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Integrated clinical-ultrasonographic diagnosis in acute appendicitis

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KEYWORDS

Ultrasonography;
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Abstract *Purpose:* Acute appendicitis is one of the commonest diseases encountered in the field of emergency surgery. If untreated, it can rapidly develop severe complications such as perforation and peritonitis. Surgeons therefore often choose early surgical treatment also when the diagnosis is only probable, facing the risk of performing an elevated amount of unnecessary appendectomies. The aim of this study is to analyse our experience with integrated clinical-ultrasonographic diagnosis in acute appendicitis.

Material and methods: From January 1999 to December 2006, 1447 patients underwent clinical examination, leucocyte count, evaluation of C-reactive protein level, and abdominal ultrasonography using graded compression technique and a high frequency probe.

Results: In 368 patients (25%) ultrasonographic diagnosis was acute appendicitis; 8 patients were operated on the basis of clinical evaluation only. Ultrasonography yielded false positive results in 7 cases. In 1079 patients (75%) diagnosis was negative for acute appendicitis; 173 of these patients (12%) received a different diagnosis. The remaining 906 patients underwent clinical follow-up until the symptoms disappeared; there were no complications. In our study, sensitivity of ultrasonography was 98%, specificity 99%, positive predictive value 98%, and negative predictive value 99%. Overall diagnostic accuracy was 99%.

Conclusion: Integrated diagnosis of acute appendicitis based on clinical evaluation, laboratory tests and ultrasonography is safe and saves resources by preventing unnecessary operations.

Sommario *Scopo:* L'appendicite acuta è una delle urgenze chirurgiche addominali più comuni. Se non trattata, può rapidamente progredire verso complicanze severe, quali la perforazione e la peritonite. Spesso i chirurghi optano per un intervento chirurgico precoce anche in caso di diagnosi solo probabile, con il rischio di eseguire una quota importante di appendectomie inutili. Lo scopo dello studio è di analizzare la nostra esperienza con la diagnosi integrata clinico-ultrasonografica dell'appendicite acuta.

Materiali e metodi: Durante il periodo gennaio 1999-dicembre 2006 1447 pazienti sono stati sottoposti a valutazione clinica, a conta leucocitaria, dosaggio della proteina C reattiva ed ecografia addominale. È stata utilizzata la tecnica ecografia di compressione graduale, con sonda ad alta frequenza.

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Risultati: È stata formulata diagnosi ecografica di appendicite acuta in 368 pazienti (25%). Ulteriori 8 pazienti sono stati operati sulla base del solo giudizio clinico. Abbiamo osservato 7 casi di falsi positivi ecografici. In 1079 (75% del totale) pazienti è stato espresso un giudizio diagnostico negativo per appendicite acuta: in 173 di essi (12%) è stata formulata una diagnosi diversa. I restanti 906 pazienti sono stati sottoposti a controllo clinico fino alla risoluzione della sintomatologia, senza alcuna complicanza. I nostri risultati hanno dimostrato una sensibilità dell'ecografia del 98%, una specificità del 99%, un valore predittivo positivo del 98% e un valore predittivo negativo del 99%. L'accuratezza diagnostica globale è stata del 99%.

Conclusioni: La diagnosi integrata (clinica, di laboratorio ed ecografica) dell'appendicite acuta consente una diagnosi sicura, con risparmio di risorse evitando il ricorso ad appendicectomie inutili.

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Introduction

Acute appendicitis is one of the commonest surgical emergencies. It can rapidly develop severe acute abdominal complications such as perforation and general peritonitis. Surgeons have therefore been inclined to perform appendectomy, a simple operation which rarely presents complications, also in cases where the diagnosis was only probable thus accepting an elevated rate (about 15–30%) of removal of normal appendices [1]. A wait-and-see approach can increase the risk of complications.

Among the diagnostic methods used in order to improve the diagnosis of acute appendicitis and reduce the amount of "useless" appendectomies without increasing the risk of inflammation are ultrasonography (US), computerized tomography (CT) [2], magnetic resonance imaging (MRI) [3], and diagnostic laparoscopy. US performed by an expert reaches an elevated diagnostic accuracy, from 70% to 95% [4]. This method is furthermore non-invasive, repeatable, inexpensive and widely available. However, US diagnosis of acute appendicitis requires a specific experience combined with adequate clinical workup, as US alone cannot substitute clinical evaluation.

From 1999 all patients referred to our department with clinical suspicion of acute appendicitis have undergone US combined with leucocyte count and evaluation of the C-reactive protein (CRP) level. Two surgeons with specific US

expertise perform the US examinations. The results obtained are reported below.

Materials and methods

From January 1999 to December 2006, 1447 patients clinically suspected of having acute appendicitis underwent clinical and US evaluation at our institution; 829 (53%) were women and 618 (47%) were men; mean age was 35 years (range 9–89 years).

All patients clinically suspected of having acute appendicitis underwent surgical examination, biochemical analysis (leucocyte count and evaluation of CRP level) and abdominal US upon arrival at our institution. CRP cut-off value was 0.80 mg/dL, which is considered maximum normal value by our laboratory. Maximum normal value of white blood cells was 10,000 cells/mcl.

A complete US study of the abdomen was performed using a 2.5–5 MHz probe, followed by a systematic evaluation of the appendiceal region using graded compression US [5] and a high frequency 7.5–12 MHz probe (HDI 5000 ATL-PHILIPS).

US diagnosis was acute appendicitis if one of the following abnormalities was revealed [6,7]:

1. The appendix could not be compressed; parietal thickness >3 mm and diameter >6 mm (Fig. 1).
2. Loss of normal parietal stratification (Fig. 2).
3. Increased volume and hyperechoic periappendiceal fat.
4. Abscess collection in the appendix (Fig. 3).
5. Periappendiceal fluid collection.

Fig. 1 Enlarged appendix containing coprolith.

Fig. 2 Loss of parietal stratification.

Fig. 3 Appendiceal abscess.

If the examination did not reveal any of the above abnormalities, US result was considered negative for acute appendicitis. However, an unequivocal Blumberg's sign associated with compatible clinical and laboratory data determined a strong suspicion of acute appendicitis and a consequent indication for laparoscopic surgery even in the absence of the above listed abnormalities.

Patients whose appendix could not be visualized or whose US outcome was dubious underwent a second clinical, biochemical and US evaluation after 12 h. Patients, who were diagnosed pathologies other than acute appendicitis, received required treatment. The remaining patients were discharged from the hospital.

Results

In 368 patients (25%) US diagnosis was acute appendicitis. Strong clinical suspicion and elevated biochemical values led to laparoscopic appendectomy in 8 patients whose US outcome was negative. In this group of false negative US results, surgery revealed 7 cases of acute appendicitis (4 cases of mild inflammation; 2 cases of phlegmonous appendicitis; 1 case of chronic appendicitis) and 1 case of pelvic inflammation. Five of these patients were obese. In 3 cases diagnosis was made after a second evaluation, which was required in 12% of cases. Results of the diagnostic workup are summarized in Table 1.

Laparoscopic appendectomy was carried out in 376 patients. In 369 out of 376 patients, surgery revealed histologically confirmed acute appendicitis. There were 7 false positives among the patients whose US outcome was positive: 1 case of normal retrocecal appendix and acute inflammation of an epiploic appendix; 2 cases of perforated duodenal peptic ulcer; 3 cases of pelvic inflammation; 1

Table 2 Distribution of diagnoses other than appendicitis revealed by this protocol

173 Patients (%)	Other pathologies
65	Ovarian pathology
16	Pathology of the urinary system
14	Gastroenteritis
4	Diverticulitis
2	Ileal Crohn's disease

case of Chron's disease (in the latter 6, inflammation had spread to the appendiceal region).

In 1079 patients (75%) diagnosis was negative for acute appendicitis; 173 of these patients (12%) received a different diagnosis (Table 2). The remaining 906 patients underwent clinical follow-up until the symptoms disappeared; there were no complications (Fig. 4). A telephone interview after at least one month confirmed that none of these patients were affected by acute appendicitis. In our study, US sensitivity was 98%, specificity 99%, positive predictive value (PPV) 98%, and negative predictive value (NPV) 99%. Overall diagnostic accuracy was 99%.

Discussion

Acute appendicitis is one of the surgical diseases, which most frequently constitutes an indication for emergency surgery. When the typical clinical signs are unequivocal, surgical approach is mandatory. However, abdominal pain in the lower right quadrant is often equivocal and atypical. In this case a decision based entirely on clinical data implies an elevated risk of errors. In dubious cases, a wait-and-see approach may delay required surgery with the consequent risk of infective complications, while a more aggressive approach increases the amount of unnecessary appendectomies [8].

Laboratory tests do not permit a safe identification of patients with acute appendicitis, as PPV of leucocyte count and CRP level is low. However, these tests are useful in ruling out acute appendicitis, as NPV of leucocyte count and CRP is 91% and 85%, respectively, according to data published by other authors [9,10].

US has shown an elevated diagnostic accuracy as an additional tool in the diagnosis of acute appendicitis [11,12]. This was confirmed by the results obtained in our study in line with other radiological and clinical studies. Graded compression US permits an improved visualization of the appendix due to displacement of the bowel gas contained in the cecum and the ascending colon.

Table 1 Significance of leucocytosis, CRP value and US in the diagnosis of acute appendicitis

	Leucocyte (mean values)	Neutrophil (%)	CRP (mean values)	US
Appendicitis	13749 PPV 41%	78.6	5.704 PPV 32%	PPV 98%
Non-appendicitis	9486 NPV 91%	63.3	2.45 NPV 85%	NPV 99%
	$p < 0.001$	$p < 0.001$	$p < 0.001$	
	Sensitivity 81%		Sensitivity 66%	Sensitivity 97%
	Specificity 62%		Specificity 58%	Specificity 99%

Fig. 4 Outcome of integrated evaluation.

Our data confirm that a combined clinical, US and biochemical evaluation permits a correct and safe selection of patients who can profit from a conservative wait-and-see approach with a subsequent diagnostic clarification or spontaneous disappearance of clinical symptoms, thus substantially reducing unnecessary appendectomies. The results of laboratory tests correlated with US outcome can help in identifying patients with acute appendicitis.

Some patients underwent surgery on the basis of clinical and biochemical evaluation despite a negative US outcome. A subsequent analysis showed that 80% of these patients were overweight, a condition, which substantially reduces the sensitivity of US also according to other scientific studies [13].

It should be kept in mind that diagnosis of acute appendicitis is mainly clinical and that the limit of US is that this method is strictly operator-dependent. Numerous radiological studies show the elevated diagnostic sensitivity of US, but in daily clinical practice the diagnostic procedure can be undermined by an insufficient collaboration between the clinician and the radiologist.

On the basis of our results, we conclude that the best solution is that a clinician, who has the adequate US experience and expertise, performs an overall evaluation of patients suspected of having acute appendicitis, correlating clinical data with laboratory data and US outcome. Finally, seen from a cost-benefit point of view, it seems

highly advantageous that US, which is an inexpensive diagnostic tool, is performed in the surgical department to prevent unnecessary operations and avoid prolonged observation and hospitalisation [14].

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