Original Article

Acute Appendicitis: Diagnostic Algorithm Using Routine Ultrasonography and Optional Computed Tomography

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Objective: To access the algorithm in diagnosis of acute appendicitis, using routine ultrasonography and optional computed tomography (CT).

Material and Methods: It was prospective study of 128 patients presenting in emergency department with complaint of pain right lower quadrant of abdomen. After clinical evaluation and lab investigations, ultrasonography abdomen was done for all patients. If provisional diagnosis was made on these bases, treatment was started. If ultrasonography findings were negative or inconclusive, CT was done with intravenous contrast. The final diagnosis was made by ultrasonography/CT report, operative findings, histopathology report of the removed specimen and outcome of the treatment.

Results: After completion of initial clinical workup and ultrasonography, we were able to make provisional diagnosis in 90 patients. Ultrasonography showed inflamed appendix in 76 patients, alternate diagnosis in 14 patients and in 38 patients report was normal or inconclusive. CT was done in these 38 patients. CT scan showed inflamed appendix in 15 patients and alternative diagnosis in 4 patients. In 19 patients CT report was normal. 91 patients were operated for open appendectomy. In 85 patients, inflamed appendix was proved on histopathology and in 6 patients, appendix was normal. Accuracy of clinical diagnosis alone was 81%, with Ultrasonography was 85%, with CT was 97% and accuracy of whole diagnostic pathway was 95%.

Conclusion: In suspected case of acute appendicitis, diagnosis algorithm using routine ultrasonography and optional CT yields high diagnostic accuracy. Patients with normal ultrasonography and CT findings can be safely observed.

Key words: Acute appendicitis, ultrasonography, computed tomography

Introduction

Acute pain right lower quadrant of abdomen is a common chief complain in clinical practice. The differential diagnosis of right lower quadrant pain includes broad spectrum of clinical entities that range from self-resolving nonspecific pain to diseases with high morbidity. In about 30% of patients no diagnosis is made and symptoms resolve spontaneously.[1] It is important to separate these cases from those who need emergency surgery. Acute appendicitis is the most common cause of acute pain right lower quadrant, and appendectomy is the most common surgical procedure performed for pain abdomen.[2] The overall diagnostic accuracy achieved by traditional history, physical examination, and laboratory tests has been approximately 80 percent.[3] The ease and accuracy of diagnosis varies by the patient's age and sex, and is more difficult in women of childbearing age, children, and elderly persons. About 20-33 percent of patients of acute appendicitis present atypically[1] and delay in diagnosis of these patients may lead to perforation of appendix with increased morbidity and mortality. The mortality rate of appendicitis jumps from less than 1 percent in non-perforated cases to 5 percent or higher when perforation occurs.[4] To prevent high morbidity and mortality, surgeons have traditionally accepted higher rate of negative appendectomies.[4] Historically, negative appendectomy rates of 1020 percent have been accepted. Negative appendectomy rates of up to 40% have been reported in women of child-bearing age.[4,6,7] However there are significant clinical and financial costs incurred by patients undergoing negative appendectomy.[8] the medical and economic consequences of this approach are

difficult to justify in the current cost effective healthcare environment. In order to improve the diagnostic accuracy, many imaging techniques have been used including barium enema, ultrasonography, computed tomography (CT) and Magnetic Resonance Imaging (MRI). The ultrasonography as imaging modality in acute appendicitis was first popularized by Puylaert in 1986.[9,10] The use of CT in the diagnosis of acute appendicitis began in 1990 but its popularity increased with landmark study by Rao and colleagues published in 1998.[11,12] Further studies popularized CT scan as better imaging modality than ultrasonography because CT scan results showed high sensitivity, specificity and decreased negative appendectomy rate.[13-15] With the increased use of CT, concern has also increased about the effects of radiation exposure, particularly since the majority of the patients undergoing imaging for suspected acute appendicitis are relatively young. A few studies have used algorithms with ultrasonography as primary imaging modality after clinical evaluation and CT was reserved for cases where ultrasonography was inconclusive or negative.[16-18]

Materiel and Methods

This prospective study was carried at Prince Abdal Rahman Al Sudairi Central Hospital Sakakah, Al Jauf, Saudi Arabia, from July, 2010 to June, 2011. Patients presented in emergency department of hospital with acute pain right lower quadrant abdomen were included. Children 12 years and below, pregnant patients, and patients discharged from emergency department by treating physician without diagnostic imaging were not included. Also patients with renal failure and contrast medium allergy were excluded.

All patients had medical history, complete physical examination and basic laboratory investigations. A provisional diagnosis was made on these findings and recorded. Ultrasonography of abdomen was done for all patients by radiologist. If provisional diagnosis was made after ultrasonography, treatment was started. If ultrasonography findings were negative or inconclusive, CT was done with intravenous contrast. No oral or rectal contrast was used. CT findings were reported by the radiologist. The final diagnosis was made by ultrasonography/CT report, operative findings, histopathology report of the removed specimen and outcome of the treatment. All patients were followed for two months.

Results

128 patients were included in study. The mean age was 28 years (range from 12 to 51 years). Male were 52% of total and 48% were females. After completion of initial clinical work up and ultrasonography, we were able to make provisional diagnosis in 90 patients. Ultrasonography showed inflamed appendix in 76 patients, alternate diagnosis was made in 14 patients and in 38 patients report was normal or inconclusive. CT was done in these 38 patients. CT scan showed inflamed appendix in 15 patients and alternative diagnosis in 4 patients. In 19 patients CT report was normal. For statistical purpose, alternate diagnoses were taken as true negative as regards acute appendicitis of total 128 patients, 116 patients were admitted for surgery/observation and 12 patients were referred to other specialties. The referred patients were also followed with the treating physician. Total 91 patients were operated for open appendectomy. In 8 patients, appendix was looking normal per-operatively. So alternative pathology was searched, and in one patient, enlarged mesenteric lymph nodes were found. One was excised for histopathology. Appendectomy was done in all operated patients and specimen sent for histopathology. On histopathology acute appendicitis was confirmed in 85 patients and in 6 patients appendix was normal.

Table-1: Number of patients in all diagnostic modalities

Modality	No. Of Patients
Clinical dignoesis	128
Ultrasonography	128
CT Scan	38
Study of Algorithm	128

Table-2: Final diagnosis for all patients.

Diagnosis	No. Of Patients
Acute Appendicitis	85
INon-Specific Abdominal Pain*	24
Gynecological Disorders**	08
Right Ureteric Stone	05
Mesenteric Lymphadenitis	04
Crohn's Disease	02
Total	128

**Non-specific abdominal pain (NSAP) is not truly a diagnosis but merely negative patients, without disease. **Ovarian cyst, pelvic nflammatory disease, ovulation pain and tubo-ovarian abscess.*

Table-3: True & false positive and true & false negative for diagnostic modalities .

Diagnosis	No. Of Patients	True Positive	False Positive	True Negative	False Nagative
Clinical Diagnosis	128	72	17	26	13
Ultrasonography	128	71	05	38	14
CT Scan	38	14	01	23	Nil
Study algorithm	128	85	06	37	Nil

Table-4: Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Accuracy of Diagnostic Modalities.

Modality	No. Of Patients	Sensitvity	Specificity	PPTV	NPV	Accuracy
Clinical Diagnosis	128	91%	60%	82%	79%	81%
Ultrasonography	128	84%	88%	93%	73%	85%
CT Scan	38	100%	96%	93%	100%	97%
Study algorithm	128	100%	86%	93%	100%	95%

Patients with normal CT scan report were also admitted under observation their symptoms relieved on conservative treatment. All patients were followed for two months. **Table 1** shows number of patients in all diagnostic modalities.There was no mortality. **Table-2** shows the list of final diagnosis of 128 patients. Sensitivity, specificity, positive productive value (PPV), negative productive value (NPV) and accuracy was calculated for clinical diagnosis alone, with ultrasonography, with CT scan and for whole study algorithm. This comparison is shown in **Table 3** and **4.**

Discussion

Ultrasonography and CT scan both have proven diagnostic value in suspected cases of acute appendicitis. The choice between ultrasonography and CT depends upon available expertise and institutional preference. Ultrasonography is rapid, noninvasive and inexpensive means of imaging inflamed appendix.[9] it doesn't need contrast material administration and not associated with exposure to ionizing radiation. As the examination is interactive, the patient can point to the most tender area and help in diagnosis. Ultrasonography is especially useful in pregnant patients, women of childbearing age and children. Difficulties with ultrasonography include the fact that a normal appendix must be identified to rule out acute appendicitis.[19] M Rioux, in 1992, claimed that he clearly identified normal appendix in102 (82%) of 125 patients without acute appendicitis[20], but most observers report that normal appendix is women of childbearing age and children. Difficulties with ultrasonography include the fact that a normal appendix must be identified to rule out acute appendicitis.[19]M Rioux, in 1992, claimed that he clearly identified normal appendix in102 (82%) of 125 patients without acute appendicitis[20], but most observers report that normal appendix is visualized in small minority of cases.[9,21]A normal appendix, when visualizes, appears as blind-ending tubular structure 5 mm or less in diameter. A confident diagnosis of acute appendicitis is made if non-compressible appendix measuring 7 mm or more in antero-posterior diameter is visualized.[21,22] Appendixes measuring between 5 to 7 mm are borderline in size. Visualization of normal appendix is more difficult in retrocecal appendix, in overweight patients and in presence of ileus. It is operator dependent technique and sensitivity and specificity varies between operators. Also tenderness at the area prevents compression by ultrasonography probe and limits examination. CT demonstrates superior sensitivity and specificity as compared to ultrasonography. The accuracy of CT relies in part on its ability to reveal a normal appendix better than ultrasonography. An inflamed appendix revealed on CT is larger than 6 mm in diameter with wall thickening, periappendiceal fat stranding and wall enhancement after contrast media infusion.[23] Disadvantages of CT include possible contrast-media allergy, exposure to ionizing radiation, and cost. However, the cost is considerably less than that of removing a normal appendix or hospital observation.[24]In our study, out of 128

patients, 85 were confirmed positive and 43 were negative as regards acute appendicitis. Clinical diagnosis had high sensitivity (91%), but low specificity (60%), i.e., lot of false positive cases. PPV, NPV and accuracy for clinical diagnosis was 82, 79 and 81 percent respectively. Keeping low threshold for making diagnosis of acute appendicitis during clinical examination increases the sensitivity (few missed cases) but decreases specificity (more negative appendectomies). Keeping high threshold has the effect vice versa. Ultrasonography was helpful in decreasing the false positive cases i.e., decreasing negative appendectomy rate. In our study sensitivity, specificity and accuracy of ultrasonography was 84, 88 and 85 percent respectively. Low sensitivity of ultrasonography is due to inability to visualize the appendix in every patient. Studies have shown the sensitivity and specificity of ultrasonography as 77-99 and 81-95 percent respectively.[13,17,22,25] We did CT scan in 38 patients. There was one false positive case but there was no false negative. Sensitivity and specificity of CT scan was 100 and 96 percent respectively with accuracy of 99%. In literature sensitivity and specificity of CT scan is reported as 87-100 and 83-100 percent respectively in diagnosis of acute appendicitis.[1,3,13,17] In our study algorithm i.e clinical evaluation followed by ultrasonography in all cases and CT scan in selected patients, the sensitivity and specificity was 100 and 86 percent respectively and accuracy was 95%. Negative appendectomy rate was 4.7% and there was no missed case of acute appendicitis. Studies following this algorithm have shown pathway sensitivity and specificity 97-100 and 86 percent respectively and negative appendectomy rate 3-8%.[16,17,18]

Conclusion

In suspected case of acute appendicitis, diagnosis algorithm using routine ultrasonography and optional CT yields high diagnostic accuracy. Although ultrasonography has low accuracy than CT, it can be used as primary imaging modality, avoiding disadvantages of CT. CT can be used where ultrasonography is negative or inconclusive. Patients with normal ultrasonography and CT findings can be safely observed.

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