upper abdominal diseases.

Intestinal structures, however, have tended to be more or less ignored during routine abdominal US, even when evaluating patients with acute abdominal problems (9). With recent improvements in definition, state-of-the-art US has documented the US features of normal intestinal structures as well as the mural abnormalities of various intestinal diseases (1), and in this respect, has proved to be a good screening modality in cases involving intestinal diseases, especially in patients whose clinical condition is acute.

Acute abdominal pain is one of the three most common symptoms in patients who visit an emergency department or are admitted to hospital, and among acute abdominal diseases, acute appendicitis most commonly requires emergency surgery. Though the diagnosis of appendicitis is regarded as a classic example of clinical skill, the clinical features are not always clear, and the overall incidence of negative appendectomy has been stated to be 15 to 20% (10). When a practitioner is confronted with right lower quadrant abdominal pain, a variety of diseases other than acute appendicitis should be differentiated. These include intestinal conditions (inflammatory and infectious bowel diseases, diverticulitis), gynecologic conditions (pelvic inflammatory disease, ruptured ovarian cyst, ectopic pregnancy), urologic conditions (ureterolithiasis, pyelonephritis), and other conditions (mesenteric lymphadenitis, peritonitis, abscess) (11). To determine the cause of pain, imaging studies are therefore often required, and the findings can affect the patient's treatment plan by definitively diagnosing or ruling out a strongly suspected cause (1). Because it is noninvasive, inexpensive, and rapidly accessible, US enjoys certain advantages over other imaging modalities particularly in the management of patients with acute abdominal pain (2).

US is known to be valuable in the diagnosis of acute appendicitis, and in this respect, Davies *et al.* (12) reported that its sensitivity, specificity, positive and negative predictive values, and accuracy were 96%, 94%, 96%, 94% and 95%, respectively. Chen *et al.* (13) reported these values to be 99.3%, 68.1%, 90.5%, 97% and 91.6%, respectively, and our results were similar to the findings of both these reports.

US is also useful in establishing alternative diagnoses in patients with suspected acute appendicitis. Gaensler *et al.* (8) reported that it indicated correct alternative diagnoses in 70% of patients with specific diagnoses other than acute appendicitis, including gynecologic and visceral diseases, and urinary tract abnormalities. In our

study, 25 patients were diagnosed with conditions other than acute appendicitis, and in 21 of these (84%), diagnosis was correct, as described above. Our results also showed that US effectively diagnosed various diseases other than acute appendicitis that occur in the right lower quadrant of the abdomen.

Some gynecologic diseases commonly mimic acute appendicitis, and the US findings of these have been well documented. Lewis *et al.* (14) claimed that gynecologic diseases were frequently misdiagnosed as acute appendicitis, especially in women aged 20 - 40 years, in whom the rate of misdiagnosis reached 40% (14). Gaensler *et al.* (8) however, reported that US provided a correct diagnosis in 80% of women with gynecologic disease mimicking acute appendicitis (8). In our study, seven of ten patients with gynecological disease were correctly diagnosed on the basis of US findings; despite these limited numbers, the rate of correct diagnosis for women in whom gynecologic diseases mimicked acute appendicitis was fairly high. Gynecological US should thus be routinely used for women with lower abdominal pain, even if the presence of gynecologic disease is uncertain.

Only a few reports have described the contribution of US to treatment plans. McGrath *et al.* (1) reported that a clinically unexpected diagnosis was made by US in 18.7% of patients with acute abdominal pain. In the same report, US confirmed the clinical diagnosis in 46.7% of cases, made no contribution to this in 32%, and was considered misleading in 2.6%. In 88% of the patients in our study, US provided a correct diagnosis. In addition, the overall treatment plan, including both surgical and medical procedures, was properly guided in 95% of our patients. These results reemphasize that US is an accurate diagnostic tool which makes an important contribution to a treatment plan.

Our study had several limitations: first, the total number of patients was insufficient to permit the estimation of diagnostic values for individual diseases other than acute appendicitis which cause right lower quadrant abdominal pain. Second, in most patients with medical diseases and abdominal pain of unknown origin, the condition was not pathologically confirmed. In some of these cases, US diagnosis might, therefore, have failed to indicate the real disease. Since the use of clinical results only was in most cases sufficient for a definitive diagnosis, this bias appears to be insignificant. Furthermore, we believe that in none of these patients did we fail to detect the existence of a surgical disease. Third, among the patients misdiagnosed by US, there were some for

whom appropriate surgical or medical treatment would have been unlikely if the treatment guidance depended upon US report alone. Misdiagnosed by US, these patients were included as such in the data used for calculating the diagnostic values of the treatment plans.

Despite these limitations, our study indicated that US is able to provide a correct diagnosis in 88% of patients with right lower quadrant abdominal pain, and, moreover, can suggest an appropriate treatment plan in 95% of such patients. In conclusion, US is a valuable screening tool in the diagnosis and therapeutic guidance of patients with right lower quadrant abdominal pain.

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11	76 (60%)	16 (14%)	84 (88%)
11 (14%)	40 (53%)	25 (33%)	40 (46%)
67 (88%)	25 (33%)	21 (27%)	46 (61%)
(97%)	72 (95%)	46 (61%)	30 (39%)
		46 (61%)	44 (96%)
		88%	95%