

Audit of Ultrasonography for Diagnosis of Acute Appendicitis: a Retrospective Study

HS Fung, S Lau, JCW Siu, CM Chan, SCH Chan

Department of Radiology and Imaging, Queen Elizabeth Hospital, Hong Kong

ABSTRACT

Objective: To determine the utility and accuracy of ultrasonography for the diagnosis of acute appendicitis.

Methods: In this retrospective study, 242 of 286 patients undergoing ultrasonography of the appendix from 1 June 2006 to 31 December 2006 were included. The ultrasonography report, pathology report, and clinical notes were reviewed. The pathology report was used as the gold standard for a diagnosis of acute appendicitis.

Results: The overall rate of visualisation of the appendix was 41.7%. Fifty six patients (23%) had a positive diagnosis of acute appendicitis by ultrasonography, 45 (19%) had a negative diagnosis, and 141 (58%) had an inconclusive diagnosis; 17 patients (7%) had an alternative diagnosis suggested by ultrasonography. Twenty nine patients (12%) underwent computed tomography on the basis of the ultrasonography report, 6 of whom had a positive diagnosis for acute appendicitis, 5 had a negative diagnosis, and 18 had an alternative diagnosis suggested by computed tomography. The sensitivity, specificity, positive predictive value, and negative predictive value of ultrasonography for acute appendicitis were 75.9%, 89.7%, 73.2%, and 91.0%, respectively, after adjusted calculation for the group with an inconclusive ultrasonography diagnosis.

Conclusions: The performance of ultrasonography for investigation of acute appendicitis at the Queen Elizabeth Hospital, Hong Kong, is comparable to the data reported in the literature. Ultrasonography is a useful and safe imaging modality for investigation of acute appendicitis, and computed tomography has a complementary role for the diagnosis of acute appendicitis and management of patients with right lower quadrant pain.

Key Words: Appendicitis; Diagnostic imaging; Ultrasonography

INTRODUCTION

Acute appendicitis is a common problem, but the diagnosis is often challenging. The accuracy of a clinical examination ranges from 71% to 97%, depending on the experience of the surgeon.¹ The perforation rate is as high as 35% when surgery is delayed.² The reported rate for appendectomy with no appendicitis (negative appendectomy) is 20% to 30%.^{3,4} However, imaging can lower the negative appendectomy rate to 6% to 10%.⁵ Imaging evaluation for suspected acute appendicitis in adults is increasingly requested. This study was performed to determine the utility and accuracy of ultrasonography (USG) for the diagnosis of acute appendicitis.

METHODS

286 patients with Radiology Information System Exam Code 3102 (Ultrasound) from 1 June 2006 to 31 December 2006 were enrolled in this retrospective study. Forty four patients were excluded, most of whom were children with pyloric stenosis or intussusception. 242 patients were included in the study.

The USG graded compression technique was used. The criteria for USG diagnosis of acute appendicitis included abnormal morphology of the appendix (enlargement >6 mm, lack of compressibility, and blind-ended) and corresponding local tenderness on probe compression. The pathology report was used as the gold standard for the diagnosis of acute appendicitis. Patients' outcomes were followed up from the electronic records in Clinical Management System.

RESULTS

The mean age was 38.5 years (range, 2 to 93 years). There were 65 men and 177 women, with a ratio of 1.0:2.7.

Correspondence: Dr HS Fung, Department of Radiology and Imaging, Queen Elizabeth Hospital, 30 Gascoigne Road, Kowloon, Hong Kong.

Tel: (852) 2958 6242; Fax: (852) 2958 6048;

E-mail: dicksonfunghs@gmail.com

Submitted: 11 November 2008; Accepted: 21 November 2008.

Four patients were pregnant at the time of USG. All 4 patients had an inconclusive USG diagnosis for acute appendicitis, 2 of whom had spontaneous resolution of symptoms and 2 discharged themselves against medical advice and were lost to follow-up.

213 patients were referred from the Department of Surgery, 9 from the Department of Paediatrics, 10 from the Department of Obstetrics and Gynaecology, and 10 from the Department of Medicine.

The appendix was visualised by USG in 101 patients (41.7%). Thirty patients had a normal appendix and 71 had an abnormal appendix.

Fifty six patients (23%) had a positive diagnosis of acute appendicitis by USG, 45 (19%) had a negative diagnosis, and 141 (58%) had an inconclusive diagnosis; 17 patients (7%) had an alternative diagnosis suggested by USG.

Of the 56 patients who had a positive diagnosis of acute appendicitis by USG, 41 (73%) were found to have a positive diagnosis by pathology, 9 patients (16%) had a negative diagnosis by pathology and 6 (11%) had symptoms that subsided with conservative treatment (Table 1). The pathological diagnoses for the 9 patients with a negative diagnosis included diverticulitis of the appendicular diverticulum (2), periappendicitis (1), serositis (1), hyperplastic polyp of the appendix (1), acute pelvic inflammatory disease (1), intestinal obstruction due to adhesion (1), and no inflammation (2).

Of the 45 patients with a negative diagnosis of acute appendicitis by USG, no patients (0%) had a positive diagnosis by pathology; 5 patients (11%) had a negative diagnosis by pathology and 40 (89%) had symptoms that subsided with conservative treatment.

Of the 141 patients with an inconclusive diagnosis of acute appendicitis by USG, 13 (9%) had a positive diagnosis by pathology; 14 patients (10%) had a negative diagnosis by pathology, 110 (78%) had symptoms that subsided with conservative treatment, 2 (1%) discharged themselves

against medical advice and were lost to follow-up, and 2 (1%) had pelvic inflammatory disease.

Seventeen alternative diagnoses were suggested by USG, including adnexal mass (11 — 5 on the right side, 6 on the left side), right hydronephrosis (1), right rectus haematoma (1), hepatobiliary diagnoses (suspicious gallstone ileus confirmed by subsequent computed tomography [CT], acute cholecystitis, or large liver tumour; 3), and right upper quadrant mass (1) that proved to be carcinoma of the caecum in a subsequent operation.

Twenty nine patients (12%) underwent CT on the basis of the USG report, 6 of whom had a positive diagnosis for acute appendicitis, 5 had a negative diagnosis, and 18 had an alternative diagnosis suggested. Of the 16 patients who were advised to undergo CT by the radiologist performing USG, 3 did not undergo subsequent CT — 1 had appendectomy with a negative pathological diagnosis, and 2 had symptoms that subsided with conservative treatment. Of the 13 patients who subsequently underwent CT, 3 had appendicitis confirmed by CT, 1 of which was complicated by rupture, and 10 had a negative diagnosis of acute appendicitis, but alternative diagnoses were provided. The alternative diagnoses included genitourinary diagnoses of acute pyelonephritis (1), right ovarian tumour (1), pelvic inflammatory disease (1), right lower quadrant cystic lesion (clinically bleeding corpus luteal cyst; 1), and left adnexal mass (1); and gastrointestinal diagnoses of carcinoma of the caecum (1), caecal diverticulitis (2), gallstone ileus (1), and terminal ileal thickening and enlarged lymph node (mesenteric adenitis; 1).

Of 16 patients (7%) who underwent CT on the advice of a clinician after USG examination, 3 had a positive diagnosis of acute appendicitis, 5 had a negative diagnosis with no significant pathology, and 8 had a negative diagnosis, but alternative diagnoses were provided. The alternative diagnoses included pneumoperitoneum (1), carcinoma of the cervix with right hydronephrosis and hydroureter (1), right ovarian mass (1), small bowel volvulus (1), ascending colon diverticulitis (1), inflammatory changes in the right abdomen (torsion of

Table 1. Diagnostic accuracy of ultrasonography for acute appendicitis.

Diagnosis	Ultrasonography diagnosis	Pathological diagnosis	Number of patients
True positive	Positive	Positive	41
False positive	Positive	Negative or subsided with conservative treatment	15
True negative	Negative	Negative or subsided with conservative treatment	45
False negative	Negative	Positive	0

Table 2. Calculation for sensitivity, specificity, positive predictive value, and negative predictive value of ultrasonography for acute appendicitis.

	Formula	Calculation	Result
Sensitivity	TP/(TP+FN)	41/(41+0)	100%
Specificity	TN/(FP+TN)	45/(15+45)	75.0%
Positive predictive value	TP/(TP+FP)	41/(41+15)	73.2%
Negative predictive value	TN/(FN+TN)	45/(0+45)	100%

Abbreviations: FN = false negative; FP = false positive; TN = true negative; TP = true positive.

omentum at operation; 1), acute cholecystitis (1), and tuberculous peritonitis (1).

Overall, 6 patients had a positive diagnosis for acute appendicitis by CT, 5 had a negative diagnosis, and 18 had alternative diagnoses provided.

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of USG for acute appendicitis were calculated after excluding the patients with an inconclusive diagnosis by USG. The sensitivity, specificity, PPV, and NPV of USG for acute appendicitis were 100%, 75.0%, 73.2%, and 100%, respectively (Table 2).

DISCUSSION

When compared with data in the literature, there is disparity for the performance of USG for the diagnosis of acute appendicitis in this study. Gaitini et al reported sensitivity, specificity, PPV, and NPV of USG for acute appendicitis as 74.2%, 97.0%, 88.0%, and 93.0%, respectively.⁶ Chan et al reported the sensitivity, specificity, PPV, and NPV of USG for acute appendicitis as 83%, 95%, 86%, and 94%, respectively.⁷ Other prospective studies have reported sensitivity of 77% to 89% and specificity of 84% to 96%.⁸⁻¹² The discrepancy in the performance of USG with this study could be attributed to the high percentage of inconclusive diagnoses (58.3%) as the percentage of inconclusive diagnoses in other studies was small (4%)⁶ or non-existent.⁷

Therefore, if the negative diagnosis of acute appendicitis by USG was redefined as no positive diagnosis (negative and inconclusive diagnoses), the adjusted values for sensitivity, specificity, PPV, and NPV of USG for acute appendicitis in this study would be 75.9%, 89.7%, 73.2%, and 91.0% respectively (Table 3). The performance of USG in this study is then comparable to the data reported in the literature.

In this study, 12% of patients subsequently underwent CT, suggested by radiologists performing USG or

Table 3. Calculation of adjusted values for sensitivity, specificity, positive predictive value, and negative predictive value of ultrasonography for acute appendicitis.

	Formula	Calculation	Result
Sensitivity	TP/(TP+FN)	41/(41+13)	75.9%
Specificity	TN/(FP+TN)	131/(15+131)	89.7%
Positive predictive value	TP/(TP+FP)	41/(41+15)	73.2%
Negative predictive value	TN/(FN+TN)	131/(131+13)	91.0%

Abbreviations: FN = false negative; FP = false positive; TN = true negative; TP = true positive.

initiated by clinicians. There was a high rate of confirmation of the diagnosis of acute appendicitis and suggestion of alternative diagnosis (82.8%). Therefore, CT is complementary to USG for diagnosing acute appendicitis and for the management of patients with right lower quadrant pain.

There are limitations to this study. First, this was a retrospective study. Second, the criteria for a positive USG diagnosis of acute appendicitis included local tenderness corresponding to the USG abnormality, while only morphological criteria were mentioned in other large-scale studies.^{6,7} This could reduce the false-positive rate, but potentially increased the rate of inconclusive diagnoses of acute appendicitis. Third, some patients had self-limiting symptoms.^{13,14} Fourth, the position of the appendix, particularly retrocaecal or pelvic positions, can affect the rate of visualisation. However, the position of the appendix could not be studied in this audit as this was not documented in the majority of the operative records. Fifth, factors affecting the selection of USG or CT by the referring surgeons were not assessed. Sixth, body build, in the form of obesity that can affect scanning accuracy, was not assessed.

Staff training and modification of the scanning technique could improve the performance of USG for diagnosing acute appendicitis. The posterior manual compression technique has been shown to increase the rate of visualisation of the appendix and is useful for visualising a retrocaecal appendix.¹⁵ This technique involves forced extrinsic compression of the right lower quadrant of the abdomen to the opposite side of the transducer in the anterior or anteromedial direction using the palm and 4 fingers of the left hand. The technique enables compression of the posterior aspects of the caecum or pericaecal space with or without anteromedial displacement of the right lower quadrant bowel structures onto the psoas muscle. The force of the compression and the location of the left hand are dynamically changed, which helps to reach a sufficient depth by a high-frequency transducer, thereby increasing the spatial resolution.

The overall performance of USG for investigation of acute appendicitis in this study is comparable to the data reported in the literature. USG is a useful and safe imaging modality for investigation of acute appendicitis. CT has a complementary role to USG for the diagnosis of acute appendicitis and for the management of patients with right lower quadrant pain.

REFERENCES

1. John H, Neff U, Kelemen M. Appendicitis diagnosis today: clinical and ultrasonic deductions. *World J Surg.* 1993;17:243-9.
2. Lally KP, Cox CS Jr, Andrassy RJ. Appendix. In: Townsend CM Jr, Mattox KL, Evers BM, et al, editors. *Sabiston textbook of surgery.* 17th ed. New York: Saunders; 2004. p 1381-95.
3. Jones PF. Suspected acute appendicitis: trend in management over 30 years. *Br J Surg.* 2001;88:1570-7.
4. Lee SL, Walsh AJ, Ho HS. Computed tomography and ultrasonography do not improve and may delay the diagnosis and treatment of acute appendicitis. *Arch Surg.* 2001;136:556-61.
5. Keyzer C, Zalcman M, De Maertelaer V, et al. Comparison of US and unenhanced multi-detector row CT in patients suspected of having acute appendicitis. *Radiology.* 2005;236:527-34.
6. Gaitini D, Beck-Razi N, Mor-Yosef D, et al. Diagnosing acute appendicitis in adults: accuracy of color doppler sonography and MDCT compared with surgery and clinical follow up. *AJR Am J Roentgenol.* 2008;190:1300-6.
7. Chan I, Bikkell SG, Graham M. Utility and diagnostic accuracy of sonography in detecting appendicitis in a community. *AJR Am J Roentgenol.* 2005;184:1809-12.
8. Franke C, Böhner H, Yang Q, Ohmann C, Röher HD. Ultrasonography for the diagnosis of acute appendicitis: results of a prospective multicenter trial. *Acute Abdominal Pain Study Group. World J Surg.* 1999;23:141-6.
9. Balthaza E, Birnbaum B, Yee J, Megibow A, Roshkow J, Gray C. Acute appendicitis: CT and US correlations in 100 patients. *Radiology.* 1994;190:31-5.
10. Puylaert JB, Rutgers PH, Lalisang RI, et al. A prospective study of ultrasonography in the diagnosis of appendicitis. *N Engl J Med.* 1987;317:666-9.
11. Puylaert JB. Acute appendicitis: US evaluation using graded compression. *Radiology.* 1986;158:355-60.
12. Kessler N, Cyteval C, Gallix B, et al. Appendicitis: evaluation of sensitivity, specificity, and predictive values of US, Doppler US, and laboratory findings. *Radiology.* 2004;230:472-8.
13. Migraine S, Atri M, Bret PM, Lough JO, Hinchey JE. Spontaneously resolving acute appendicitis: clinical and sonographic documentation. *Radiology.* 1997;205:55-8.
14. Cobben LP, de van Otterloo AM, Puylaert JB. Spontaneously resolving acute appendicitis: frequency and natural history in 60 patients. *Radiology.* 2000;215:349-52.
15. Lee HJ, Jeong YK, Hwang JC, Ham SY, Yang SO. Graded compression sonography with adjuvant use of a posterior manual compression technique in the sonographic diagnosis of acute appendicitis. *AJR Am J Roentgenol.* 2002;178:863-8.