COST-EFFECTIVENESS OF ABDOMINAL ULTRASONOGRAPHY IN APPENDICITIS

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The objective of this study was to find out the cost-effectiveness of ultrasonographic examination in patients with lower abdominal pain to diagnose acute appendicitis. During July, 1991 to August 2000, we have performed abdominal ultrasonography in 4289 patients of lower abdominal pain by Puylaert's graded compression technique[1] for acute appendicitis using Pie Medical 3.5-5 Mega-Hertz linear transducer, Aloka 210, SSD 500/1100 curvilinear probe, Fukuda 1000/3500 linear, Siemens SL 2 sector and linear probes. Among the 100 patients (M51, F49, ages 9 to 75 years) suspected of having acute appendicitis, 29 actually had appendicitis. Interpretation of appendiceal sonographic results was 98% accurate. The sonographic result led to changes in the treatment of 52 patients, and prevention of unnecessary appendectomy in 13 patients, providing a savings of about Takas 65000 ($ 1300) and prevented unnecessary hospital admission for 69 patients, thus saving approximately Tk. 7800/-. The cost of performing the 100 sonographic examinations was about Tk. 35000/- and thus the overall savings was about Tk. 500/- ($ 9.45) per patient. It is concluded that ultrasonography performed in patients with suspected acute appendicitis improves diagnostic accuracy, thus leading to more appropriate selection of patient treatment and with reduction of expenditure.

Key words: Ultrasonography, vermiform appendix, appendicitis.

Diagnosis of acute appendicitis is not simple as numerous other conditions including ascending diverticulitis, mesenteric adenitis, and genitourinary diseases show similar symptoms. Sonography has become an important tool in the investigation and diagnosis of many abdominal pathologic entities. Since 1986, 14 studies including more than 9956 patients have been published to diagnose acute appendicitis by ultrasound showing an overall sensitivity of 85% and specificity of 96% if the sonography was done by expert.[2,3] In a study of 609 patients clinically suspected to be having appendicitis, 426 cases turned out to be appendicitis on ultrasound examination and the rest (173/609) had a broad spectrum of gastrointestinal, gynecologic, biliary and urologic diseases.[4] However, the overall efficacy of appendiceal sonography in the clinical management of patients with suspected acute appendicitis in respect to effective use of resources has not yet been studied in Bangladesh. Here, we examine the cost-effectiveness of sonography in relation to improved diagnostic accuracy in patients with acute appendicitis.

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MATERIALS AND METHODS

From July 1991 to August 2000 we performed sonography on 4289 patients at Nuclear Med. Centers (NMC), Dinajpur and Rangpur, and private clinics at Kurigram, Gaibandha and Lalmonirhat. Of these, 100 consecutive patients (51 male and 49 female, ages 9 to 75 years) with clinically suspected acute appendicitis participated in this study. None of the patients had undergone appendectomy. The follow-up duration was 1 to 14 days (average 7 days), during which time none of the patients was lost. The 100 patients were attended to by one of 10 physicians, consisting of 5 surgeons, 1 gastroenterologist, 1 pediatrician and 3 general practitioners, who determined whether hospitalization for suspected acute appendicitis was necessary on the basis of the clinical information. Appendiceal sonography was indicated for all 100 patients. Before sonography was performed, the attending physicians determined the likelihood of acute appendicitis based on the following scale: definitely appendicitis (indication for immediate surgery), probably appendicitis (indication for immediate hospitalization and possible surgery). The patients' medical history was taken and physical examination was performed, followed immediately by sonography. The patients did not undergo and prior preparations, such as fasting or instillation of fluid into the intestines. The sonography operator received no prior information about the laboratory test results of the patients, and examined the hepatobiliary and urogenital systems routinely to rule out any calculus for focal lesion, and followed the technique using graded compression proposed by Puylaert.[1] A swollen appendix diameter of 6 mm or more was considered pathologic. The appendix was differentiated from the terminal ileum on sonography based on the absence of peristalsis. Other important signs in acute appendicitis are appendicolith, increased echogenicity of the periappendicular fat, loss of the submucocal layer, pericecal abscesses, lymphnodes and extraluminal gas. The ultrasonic features of the layer stratification of the pathologic appendix were used to classify the pathologic appendix into the following three types:

(1) Catarrhal: abnormal wall thickening, mainly of mucosa with distinct layer stratification,

(2) Phlegmonous: abnormal wall thickening, mainly of the submucosa with distinct layer stratification,

(3) Gangrenous: abnormal wall thickening with blurred layer stratification. Other pathologic findings included abscess formation and thickening of the mesoappendix. Clinically, we considered type 1 is compatible with early appendicitis, type 2 is non-perforating appendicitis, and type 3 is perforating appendicitis. We indicated conservative treatment for patients with catarrhal appendicitis on sonography, whereas immediate surgery is indicated for patients with phlegmonous or gangrenous appendicitis.

After sonography the operator estimated the likelihood that the patient had acute appendicitis on the following scale: definitely appendicitis (swollen appendix could be seen on sonography), or definitely not appendicitis (no pathologic finding indicative of appendicitis could be seen), We used sonographs (Pie Medical, Fukuda 1000/3500, Aloka 210,SSD 500/1100, Siemens SL 2) sector, linear and curvilinear probes with 3.5—5 Mega-Hertz frequency. (Figs 1+2)

Definitive diagnosis was established at surgery in 25 patients and at the clinical follow-up examination in 75 patients. The patients were diagnosed as having acute appendicitis, other specific conditions or nonspecific abdominal pain. Changes in patient care were determined by comparing the planned treatment (hospitalization for observation or emergency appendectomy) with the actual treatment (discharge from hospital,

hospitalization for observation, treatment for an alternative condition, emergency appendectomy or other surgery) received after the sonographic findings had been taken into account. We assumed that each patient who avoided hospitalization for observation would have been hospitalized for only one day of observation if sonography had not been done.

The mean cost of appendectomy and of one day of observation in the hospital were determined from the data of the patients. The cost of sonography ranged form Tk. 100 to Tk. 400 per patient during the study period. Changes in hospital resources used were determined by comparing the treatment plans made before sonography with the actual treatment regimen the patient underwent. The number of unnecessary appendectomies avoided was multiplied by the cost of removing pathologic appendix. The number of hospital observation days avoided was multiplied by the cost of one hospital day excluding incidental charges. The overall cost savings as a result of using routine sonography was determined by subtracting the cost of performing 100 appendiceal sonography from the savings that resulted from incorporating the sonographic results into treatment decisions.

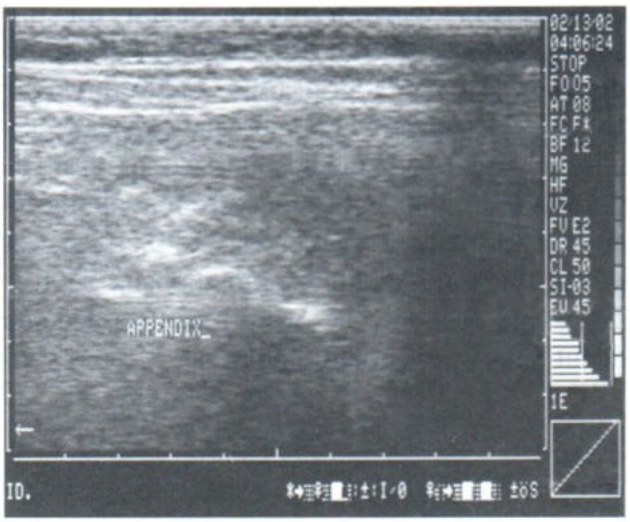

Fig. 1. Nromal appendix at USG.

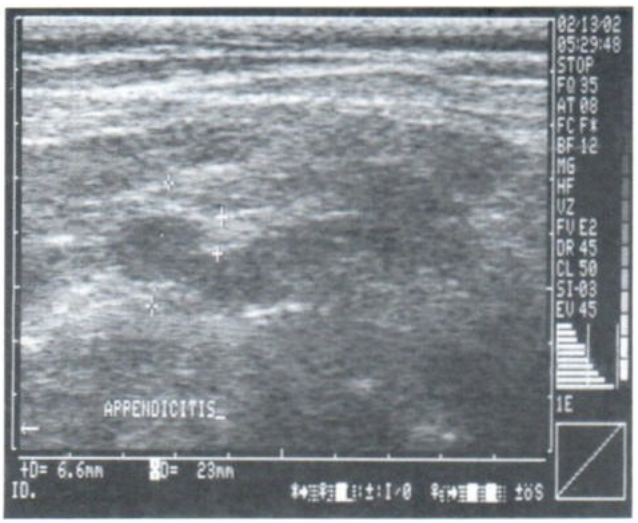

Fig. 2. Appendicitis at USG.

RESULTS

Typical sonographic features of acute appendicitis are shown in figures 1 and 2. Acute appendicitis was the definitive diagnosis in 29 of the 100 patients (29%). Of these, diagnosis of 4 patients having suspected caterrhal-type acute appendicitis was confirmed during follow-up hospitalization, while the other 25 patients were confirmed at surgery by pathologic examination. In 71 patients (71%) acute appendicitis was ruled out during clinical follow-up examination including additional imaging results such as radionuclide scans, endoscopy with biopsy and barium contrast studies. The results of sonography were positive in 27 patients (23 patients with surgical and pathologic evidence of phlegmonous or gangrenous type acute appendicitis and 4 patients with follow-up evidence of catarrhal-type acute appendicitis) and negative in 71 patients (all negative throughout clinical follow-up examination). Sonography produced false-negative results

in two patients with surgical and pathologic proof of phlegmonous or gangrenous-type acute appendicitis and no false-positive result. Overall sonographic interpretation had 95% sensitivity, 100% positive predictive value, 98% negative predictive value, and 98% overall accuracy for diagnosing or ruling out acute appendicitis.

Definitive diagnosis was made in 42 of the patients (42%) (Table 1). Sonography revealed the correct diagnosis in 40(95.2%) of these patients. Nonspecific abdominal pain was diagnosed in 58 patients. Of this group, no organic disease was included in the definitive diagnosis.

A comparison of clinical likelihood versus the sonographic likelihood of acute appendicitis with respect to the final diagnosis of this disorder is shown in Table 2.

The sonographic results prompted 52 changes in treatment strategy. These changes involved prevention of unnecessary appendectomy in 13 patients whose diagnoses were established as definitely appendicitis' sonographically (6 with gynecologic disease and 7 with urinary disease), unnecessary hospitalization in 60 patients who were established as probably or possibly appendicitis' clinically but definitely not appendicitis' sonographically (57 patients with nonspecific pain, 1 with gynecologic disease and 2 with urinary disease). On the other hand, 9 patients were admitted for emergency appendectomy based on sonography that were considered definitely appendicitis' contrary to the clinical findings of probably or possibly appendicitis. The mean cost of necessary appendectomy was $100(range 90-110). Thus the overall cost savings from avoiding appendectomy in 13 cases was $1300. The mean cost of one day observation was approximately $5. At least 69 hospital days of observation were avoided based on the sonographic results: 60 days for patients discharged after sonography and 9 days for patients who underwent emergency appendectomies without first being hospitalized for observation. In total, the cost savings from avoiding 69 days of hospital observation was $ 345. If the cost of the 100 sonographic examinations at $700 is taken into account, the overall savings become about $ 9.45 per patient (Table 3).

TABLE 1. Definitive Diagnosis of our patients

Definitive Diagnosis	Number of patients
Appendicitis	29
Catarrhal	4
Phlegmonous, gangrenous	25
Urinary diseases	7
Gynecologic diseases	6
Nonspecific abdominal pain	58

Total =100

TABLE 2. Estimated clinical and sonographic likelihood of acute appendicitis compared with definitive diagnosis

	Definitive diagnosis	
	Appendicitis confirmed	Appendicitis ruled out
Clinical likelihood		
Definitely appendicitis	20	13
Probably appendicitis	9	58
	Total = 29	71
Sonographic likelihood		
Definitely appendicitis	27	0
Probably not appendicitis	2	71
	Total = 29	71

TABLE 3. Cost Savings because of incorporation of sonography in the diagnosis of acute appendicitis

Treatment changes	Number of patients	Savings or Costs per Patient ($)*	Overall saving or Costs ($)*
Savings			
Avoided unnecessary appendectomy	13	100	1300
Avoided observation for 1 day before Appendectomy / discharge	69	5	345
Costs			
Sonography	100	7	700
Total cost savings		9.45	945

*Dollar estimates reflect exchange rate of $1=Tk.39 --56/-

DISCUSSION

The present results demonstrate that sonography had a high diagnostic accuracy for acute appendicitis. Moreover, its use led to improved patient care and reduced use of hospital resources. Sonographic diagnosis is useful in patients clinically suspected of having acute appendicitis, including those who are ultimately diagnosed as having other conditions. The normal appendix is seen in less than 30% of patients. Occasionally a mass consisting of inflamed appendix, periappendiceal fluid and thickened omentum may be seen in the right iliac fossa.[5] Sometimes degenerated uterine leiomyoma may mimic acute appendicitis,[6] and sonographic findings of carcinoid appendix has also been described.[7] Sonography is also excellent in showing an abscess and may demonstrate an appendicolith, a 'coffee-bean' sign, a hyperechogenic finger-like projection (inflamed appendix) extending into a cystic mass (pus) with or without scattered internal echoes may be seen in an appendix abscess.[8] Rarely a radionuclide scan (Gallium-67 citrate or Technetium-99 metastable monoclonal antibodies against granulocytes) is required to demonstrate an occult abscess in right iliac fossa or a 'hot' appendix.[9-10]

Appendicitis is still a fascinating subject. It is a common disease and still difficult to understand, to diagnose and to treat. Does ultrasound have a role in the management of patients suspected of having appendicitis? Some will say it has a limited yet positive impact.[11] Surgeons do not find the use of ultrasound nor CT scan valuable in the diagnosis of appendicitis.[12,13] They recommend laparoscopy instead.[12] The problem is even more complicated when special new pathological techniques will show appendicitis in otherwise normal looking appendices.[14] This article may be of value for it shows how in countries where access to technology is limited the use of ultrasound may be cost-effective. The cost saving may look trivial when compared to what has been published for rich countries,[2] but should have a positive impact in health care.

The cost savings in the present study may have been overestimated because of the lack of false-positive data. Patient selection by clinical history and physical examination may further optimeze the situation.

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