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Diagnostic Outcome of Unenhanced Focused Computed Tomography in Acute Appendicitis

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Abstract
Background: *Acute appendicitis is one of the emergency surgeries. Confirming the diagnosis of acute appendicitis is challenging in those who present with atypical clinical features and non-specific physical findings. The newer techniques of ultrasonography (USG) and computed tomography (CT) are the promising diagnostics for evaluating patients with suspected acute appendicitis. We conducted a study to evaluate diagnostic performances of unenhanced focused CT in patients suspected of having acute appendicitis without a selection between typical and atypical clinical signs of acute appendicitis.*
Patients and Methods: *We enrolled (n=61) patients in a prospective observational study between 2008 and 2010 at the Department of Radio Diagnosis, Medical College, Thiruvananthapuram. Computed tomography (CT) examination was performed with four slice helical CT scanner (Asteion Toshiba) by means of a rapid thin-scanning technique.*
Results: *Out of 61 patients, 28 (45.9%) had acute appendicitis and 33 (54.1%) did not have appendicitis. CT diagnosed all 28 cases of appendicitis and 32 cases without appendicitis correctly. There was one false positive case.*
Conclusion: *Thus the present study, underscores that the unenhanced focused CT is accurate imaging modality in patients with suspected appendicitis.*
Keywords: *Acute appendicitis, computed tomography, radiology.*

Introduction

Acute appendicitis is the most common abdominal surgical emergency that can affect individuals of all ages [1]. An accurate diagnosis of acute appendicitis can be established with great confidence in the majority of patients, on the basis of history and physical examination. Sometimes, patients present with atypical clinical features and non-specific physical findings, and evaluation of these patients becomes challenging. The aim of investigations in patients with atypical clinical features and non-specific physical findings is to diagnose the condition as early as possible, in order to operate before appendiceal perforation and peritonitis develop [2].

Array of imaging modalities have been used to improve the diagnostic accuracy in patients with acute appendicitis. In the past, radiographs of abdomen and barium studies were done but they had a limited role in the diagnosis of acute appendicitis. The newer techniques of ultrasonography (USG) and computed tomography (CT) have shown great promise in evaluation of patients with suspected acute appendicitis.

CT is readily available, is supposed to be operator-independent, is relatively easy to perform, and has results that are easy to interpret. Unenhanced helical CT provides global cross-sectional evaluation and important information regarding the appendix, mesentery and retroperitoneum. A distinct advantage of unenhanced helical CT is the short examination time because it does not require patient preparation or contrast administration. Further, reports underscores that helical CT has sensitivities of 70–100% and specificities of 91–99% [3, 4].

Recently, focused appendix CT is a technique that employs contiguous, thin collimation helical scanning limited to the right lower quadrant. This technique is designed to minimize the time, radiation exposure, and patient discomfort in patients with suspected appendicitis [5].

In this backdrop, the present study was carried out to evaluate the diagnostic performances of unenhanced focused CT in patients suspected of having acute appendicitis without a selection between typical and atypical clinical signs of acute appendicitis.

Patients and Methods

This is a descriptive diagnostic study was carried out over a period of two years between 2008 to 2010. The study comprised of 61 consecutive patients who presented to the Department of Radio Diagnosis, Medical College, and Thiruvananthapuram.

Inclusion criteria

Patients with clinical suspicion of appendicitis were included in the study.

Exclusion criteria

The following categories were excluded from the study, like pregnant patients, unwilling patients and patients with previous history of appendicectomy.

CT Examination

CT examination was performed with four slice helical CT scanner (Asteion Toshiba) by means of a rapid thin-scanning technique. A single breath hold helical scan from the top of the L3 vertebral body to the pubic symphysis was obtained in supine position .The technical parameters were as follows: collimation of 4* 5 mm, table speed of 17.5 mm per rotation, pitch of 0.825, rotation time of 0.75seconds, 120 kVp, and 100 – 240 mA. The axial section data were reconstructed with a 5-mm thickness at 5-mm intervals and viewed using different soft-tissue window settings (width, 450 H; level, 50 H). No oral, rectal, or IV contrast material was administered. CT scan images were analyzed both at a workstation and on hard copy.

Observations

In CT – following observations were made.

- ✓ Whether appendix was visible, if seen its maximal outer transverse diameter, and
- ✓ The presence or absence of following findings: (a) gas in the appendiceal lumen, (b) Appendicolith, (c) periappendiceal fat stranding, (d) caecal wall thickening, and (e) abscess or phlegmon in the right iliac fossa. Each finding was separately coded.
- ✓ If the above findings were absent, a general survey of visualized parts of abdomen to find an alternative diagnosis that could explain the patient's symptoms was done.

CT diagnosis of appendicitis was given if the outer transverse diameter of appendix is >= 6 mm with or without appendicolith .If the appendix was not visualised then the presence of abscess or phlegmon is taken as a positive criteria. The presence of gas in the appendiceal lumen was considered as a possible negative criterion for acute appendicitis.

Final diagnosis

The CT findings was independently reported as (a) suggestive of appendicitis, (b) no evidence of appendicitis, or (c) An alternative diagnosis

Definite diagnosis

In all patients who underwent surgery, definite diagnosis was made on the basis of operative findings and/or from histopathological examination of specimen. In the group that did not undergo surgery, the standard of reference was the clinical consensus based on follow-up over a period ranging from six to eight weeks.

Statistical analysis

All the data was processed SPSS statistical packages. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated for each of the findings and also the overall diagnosis in CT and USG.

Results

Totally, 61 patients (40 males and 21 females) aged 7 – 68 years (mean age 29.8 years) clinically suspected with acute appendicitis underwent CT. Out of these patients, 28 patients (22 males and 6 females) had appendicectomies- 25 as emergency and 3 as interval appendicectomy (1 due to appendicular phlegmon and 2 due to clinical improvement) and appendicitis was confirmed by microscopic examination of the surgical specimen. Appendicectomy was not performed in 33 patients. Among these patients, 14 had an alternate diagnosis (8 males and 6 females) (Table 1). The remaining 19 patients (10 males and 9 females) were considered to have nonspecific abdominal pain as their symptoms could not be elucidated with any diagnostic modality and resolved without any specific treatment. They were followed up for 6-8 weeks. All of them had complete relief of symptoms within 36 -48 hours and none had recurrent pain during the follow-up period. These patients could be classified as not having appendicitis based on the clinical profile.

CT Diagnosis

CT was positive for appendicitis in 29 cases which constituted of

- Acute appendicitis– 22 (21 confirmed, 1 false positive)
- Acute appendicitis with appendicular mass –4 (confirmed)
- Appendicular abscess – 3 (confirmed)

There were 28 cases confirmed by surgery, identified as true positive case. CT detected all case of acute appendicitis. One case reported as appendicitis by CT was diagnosed as non-specific pain as the patient's symptoms resolved during the follow-up and never recurred. This was considered as false positive. All 4 appendicular mass and all 3 appendicular abscesses were correctly diagnosed by CT.

Of the 32 cases in whom CT was negative for appendicitis, 10 cases had alternate diagnosis by CT. The remaining 22 cases were reported as normal of which 4 had alternate diagnosis (2 pelvic inflammatory disease, 1 inguinal hernia, and 1 duodenal perforation peritonitis) (Table 2).

CT had a sensitivity of 100%, specificity of 96.97% and accuracy of 98.36% for the diagnosis of acute appendicitis (Table 3). There was discordance between CT and USG in the diagnosis of appendicitis in 6 cases. CT diagnosis was correct in all 6 cases (2 false positive in USG were correctly reported as no appendicitis by CT, and 4 cases missed by USG were correctly diagnosed as appendicitis by CT)

Alternate diagnosis

CT identified 10 correctly. One D1 perforation peritonitis was missed. Two case of PID was reported as normal. One inguinal hernia was reported as normal.

Other findings

Visualization of appendix

In CT, appendix was visualised in 22 cases of appendicitis and 15 cases with no appendicitis of which 5 had alternate diagnosis. Appendix was not visualised in 6 cases of appendicitis of which 3 cases had appendicular abscess and 3 had appendicular mass.

Inflamed appendix was visualised in 78.6% cases of appendicitis by CT compared to 67.9% by USG. In the 19 patients with nonspecific pain

normal appendix was visualised in 52.63% (10) of cases by CT compared CT was able to exclude appendicitis by demonstrating normal appendix in more cases.

Outer diameter of appendix

The outer diameter of appendix in appendicitis ranged from 8.2 mm to 16.5mm in USG, and from 6.2mm to 17.5mm in CT.

Lumen

All the 22 cases of appendicitis in which appendix were visualized by CT had fluid in the lumen. This sign has high sensitivity in diagnosing appendicitis.

Appendicolith

By CT, appendicolith was identified in 8 cases of appendicitis (4 in the base, 2 extra luminal, and 2 multiple within the lumen). The 2 cases with extra luminal appendicolith had appendicular abscess. Thus the presence of appendicolith has 100% positive predictive value for diagnosis appendicitis. Also the identification of extra luminal appendicolith is a sign of perforation. CT was more sensitive in identification of appendicolith.

Caecal wall thickening

Caecal wall thickening was present only in 18 (64.3%) cases with appendicitis in CT.

Appendicular phlegmon

There were 4 cases of appendicular phlegmon. Three cases underwent emergency appendicectomies. They had early mass formation. One patient underwent interval appendicectomy. All 4 had histologically proven appendicitis. CT reported all 4 cases correctly.

Appendicular abscess

Three cases had appendicular abscess secondary to appendicular perforation, confirmed by surgery. CT diagnosed all the 3 cases as appendicular abscess.

Others

Local ileus, lymphadenopathy and probe tenderness were seen in 15, (57.57%) 5, (17.85%) and 25 (89.28%) cases of appendicitis, respectively.

Sensitivity and specificity CT for other parameters in the diagnosis of appendicitis is given in Table 4.

Table 1: Summary of number of cases confirmed

	N	%
Confirmation of appendicitis in suspected cases	28/61	45.9%
No appendicitis in clinically suspected cases	33/61	54.1%
Alternative diagnosis established	14/61	21.3%

Table 2 CT vs. Final diagnosis in the study

Final diagnosis	Normal	Appendicitis	Alternate diagnosis	Total	Percentage
CT diagnosis					
Normal	18	0	4	22	**36.06**
Appendicitis	1	28	0	29	**47.54**
Alternate diagnosis	0	0	10	10	**16.39**
Total	**19**	**28**	**14**	**61**	

Table 3. Performances of CT in the overall diagnosis of acute appendicitis

Modality	Sensitivity	Specificity	PPV	NPV	Accuracy
CT	**100 (28/28)**	**96.96 (32/33)**	**96.55 (28/29)**	**100 (32/32)**	**98.36**

PPV: Positive Predictive value; NPV: Negative Predictive value

Table 4 Diagnostic Performances of CT findings in the study

Finding	Sensitivity	Specificity	PPV	NPV	Accuracy
CT					
Outer dia>=6mm	100 (22/22)	93.33 (14/15)	95.65 (22/23)	100 (14/14)	**97.29**
Fluid in lumen	100 (22/22)	73.33 (11/15)	84.61 (22/26)	100 (11/11)	**89.18**
Appendicolith	28.57 (8/28)	100 (33/33)	100 (8/8)	62.26 (33/53)	**67.21**
Periappendiceal fat stranding	96.42 (27/28)	93.93 (31/33)	93.10 (27/29)	96.87 (31/32)	**95.08**
Caecal wall thickening	64.28 (18/28)	96.96 (32/33)	94.73 (18/19)	76.19 (32/42)	**81.96**
Phlegmon	14.28 (4/28)	100 (33/33)	100 (4/4)	57.89 (33/57)	**60.65**
Abscess	**10.71 (3/28)**	**100 (33/33)**	**100 (3/3)**	**57.89 (33/57)**	**59.01**

PPV: Positive Predictive value; NPV: Negative Predictive value

Discussion

The usefulness of sonography and CT in the diagnosis of appendicitis has been reported extensively in the literature. As the literature related to surgery report an average rate of 20% negative findings at appendectomy,[6-8] imaging techniques are useful to prevent unnecessary appendectomies and to avoid costly hospital admissions. Furthermore, imaging can expedite the diagnosis of appendicitis, minimizing surgical delays and the subsequent risk of appendiceal perforation.

In this study, 61 patients clinically suspected of appendicitis underwent graded compression sonography and unenhanced focused CT. Of these, 28 (45.9%) had acute appendicitis and 33 (54.1%) did not have appedicitis. USG diagnosed 24 cases of appendicitis and 30 cases without appendicitis correctly. There were 3 false positive and 4 false negative cases. CT diagnosed all 28 cases of appendicitis and 32 cases without appendicitis correctly. There was one false positive case.

In the present study, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of unenhanced focused CT are 100%, 96.9%, 96.6%, 100%, and 98.4% respectively.

The diagnostic performance of unenhanced focused CT was comparable to published literature [9-15]. The study by Ege et al [5] who used similar CT protocol for imaging patients reported a sensitivity of 96%, specificity of 98%, and positive predictive value of 97%, negative predictive value of 98% and accuracy of 97% .This is comparable to the present study.

In this study, the unenhanced focused CT showed better diagnostic performances sensitivity, specificity and predictive values.

An important issue to be addressed while evaluating the positive impact of an imaging examination on the assessment of patients with suspected appendicitis is the value of normal findings on an examination using a modality. The higher the sensitivity of the imaging examination, the lower the number of false-negative examinations, and, consequently, more trust can be placed on normal findings from that examination by caregivers. Because of the significantly higher sensitivity of CT (100%) when compared with sonography (85.7%) for the diagnosis of appendicitis, a negative CT examination in still greater diagnostic confidence for the exclusion of appendicitis than does negative sonographic findings. Thus, use of CT can avoid unnecessary appendicectomy.

Several other factors emphasize the value of CT in patients with suspected acute appendicitis. Unenhanced focused CT was able to visualize 37 (60.7%) of appendices and the visualization of appendix in appendicitis was also higher with CT, with CT being able to show inflamed appendix in 22 (78.6%). Visualization of normal appendix in patients who do not have appendicitis can exclude appendicitis. This is particularly important in patients who have normal findings in the examination and do not have an alternative diagnosis as well. In this study, normal appendices was visualized in 10 (52.63%) of cases by CT In the study by Balthazar et al, [16] the normal appendix, when present, was noted 48% of the time by CT.

Outer diameter ≥6 mm as the criteria for diagnosing appendicitis has a sensitivity of 100% in CT. However, 1 case with no appendicitis had a diameter of >6mm (6.4mm in CT). This has reduced the specificity of the parameter. This result stressed the fact that isolated finding of an appendix with a diameter exceeding 6 mm is an insufficient basis for a diagnosis of acute appendicitis. This finding when combined with findings of inflammatory changes involving the thickened appendix (i.e., streaking and poorly defined increased attenuation in the periappendiceal fat in CT) can increase the specificity. CT is better in showing the periappendiceal inflammatory changes.

According to Malone et al [13] the identification of inflammatory changes in the pericecal and periappendiceal fat are the most important findings when the diagnosis of acute appendicitis is done by unenhanced CT. Balthazar et al [17] found that lack of visualization of an abnormal appendix in contrast- enhanced CT scans, even in the presence of obvious inflammatory changes in the right lower quadrant, is a nonspecific finding and is an insufficient basis for the diagnosis of acute appendicitis.

In the present study, periappendiceal inflammatory changes were taken as supportive evidence of appendicitis. The periappendiceal/ pericecal fat stranding was seen in 27 (96.42%) cases of appendicitis. This again highlights the fact that periappendiceal inflammation was better shown in CT.

In the present study CT identified 8 (28.6%) cases of appendicolith and two cases of appendicular abscess had appendicolith in extra luminal location. The presence of appendicolith demonstrated by CT had a 100% specificity and positive predictive value for the diagnosis of appendicitis although the sensitivity was less. Based on the above findings in this prospective study, CT was a potential diagnostic tool in evaluating patients suspected of having acute appendicitis [18-23].

Conclusion

The goal of imaging for the evaluation of patients with suspected appendicitis is to provide a sensible balance between highest possible diagnostic accuracy while considering the degree of invasiveness, radiation dose, patient discomfort, and the factors of time and cost. This study shows that both unenhanced focused CT is accurate imaging modalities in patients with suspected appendicitis. The choice of type of study to perform is likely to depend on the available resources and personnel at various institutions and the clinical history of the patient, physical examination findings, laboratory data, and differential diagnostic possibilities.

Although absolute statements regarding the most appropriate modality in individual patients are inadvisable, our data suggest that the expediency of unenhanced focused CT and its sensitivity, specificity, accuracy, lack of operator-dependence, and lack of invasiveness render it a valuable tool in the evaluation of patients who are clinically suspected of having appendicitis. Unenhanced CT findings can be used successfully and accurately to determine which patients have acute appendicitis and which do not. Unenhanced CT may also be helpful in detecting diseases other than acute appendicitis in patients with acute pain in the lower abdomen. The prevalence of surgical excision of normal appendixes can be reduced without increasing the perforation rate, and CT can be performed if sonography findings are inconclusive.

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