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Non-contrast Spiral Computed Tomography in Diagnosis of Acute Appendicitis

Background/Objective: Approach to patients with acute right lower quadrant pain remains a clinical dilemma. Decreasing the risk of negative appendectomies is one of the major goals surgery units intend to achieve. This study has been conducted to determine the accuracy of non-contrast focused appendiceal computed tomography (CT) in preoperative diagnosis of acute appendicitis.

Patients and Methods: During a period of three months, 50 consecutive adult and adolescent patients who were clinically diagnosed as acute appendicitis were included in this study. Focused non-enhanced appendiceal spiral computed tomography (CT) was performed for all patients, preoperatively. Two radiologists who were unaware of the surgical findings assessed the CT scans.

Results: After the operation and pathologic assessment, eight patients with negative appendectomy were found. The sensitivity of CT was 0.71 and 0.83 according to the interpretations of the first and second radiologists, respectively. Moreover, its specificity was 0.88 and 0.75 according to the first and second radiologists' reports, respectively.

Conclusion: In patients with clinically diagnosed acute appendicitis, relying on abdominal CT is not helpful.

Keywords: tomography, x-ray computed, appendicitis, sensitivity and specificity, appendectomy

Introduction

The diagnostic method for acute appendicitis has not changed during the past years.1 So far, the three major arms for preoperative diagnosis of acute appendicitis include patients' history, clinical examinations, and basic laboratory tests.[1-3]

Many patients have a characteristic history and physical examination. However, sometimes patients present with non-classic features of the disease.[4-7] During the management of patients suspicious of acute appendicitis, one of the most important problems is managing those with negative appendectomies or advanced perforated appendicitis.[1-9] Therefore, it is imperative to diagnose patients with acute appendicitis quickly and accurately and to operate them to prevent further morbidities and mortalities.[9]

During recent years, decrease in the rate of negative appendectomies without increase in the perforation rate led physicians to use laparoscopy, ultrasonography, and abdominal computed tomography (CT) examinations as complementary diagnostic modalities.[1]

A proper diagnostic modality should be sensitive so that the surgeon can rely on its results and not perform the operation. Moreover, it should be specific enough to decrease the rate of negative appendectomies. The other part of the diagnosis is to provide information on other pathologic conditions when the test is negative for acute appendicitis.[8] On the other hand, centers which use these

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tests, should ideally have benchmarks to assure their accuracy.[10]

Many studies have been performed to evaluate the role of CT in patients with equivocal diagnosis of acute appendicitis.[11] To evaluate the role of CT in decreasing the rate of negative appendectomies, the best design is including patients who underwent appendectomy regardless of their CT findings. We conducted this study to determine the diagnostic accuracy of focal non-enhanced abdominal CT for the diagnosis of acute appendicitis, preoperatively.

Patients and Methods

In this study, 50 adult and adolescent patients who were candidates for appendectomy at Imam Khomeini Hospital, a referral medical center in Tehran, the capital of Iran, between May 2006 and July 2006, were included. This study was approved by Ethics Committee of Tehran University of Medical Sciences. Informed written consents were obtained from all the included patients. CT was performed just before appendectomy. We did not include patients with long-lasting abdominal pain, suspicious perforated appendicits, and unstable hemodynamics. The results of CTs were not included in the management of studied patients. Therefore, all patients were operated according to the decision of surgeons, based on history, physical examination and other paraclinical investigations (e.g., white blood cell count (WBC) and/or ultrasonography).

Axial scans were obtained in a single breath hold from L2 vertebral level to the symphysis pubis with 5-mm collimation and a pitch of 1.5. All scans were obtained without administration of oral, intravenous, or rectal contrast materials. Two radiologists who were blind to the surgical findings assessed CTs. Surgical operation was done regardless of CT findings.

Positive CT findings were defined as presence of at least one of the following findings: outer-to-outer diameter of appendix > 6 mm, appendicolith, periappendicular free fluid, fat stranding (dirty fat), phlegmon , and abscess (Figs. 1 and 2).[10,12]

Moreover, Alvarado score was calculated for each patient. The Alvarado score is a 10-point score based on: a) three symptoms, i.e., migration of abdominal pain to the right lower quadrant, anorexia, and nausea/vomiting; b) three signs, i.e., tenderness in the right lower quadrant of the abdomen, elevation of body temperature, and rebound tenderness in the right iliac fossa; and c) two laboratory findings, i.e., leukocytosis and neutrophilic shift to the left.[13]

Data were analyzed by SPSS ver. 11.5 (SPSS Inc, Chicago, IL, USA). Kappa statistics was used to report the agreement between the two radiologists' reports. Diagnostic indices including sensitivity (SE), specifity (SP), positive predictive value(PPV), negative predictive value (NPV), positive likelihood ratio (PLR), and negative likelihood ratio (NLR) were calculated for each radiologist.

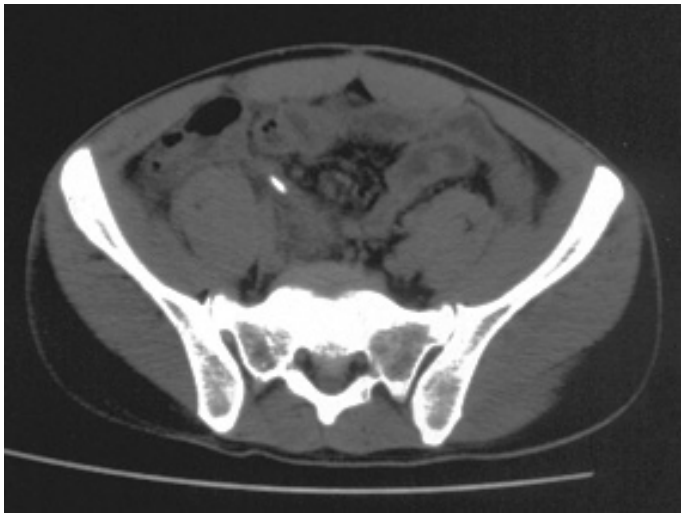

Fig. 1. CT image of a 25-year-old man with acute purulent appendicitis reveals an appendicolith, appendiceal diameter greater than 6 mm and periappendiceal inflammation.

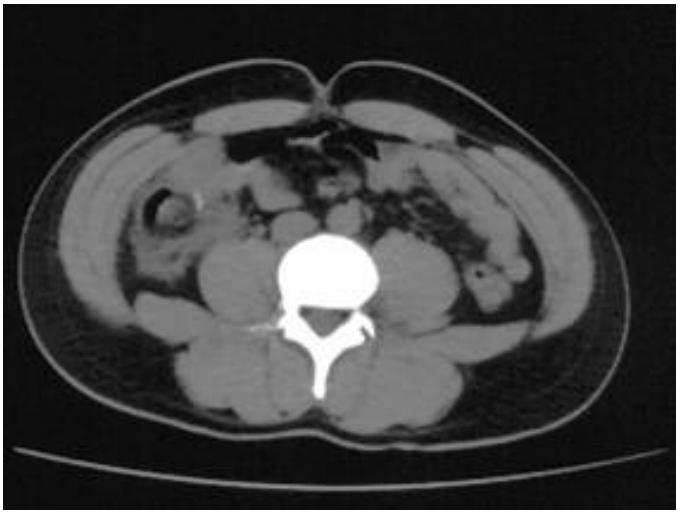

Fig. 2. CT image of a 33-year-old man with acute suppurative appendicitis shows an appendicolith, periappendiceal inflammation and fluid accumulation, and increased cecal wall thickness.

Table 1. Features of Patients with Negative Appendectomy

	Sex	Age	Alvarado Score	Shifting Pain	Nausea/ Vomiting	Anorexia	Tenderness of RLQ	Rebound Tenderness	Leukocytosis	CT Scan (Radiologist 1)	CT Scan (Radiologist 2)
Case 1	F	25	3	-	-	+	+	-	-	-	-
Case 2	F	30	9	-	+	+	+	+	+	-	-
Case 3	F	16	4	-	+	+	+	-	-	-	-
Case 4	F	21	6	-	+	+	+	+	-	+	+
Case 5	M	24	6	+	-	-	+	-	+	-	-
Case 6	M	26	3	-	+	-	+	+	-	-	-
Case 7	M	34	9	+	+	+	+	+	+	-	-
Case 8	M	23	8	-	+	+	+	+	+	-	+

F: female, M: male

+: positive finding, −: negative finding

Mann-Withney U test was hired to compare scorings. P value less than 0.05 was considered statistically significant.

Results

Fifty consecutive patients with clinically diagnosed acute appendicitis who were scheduled for appendectomy were included in this study. The median age of patients was 25 (range: 13–76) years. Thirty-seven (0.74) patients were men.

Among the operated patients, eight (0.16) were those with negative appendectomies. There was no patient with an Alvarado score less than 5 among positive appendectomies.

The mean (±SD) Alvarado score among positive and negative appendectomies was 7.7±1.5 and 6±2.5, respectively (P=0.08);

Demographic, clinical, and radiologic features of patients with negative appendectomy are summarized in Table 1.

The sensitivity and specificity of CT scan was 0.71 and 0.88 for the first radiologist and 0.83 and 0.75 for the second radiologist. Other diagnostic values of non-contrast focused spiral CT are shown in Table 2.

One of the patients with negative appendectomy was a case of ruptured ovarian cyst who was presented with dirty fat, and was misdiagnosed as acute appendicitis in her abdominal CT. In other patients with normal appendix, no pathology was diagnosed intraoperatively.

There was a moderate agreement (κ=0.55, SE=0.12) between the two radiologists in interpretation of abdominal CT (Table 3).

Table 2. Diagnostic Value of Non-contrast Focused Spiral CT in Confirmation of the Diagnosis among Patients with Clinically Diagnosed Acute Appendicitis

	TP	FN	TN	FP	SE (95% CI)	SP (95% CI)	PPV (95% CI)	NPV (95% CI)	PLR (95% CI)	NLR (95% CI)
Radiologist 1	30	12	7	1	0.71 (0.55-0.84)	0.88 (0.47-0.99)	0.97 (0.83-0.99)	0.37 (0.16-0.62)	5.7 (0.9-36.1)	3.1 (1.8-5.3)
Radiologist 2	35	7	6	2	0.83 (0.69-0.93)	0.75 (0.35-0.97	0.95 (0.82-0.99)	0.46 (0.19-0.75)	3.3 (1-11.2)	4.5 (2.1-9.9)

TP: True Positive, **FN**: False Negative, **TN**: True Negative, **FP**: False Positive, **SE**: Sensitivity, **SP**: Specificity, **PPV**: Positive Predictive Value, **NPV**: Negative Predictive Value, **PLR**: Positive Likelihood Ratio, **NLR**: Negative Likelihood Ratio

Table 3. Frequency of CT Findings according to the Radiologists' Interpretation

	Positive appendectomy		Negative appendectomy	
	Radiologist 1	Radiologist 2	Radiologist 1	Radiologist 2
Appendicolith	8	6	-	-
Diameter of appendix > 6 mm	18	13	1	1
Dirty fat	29	33	1	2
Periappendiceal fluid accumulation	4	-	-	-
Phlegmon	1	-	-	-
Abscess	1	-	-	-
Positive CT report*	30	35	1	2

* positive if at least one of the above six features was present

Discussion

Acute appendicitis is one of the most common and urgent causes of abdominal surgery. It does not have a unique manifestation, and sometimes overlaps with other clinical conditions. There is no single sign, symptom, or diagnostic test which confirms its diagnosis; morbidity is increased with diagnostic delay. No surprise, the leading cause of successful malpractice claims is failure to diagnose patients with acute appendicitis. On the other hand, the surgeons should be careful to minimize the rate of negative appendectomy among their patients.[10,12]

A patient who presents with an acute abdominal pain migrating from the umbilicus to the right lower quadrant and tenderness in the right lower quadrant should be considered for appendectomy. In this setting, the expected diagnostic accuracy is not improved by imaging.[14]

The accepted rate of negative appendectomy is approximately 20%; it ranges from less than 10% to 34% as reported in different studies.[2,8] Whether CT can decrease negative appendectomy rate is under debate.[8]

A population-based study revealed that the negative appendectomy rates have not changed during the last two decades, in spite of the increasing number of imaging procedures performed.[15] On the other hand, many studies showed that those patients who undergo CT have a lower negative appendectomy rate in comparison with previous studies.[8,16] The investigators attribute this finding to inconsistent performance characteristics in different care settings and caution against over-reliance on CT and ultrasound in diagnosing appendicitis.[15]

In previous studies, data presented on the role of abdominal CT in preoperative diagnosis of acute appendicitis were generally gathered from patients with equivocal diagnosis, or on series of patients with either suggestive or equivocal appendicitis.[1,8,9,11,16,17] In either prospective or retrospective studies, the investigators assessed the role of CT besides clinical and basic laboratory findings; therefore, control groups were needed to provide an exact statistic about the accuracy of CT in such patients. Moreover, most of them assessed the role of non-focused contrast-mediated CT in the diagnosis of acute appendicitis.[11,17]

Use of new CT techniques with a minimized radiation dose seems reasonable. In this way, CT of regions below the lower pole of the right kidney decreases the overall radiation exposure; however, the level of radiation exposure to the gonads remains unchanged with this technique.[17] On the other hand, contrast-enhanced CT which is an accurate imaging technique is expensive and may cause delay in the diagnosis (due to the time needed for orally ingested contrast material to reach and opacify the ileocecal region).[16] Focused non-enhanced CT is relatively cheaper. It is independent to special operators and well tolerated even by very sick patients, with low exposure to radiation and minimal time needed for investigation.

The standard appendiceal CT is being performed with rectal contrasts;[18,19] most of the published studies in the field of focused appendiceal CT are contrast-based. Studies on non-enhanced focal CT are scarce.[16,20,21] Evaluation of the non-contrast focal CT in patients with clinically diagnosed appendicitis who

were scheduled for surgery was the unique feature of our study.

Regarding ethical issues, we cannot set up a study to compare the diagnostic accuracy of clinical judgment and CT scan for acute appendicitis and in the current study, we only assessed the diagnostic accuracy of CT scan for these patients. Thus, the result could be generalized only to the patients that have been clinically selected for appendectomy; this situation is exactly the condition that happens in a clinical setting. On the other hand, we encountered with low negative predictive value, which means we can not rely on negative results of non-contrast focused CT scan in this setting.

Malone, et al,[16] reported 0.93 accuracy rate of the test in diagnosing acute appendicitis after investigating 211 patients with lower abdominal pain of uncertain origin. They considered it as a useful test to diagnose appendicitis in patients with acute right lower quadrant abdominal pain.

Stacher, et al,[20] evaluated non-enhanced focused appendiceal spiral CT among 56 patients with clinically suspected acute appendicitis. They found that non-enhanced spiral CT was an accurate imaging technique for the initial examination of patients with suspected acute appendicitis with a sensitivity of 0.95, a specificity 1, an accuracy of 0.98, a positive predictive value of 1, and a negative predictive value of 0.97.

Horton, et al,[21] reported a specificity of 1 and a sensitivity of 0.97, after assessment of 49 patients suspected of acute appendicitis with atypical features who were randomly assigned to limited non-contrast CT,.

The lower diagnostic value of CT observed in our study in comparison with previous studies [16,20,21] was mainly due to the patients selection; we included patients who were scheduled for appendectomy—they were clinically-confirmed cases of acute appendicitis. Therefore, patients with suspected appendicitis who were mainly observed in the emergency room for final diagnosis were not our targets. Therefore, the findings of our study cannot be generalized to all patients with suspected acute appendicitis. Another reason which may decrease the accuracy of CT in our patients might be the experience of our radiologists in interpretation of appendiceal CTs. However, the small number of patients studied may be another reason too.

In conclusion, comparison of clinical criteria and briefly Alvarado scoring with CT findings showed that CT can not improve our diagnostic yield. We found that patients with typical appendicitis should be referred immediately to a surgeon and should undergo laparotomy without undergoing any diagnostic imagings.

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