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Reducing negative appendectomy: evaluation of ultrasonography and computer tomography in acute appendicitis

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Abstract

Objective. To study the sensitivity and the specificity for ultrasonography and computed tomography in patients with suspected appendicitis, and their value to the clinician.

Design. Retrospective study.

Setting. Teaching hospital, Sweden.

Main outcome measures. The negative appendectomy rate and the sensitivity and the specificity for ultrasonography and computed tomography in patients with suspected appendicitis.

Result. The diagnostic accuracy was 88% (men 95%, women 80%). Two hundred and thirty-nine patients were examined by ultrasonography preoperatively. The sensitivity for ultrasonography was 0.82 and the specificity was 0.97. Forty-nine patients were examined by computed tomography preoperatively. The sensitivity for computer tomography was 0.88 and the specificity was 0.95.

Conclusions. We conclude that ultrasound and computed tomography investigations on patients with suspected appendicitis are of great value. Computed tomography seems to have a higher sensitivity than ultrasound and a high specificity. In fertile women, where unnecessary surgery is best avoided, we believe that computed tomography investigation or ultrasound examination are better alternatives to surgical intervention.

Keywords: acute appendicitis, appendectomy, computed tomography, diagnostic accuracy, ultrasound examination

The diagnosis of acute appendicitis in many patients can be difficult to establish. A negative laparotomy rate of about 25% is common in many reports [1]. Some of these operations on a healthy appendix are related to a higher morbidity and even mortality [2]. Several methods have been used to improve the diagnostic accuracy such as total leucocyte count, CRP, scoring system, computer-aided diagnosis and plain radiography [1,3]. In 1986, Puylaert reported on 60 consecutive patients with suspected appendicitis where in 25 of the 28 patients with acute appendicitis, the appendix could be visualized using graded ultrasonography (US) compression technique with a high resolution transducer [4]. US has a short learning curve where a high accuracy can be reached after only 20 patients [5]; it is inexpensive, has no ionizing radiation and can be performed with little or no patient preparation but demands some experience and expertise [1, 6]. It can also be used in early appendicitis with the supplement of Doppler technique [7] or to evaluate the appendix in patients treated conservatively with antibiotics [8]. At Danderyd hospital patients with suspected acute appendicitis are sent for ultrasound examination on a 24 hour basis as part of our treatment strategy. We have found this investigation of great value to the clinician [1]. All US examinations are performed by radiologists and not by the surgeons. During recent years several new radiological examinations have been established, such as computed tomography (CT) scan. The method has been used for several years in suspected left-sided diverticulitis with high diagnostic sensitivity and as a way of predicting complications [9]. CT examination has recently shown a high sensitivity in suspected appendicitis

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[10–14] and has the advantage of diagnosing or excluding other conditions simulating acute appendicitis [15]. A normal appendix can be visualized by CT scan but not by US. During recent years there has been a trend to examine patients laparoscopically – carrying out laparoscopic appendicectomy without prior investigation. Earlier small studies showed some advantages with laparoscopic appendicectomy but later randomized studies have failed to do so [16]. The aim of this retrospective study was to evaluate the sensitivity and specificity in patients investigated by US examination and/or CT during 1996 and also the diagnostic accuracy in appendicectomized patients.

Materials and methods

All patients investigated during 1996 by US and/or CT were studied. The patients were admitted to the emergency department where history and physical examination were carried out. In the majority of patients the surgeon on duty wanted US or CT to be carried out as appendicitis could not be excluded completely. The decision to make further investigation with US or CT was usually made by a specialist or a resident surgeon and in a few patients also by an internist. In some patients the radiologist changed and performed CT instead of US, mainly due to obesity. In some patients the diagnosis of acute appendicitis was obvious and no further investigations were performed prior to surgery as was the case in suspected perforation. Danderyd hospital has a catchment population of approximately 330 000; but patients less than 15 years of age are not admitted for surgery at our hospital. During 1996, 278 patients underwent surgery for suspected acute appendicitis, 146 men (mean age 33.8 years) and 132 women (mean age 33.0 years). A further nine men were treated with antibiotics only as part of a multicentre study and were not included in this study [8]. All resected appendices were sent for histopathological examination. US was performed by 16 different radiologists (eight experienced and eight less experienced). The examination was performed using an Acuson 128 or GE Logic 700 and high resolution (5 or 7.5 MHz) linear array transducers were used. The method for US examination (Figure 1) was based on the graded compression technique described by Puylaert [4,5]. The positive criterion for appendicitis was a non-compressible appendix with an outer diameter >6 mm. Appendicolithiasis was considered as a positive finding. If the examiner was unable to find the appendix the examination was considered to be negative.

One hundred and fourteen patients (67 women and 47 men) were examined by CT. No preparation with peroral or intravenous contrast material was used. Until September 1996 the examination was conducted using a conventional CT and after September 1996 a spiral CT was also available. The CT examination was performed with spiral technique (GE, CTi), using a collimation of 5 mm, pitch 1.0 and an image interval of 5 mm. The patient was scanned from the second lumbar vertebra to the symphysis pubis with no administration of oral or intravenous contrast. In a small number of patients conventional CT (GE PACE) was performed, using consecutive 5 mm slices. Appendicitis was noted if a thickened appendix or pericecal fatty infiltration was seen [17]. Figure 2 shows a patient with infiltration.

Thirty-seven patients were investigated using both US and CT. The main reason for this was that US showed inconclusive findings and a CT was needed to provide additional information.

Sensitivity was calculated as the true positive/(true positive + false negative). Specificity was calculated as the true negative/(true negative + false negative).

Results

During 1996 610 patients were investigated by US and 114 patients by CT for suspected acute appendicitis. The negative appendicectomy rate was 12% (men 5%, women 20%) for the 278 who were operated when analyzed according to the histopathological examination. At our department the negative appendicectomy rate before the use of US was 18% in 1992 [18]. Thirty-nine patients or 18% (39/222) of the operated patients had perforated appendicitis.

Two hundred and thirty-nine of 278 patients (86%) were examined by US preoperatively without delaying surgery or the decision for further investigations. An additional 12 patients were examined by only CT preoperatively. Twenty-seven patients were operated without US or CT and 26 of these had appendicitis and one without any findings. Thus a total of 251 patients were investigated using US or CT preoperatively. US examination shows a sensitivity of 0.82, and has a specificity of 0.97 (Table 1). CT examination has a sensitivity of 0.88 and a specificity of 0.95 (Table 2).

Discussion

US examination is a rapid and easy way of investigating patients with suspected appendicitis. Non-visualization of the appendix does not completely exclude appendicitis (especially in the obese), increased intestinal gas or severe abdominal pain [19] and in patients with a retroceacal appendicitis. At our hospital almost every patient with this condition is investigated by US – 610 patients during 1996. Because appendicectomy is always related to some morbidity and mortality, especially in cases of perforated appendicitis, an extended investigation should be performed to prevent unnecessary surgery [2]; the risk is small but cannot be neglected. It is therefore important to investigate the patient before making a decision for surgery [1,18]. It is more than 10 years since Puylaert showed that US examination was a useful diagnostic tool in investigating patients with suspected appendicitis. The development of new techniques for non-invasive examination has continued during this period [7].

We conclude that US and CT investigations in patients with suspected appendicitis are of great value to the clinician in his decision making. CT investigation seems to have a

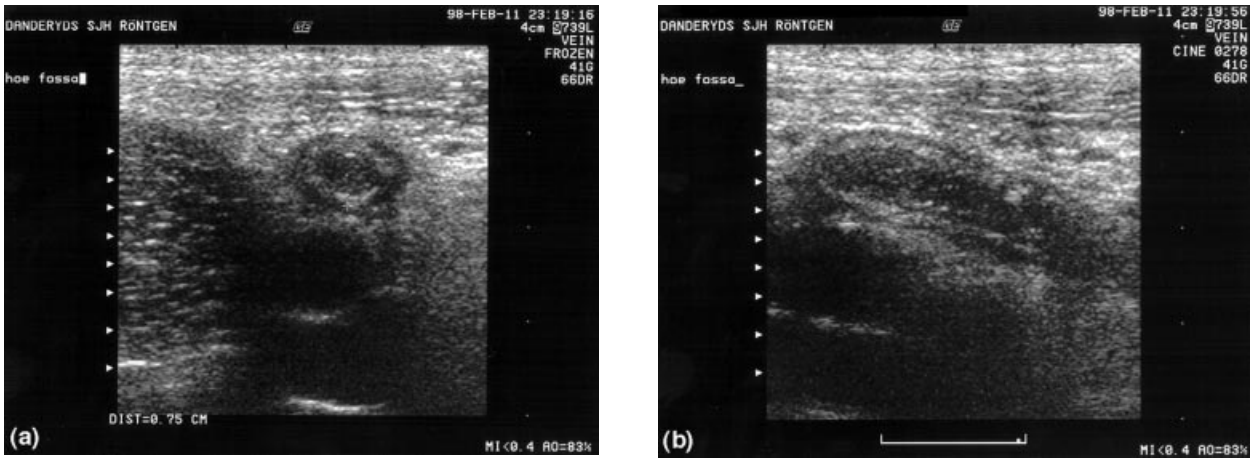

Figure 1 (a) Ultrasound examination. Sagittal section of the appendix. (b) Ultrasound examination in the same patient: longitudinal section of the appendix.

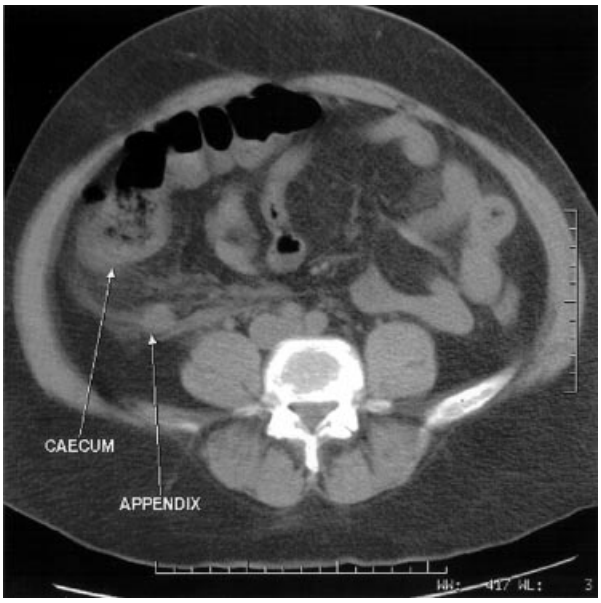

Figure 2 CT examination of appendicitis.

Table 1 Results from US examinations: sensitivity, specificity and number of examinations (*n*). The number is given to calculate the sensitivity and specificity

	Sensitivity	Specificity	(*n*)
Men	0.87 (122/141)	0.98 (125/127)	268
Women	0.76 (72/95)	0.96 (236/247)	342
Total	0.82 (194/236)	0.97 (361/374)	610

higher sensitivity and the same specificity as in US and can be advantageous if US is found to be inconclusive. CT scan is also more beneficial in obese patients due to the presence of intestinal fatty tissue. Routine CT and US performed in patients presenting with suspected appendicitis may improve patient care and may reduce the use of hospital resources.

Table 2 Results from CT examinations: sensitivity, specificity and number of examinations (*n*). The number is given to calculate the sensitivity and specificity

	Sensitivity	Specificity	(*n*)
Men	0.92 (25/27)	1.0 (20/20)	47
Women	0.83 (19/23)	0.93 (41/44)	67
Total	0.88 (44/50)	0.95 (61/64)	114

For the time being no other method is available for the investigation of patients with suspected appendicitis. All hospitals should keep a record of their negative appendicectomy frequency with routine histopathological examinations as this is a good measurement of quality assurance and could be recorded easily. In order to maintain good quality in the care of suspected acute appendicitis there are advantages with the use of CT scan and US which we have outlined here. However, with a negative appendicectomy rate in the mid-1980s of 30% [18] to 12% in 1996, this gain in quality of care has spared many patients from unnecessary surgery. The introduction of this quality management of these patients has gradually been introduced and has improved the system.

References

1. Eriksson S. Acute appendicitis - ways to improve diagnostic accuracy. *Eur J Surg* 1996; **162:** 435–442.
2. Velanovich V, Satava R. Balancing the normal appendectomy rate with the perforated appendicitis rate. *Am Surg* 1992; **58:** 264–269.
3. Körner H, Söndenaa K, Söreide J *et al.* Structured data collection improves the diagnosis of acute appendicitis. *Br J Surg* 1998; **85:** 341–344.
4. Puylaert J. Acute appendicitis US evaluation using graded compression. *Radiology* 1986; **158:** 355–360.
5. Granström L, Eriksson S, Tisell Å. Ultrasonography as a tool

in the diagnosis of acute appendicitis. A prospective study. *Surg Res Commun* 1992; **11:** 309–314.
6. Jeffrey R. In patients with right lower quadrant pain, is sonography or CT the preferred imaging technique for initial evaluation. *Am J Roentgenol* 1995; **164:** 1547–1548.
7. Lim H, Lee W, Kim T *et al.* Appendicitis: usefulness of colour doppler US. *Radiology* 1996; **201:** 221–225.
8. Eriksson S, Granström L. A randomized controlled trial of appendicectomy or antibiotics in patients with acute appendicitis. *Br J Surg* 1995; **82:** 166–169.
9. Ambrosetti P, Grossholz M, Becker C *et al.* Computed tomography in acute left colonic diverticulitis. *Br J Surg* 1997; **84:** 532–534.
10. Balthazar E, Megibow A, Siegel S, Birnbaum B. Appendicitis: prospective evaluation with high resolution CT. *Radiology* 1991; **180:** 21–24.
11. Malone A, Wolf C, Malmed A, Melliere B. Diagnosis of acute appendicitis: value of unenhanced CT. *Am J Roentgenol* 1993; **160:** 763–766.
12. Birnbaum B, Balthazar E. CT of appendicitis and diverticulitis. *Radiol Clin North Am* 1994; **32:** 885–897.
13. Rao P, Wittenberg J, Mcdowell R *et al.* Appendicitis: use of arrowhead sign for diagnosis at CT. *Radiology* 1997; **202:** 363–366.
14. Rao P, Rhea J, Novelline R *et al.* Effect of computed tomography of the appendix on treatment of patients and use of hospital resources. *N Engl J Med* 1998; **338:** 141–146.
15. Hall F. Does this patient have appendicitis? *J Am Med Assoc* 1997; **277:** 626–627.
16. Reiertsen O, Larsen S, Trondsen E *et al.* Randomized controlled trial with sequential design of laparoscopic and conventional appendicectomy. *Br J Surg* 1997; **84:** 842–847.
17. Curtin K, Fitzgerald S, Nemcek A *et al.* CT diagnosis of acute appendicitis: imaging findings. *Am J Roentgenol* 1995; **164:** 905–909.
18. Styrud J, Eriksson S, Segelman J, Granström L. Diagnostic accuracy in 2351 patients undergoing appendicectomy for suspected acute appendicitis: a retrospective study 1986–1993. *Dig Surg* 1999; **16:** 39–44.
19. Eriksson S, Tisell Å, Granström L. Ultrasonographic findings after conservative treatment of acute appendicitis and open appendicectomy. *Acta Radiologica* 1995; **36:** 173–177.

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