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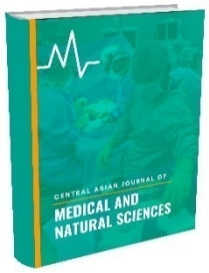

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# Ultrasound Examination for the Diagnosis of Acute Appendicitis

1. **Ataeva Saodat Khurshedovna**
2. **Umarkulov Zabur Zafarjonovich**

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*Accepted 9th Feb 2022,*
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[1,2] Samarkand State Medical Institute, Department of Medical Radiology, Republic of Uzbekistan, Samarkand

**Abstract: Objective:** to determine the usefulness and accuracy of ultrasound for the diagnosis of acute appendicitis.

**Methods.** This retrospective study included 242 of 286 patients who underwent 2021 appendix ultrasound. The ultrasound report, pathology report, and clinical records were reviewed. The pathology report has been used as the gold standard for diagnosing acute appendicitis.

**Results:** The overall rate of visualization of the appendix was 41.7%. Fifty-six patients (23%) had a positive diagnosis of acute appendicitis on ultrasound, 45 (19%) had a negative diagnosis, and 141 (58%) had an inconclusive diagnosis; 17 patients (7%) had an alternative diagnosis suggested by ultrasound. Twenty-nine patients (12%) underwent a CT scan based on the ultrasound report, 6 of whom had a positive diagnosis of acute appendicitis, 5 had a negative diagnosis, and 18 had an alternative diagnosis suggested by the CT scan. Sensitivity, specificity, positive predictive value, and negative predictive value of US for acute appendicitis were 75.9%, 89.7%, 73.2%, and 91.0%, respectively, after adjusted calculation for the US inconclusive group.

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

**Keywords:** appendicitis; Diagnostic imaging; Ultrasound echography.

## INTRODUCTION

Acute appendicitis is a common problem, but diagnosis is often difficult. The accuracy of the clinical examination ranges from 71% to 97%, depending on the experience of the surgeon. The perforation rate reaches 35% if surgery is delayed. The reported incidence of appendectomy without appendicitis (negative appendectomy) is 20% to 30%. However, imaging can reduce the rate of negative appendectomy to 6–10%. Imaging assessment for suspected acute appendicitis in adults is becoming increasingly popular. This study was performed to determine the applicability and accuracy of ultrasonography (ultrasound) for the diagnosis of acute appendicitis.

**Methods.** This retrospective study included 286 patients with exam code 3102 (ultrasound) of the radiological information system from June 1, 2006 to December 31, 2006. Forty-four patients were excluded, most of whom were children with pyloric stenosis or intussusception. The study included 242 patients.

The US graded compression technique was used. US diagnostic criteria for acute appendicitis included abnormal appendix morphology (>6 mm enlargement, lack of compressibility, and blind end) and associated local tenderness on probe compression. The pathology report has been used as the gold standard for diagnosing acute appendicitis. Patient outcomes were tracked from electronic records in the Clinical Management System.

**Results.** The median age was 38.5 years (2 to 93 years). There were 65 men and 177 women with a ratio of 1.0:2.7. At the time of the ultrasound, four patients were pregnant. All 4 patients were given an inconclusive ultrasound diagnosis of acute appendicitis, in 2 of which the symptoms disappeared spontaneously, and in 2 patients, they were discharged on their own against the doctor's recommendations and were lost to follow-up.

213 patients were referred from the surgical department, 9 from the pediatric department, 10 from the obstetrics and gynecology department and 10 from the medical department.

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

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

Of the 56 patients who had a positive diagnosis of acute appendicitis on ultrasound, 41 (73%) had a positive pathology, 9 patients (16%) had a negative pathology, and 6 (11%) had symptoms. this disappeared with conservative treatment (Table 1). Pathological diagnoses for 9 patients with a negative diagnosis included diverticulitis of the appendicular diverticulum (2), periappendicitis (1), serositis (1), hyperplastic appendix polyp (1), acute pelvic inflammatory disease (1), intestinal obstruction. due to adhesion (1) and absence of inflammation (2).

Of the 45 patients with a negative ultrasound diagnosis of acute appendicitis, none (0%) had a positive pathology diagnosis; In 5 patients (11%) the diagnosis was pathologically negative, and in 40 (89%) the symptoms disappeared with conservative treatment.

Of 141 patients with an inconclusive ultrasound diagnosis of acute appendicitis, 13 (9%) had a positive pathological diagnosis; 14 patients (10%) had a pathology-negative diagnosis, 110 (78%) had symptoms resolved with conservative management, 2 (1%) were discharged against medical advice and were lost to follow-up, and 2 (1%) had inflammatory organ disease small pelvis.

Ultrasound suggested seventeen alternative diagnoses, including adnexal formation (11-5 on the right, 6 on the left), hydronephrosis on the right (1), hematoma of the rectus muscle on the right (1),

hepatobiliary diagnosis (suspicious ileus of the gallbladder, confirmed by subsequent computer studies). tomography [CT], acute cholecystitis, or a large liver tumor; 3) and a mass in the right upper quadrant (1) that turned out to be caecal carcinoma on subsequent surgery.

Twenty-nine patients (12%) underwent CT based on the USG report, 6 of them had a positive diagnosis of acute appendicitis, 5 had a negative diagnosis, and 18 were offered an alternative diagnosis. Of the 16 patients advised by a radiologist to undergo a CT scan performed by ultrasound, 3 did not undergo a follow-up CT—1 had an appendectomy with a negative pathological diagnosis, and 2 had symptoms resolved with conservative management. Of the 13 patients who subsequently underwent CT, 3 had CT-confirmed appendicitis, 1 had a complicated rupture, and 10 had a negative diagnosis of acute appendicitis but were provided with alternative diagnoses. Alternative diagnoses included genitourinary diagnosis: acute pyelonephritis (1), right ovarian tumor (1), pelvic inflammatory disease (1), right lower quadrant cystic lesion (clinically bleeding corpus luteum cyst; 1), and left adnexal mass (1); and gastrointestinal diagnoses: caecal cancer (1), caecal diverticulitis (2), biliary ileus (1), ileal thickening and enlarged lymph nodes (mesenteric adenitis; 1).

Of the 16 patients (7%) who underwent a clinician-recommended CT scan after an ultrasound 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 had alternative diagnoses. provided. Alternative diagnoses included pneumoperitoneum (1), cervical cancer with right hydronephrosis and hydroureter (1), right ovarian mass (1), small bowel volvulus (1), ascending colon diverticulitis (1), inflammatory changes in the right abdominal cavity (omental torsion during surgery; 1), acute cholecystitis (1) and tuberculous peritonitis (1).

**Table 1.** Diagnostic accuracy of ultrasonography of acute appendicitis.

| Diagnostics | Ultrasound diagnostics | Pathological diagnosis | Number of patients |
|---|---|---|---|
| Truly | Positive | Positive | 41 |
| False positive | Positive | Negative or disappeared after conservative treatment | 15 |
| True negative | Negative | Negative or disappeared after conservative treatment | 45 |
| False positive | Negative | Positive | 0 |

**Table 2.** Calculation of sensitivity, specificity, positive and negative predictive value of ultrasound examination of acute appendicitis**.**

| | Formula | Payment | 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.
Overall, 6 patients had a positive CT diagnosis of acute appendicitis, 5 had a negative diagnosis, and 18 had alternative diagnoses.

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

**Discussion.** Compared to data in the literature, there is inconsistency in the efficacy of ultrasound in diagnosing acute appendicitis in this study. Gaitini et al. Reported sensitivity, specificity, PPV, and NPV for acute appendicitis were 74.2%, 97.0%, 88.0%, and 93.0%, respectively. Chan et al. reported sensitivity, specificity, PPV, and NPV for acute appendicitis as 83%, 95%, 86%, and 94%, respectively. Other prospective studies have reported sensitivity of 77% to 89% and specificity of 84% to 96%. The discrepancy in US performance with this study can be explained by the high percentage of inconclusive diagnoses (58.3%), since the percentage of inconclusive diagnoses in other studies was small (4%) 6 or absent.

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

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

| | Formula | Payment | 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% |

**Abbreviations:** FN = false negative; FP = false positive; TN = true negative; TP = true positive.
In this study, 12% of patients subsequently underwent CT on the recommendation of the radiologist performing the ultrasound or on the initiative of the clinicians. There was a high rate of confirmation of the diagnosis of acute appendicitis and suggestion of an alternative diagnosis (82.8%). Thus, CT complements US for diagnosing acute appendicitis and treating patients with right lower quadrant pain.

This study has limitations. First, it was a retrospective study. Second, criteria for a positive ultrasound diagnosis of acute appendicitis included local tenderness consistent with ultrasound abnormality, while other large-scale studies only mentioned morphological criteria. This could reduce the number of false positives, but potentially increase the number of inconclusive diagnoses of acute appendicitis. Third, some patients exhibited self-limiting symptoms. Fourth, the position of the process, especially retrokecal or pelvic, can affect imaging speed. However, the position of the application could not be examined during this audit as it was not documented in most operational records. Fifth, factors influencing the choice of US or CT by referring surgeons were not assessed. Sixth, obese body type, which may affect the accuracy of the scan, was not assessed.

Staff training and modification of scanning technique may improve the effectiveness of ultrasound in diagnosing acute appendicitis. The posterior manual compression technique has been shown to increase the speed of process visualization and is useful for visualizing the retrochecal process. This method involves forced external compression of the right lower quadrant of the abdomen on the opposite side of the transducer in an anterior or anteromedial direction using the palm and 4 fingers of the left hand. The technique allows compression of the posterior part of the caecum or the perikecal space with or without anteromedial displacement of the structures of the right lower quadrant of the intestine onto the psoas muscle. The grip force and position of the left hand are dynamically changed, which helps to achieve sufficient depth by the high frequency transducer, thereby increasing the spatial resolution.

The overall performance of ultrasonography for the investigation of acute appendicitis in this study is comparable to that reported in the literature. Ultrasound is a useful and safe imaging modality for investigating acute appendicitis. CT complements US in the diagnosis of acute appendicitis and in the management of patients with right lower quadrant pain.

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