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ORIGINAL ARTICLE

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The value of unenhanced CT in the diagnosis of acute appendicitis

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Objective: To establish the accuracy of unenhanced CT in the preoperative diagnosis of acute appendicitis. **Design:** Accuracy study, prospective and blinded. **Setting:** The University Hospital. **Participants:** 52 patients with clinical and laboratorial manifestations of acute appendicitis. CT diagnosis was made by: presence of an abnormal appendix, appendiceal calculi with pericecal phlegmon or alterations in the pericecal appendicular site and absence of signs that may lead to other diagnosis. **Main outcome measures:** Overall accuracy, comparing the tomographic aspects with the intra-operative findings and pathological reports ("gold standard"). **Results:** Acute appendicitis was confirmed in 44 cases. Efficacy was 92%, sensitivity was 91%, specificity was 100%, positive predictive value was 100% and negative predictive value was 67%. **Conclusions:** Unenhanced CT presents a similar overall accuracy to that reported by other authors who studied enhanced CT diagnosis of acute appendicitis.

Uniterms: Computerized tomography in appendicitis. Computerized tomography of the digestive tract. Computerized tomography. Appendix. Appendicitis.

INTRODUCTION

The diagnosis of acute appendicitis requires other complementary investigations since its clinical presentation is usually atypical or non-specific.[1-3]

Computerized tomography (CT) is indicated for investigation in elderly patients with atypical clinical manifestations of appendicitis[4] or inconclusive ultrasound examinations (US).[5]

Use of CT for diagnosis of diseases of the appendix began in 1981[6] and has been studied by several authors.[7-16]

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The most important advantages of CT are differentiation of phlegmon and abscesses,[2,5,8] assessment of inflammatory involvement outside of the colon,[12] and full evaluation of the abdominal cavity.[3] The limitations of CT occur with the administration of contrast, since it increases cost and morbidity;[17] however, many authors defend its use to assure a higher efficacy.[7,8,10]

Some authors have suggested use of unenhanced CT for the study of the appendicular region[18] and diagnosis of acute appendicitis,[13,16] and they have shown results similar to those of enhanced CT. Such results have been controversial, since many consider unenhanced CT a limited method for the diagnosis of acute appendicitis.[14,15]

The objective of this study was to evaluate the efficacy of unenhanced CT in the diagnosis of acute appendicitis by comparing results of CT with surgical and pathological reports.

METHODS

We prospectively studied unenhanced abdominal CTs of 52 patients with clinical signs of acute appendicitis that underwent surgery from September 1993 to March 1995. Twenty-five of the patients were male and 27 were female, with ages varying from 6 to 64 years (mean: 29 years). Symptom duration before examination varied from 1 to 20 days. In fourteen patients symptoms began within 24 hours of the test. All patients underwent surgery within five days following CT (mean: 36 hours). Surgical findings and pathological results were considered the gold standard. Final diagnoses were: acute appendicitis in 44 of 52 patients (84.6%), rupture of an ovarian cyst (1), salpingitis and endometritis (1), terminal ileitis (1), mesenteric adenitis with typhlitis (1) in 4 of 52 patients (who presented a normal appendix). The remaining four of the 52 patients did not have any abdominal disease.

All CT examinations were performed using Somatom DR, (Siemens), SCT 500T, (Shimatzu), and EXEL 2400 (Elscint) scanners. Images were obtained with contiguous sections 8 or 10 mm thick from L_3 to the pubic symphysis; no contrast was administered. Examinations lasted from 3 to 12 minutes (mean: 6 min.) according to the patient's height and type of scanner.

CT parameters evaluated were: pericecal fat; abscess in right iliac fossa; characteristics of appendix, when identified; appendiceal calculi; cecal, abdominal musculature, and small intestine characteristics.

Patients were divided into 4 categories, according to a model proposed by Balthazar et al in 1991:[12]

Category 1 - Appendicitis: identification of an abnormal appendix or heterogeneous pericecal fat associated with appendiceal calculi or pericecal appendicular abscess.

Category 2 - Normal examination: no evidence of appendicitis.

Category 3 - Non-specific diagnosis of appendicitis: presence of pericecal or heterogeneous appendicular fat, with or without an abnormal cecum, and no alterations that may indicate any other diagnosis (i.e. ovarian cyst, enlarged terminal ileum, ureteral calculus)

Category 4 - Other diseases: tomographic indications of extra-appendicular disease.

Periappendiceal fat was considered heterogeneous when at least one of the following was observed: hyperdense lines, extensive and pericecal inflammatory change,[8] presence of free fluid, extraluminal gas, and enlargement of lateral conal and anterior pararenal fascia.[19] Abscesses were diagnosed by the presence of accumulated and trapped fluid (Fig. 1); presence of extraluminal gas was another strong indicator.[7,20] The appendix was characterized by a tubular or ring like structure emerging from the medial or posterior cecal walls, approximately 2.0 cm below the ileocecal valve.[8,15] The appendix was abnormal when its transverse diameter was larger than 8 mm; its wall thickness was greater than 3 mm,[18] or fluid or calculus were present within it (Fig. 2). The cecum was abnormal when spastic,[21] when its wall was thicker than 5 mm,[22] or when presenting a concave shape (Fig. 3). Cecal

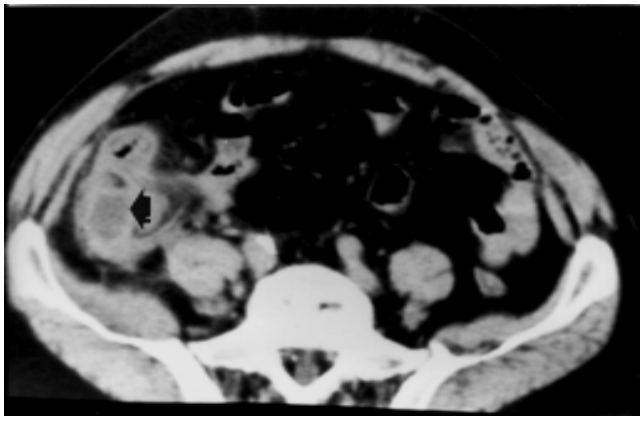

Figure 1 - Small hypodense round retrocecal encapsulated formation (arrow).

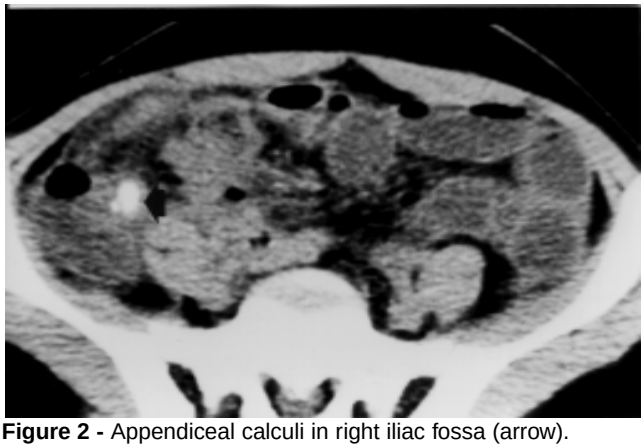

Figure 2 - Appendiceal calculi in right iliac fossa (arrow).

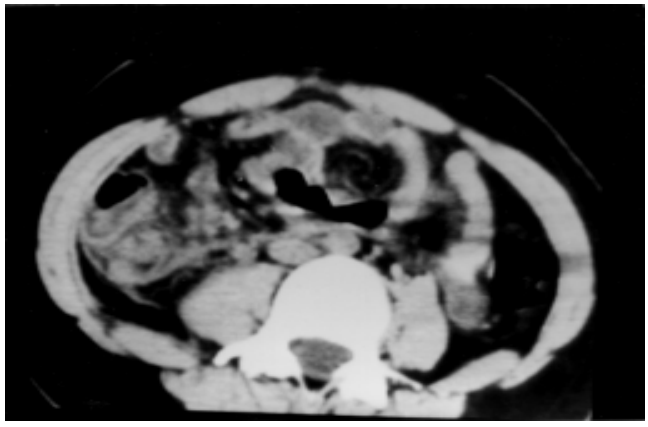

Figure 3 - Heterogeneity of retrocecal fat with diffuse thickening of lateral conal fascia.

concavity is considered an indirect sign of pericecal phlegmon[1-23] in the absence of other causes of compression such as those caused by the iliopsoas muscle in athletic or thin patients.[18] Abdominal muscles were considered abnormal when there was evidence of volume increase or heterogeneity. The small bowel was considered distended when presenting a transverse diameter larger than 2.5 cm[24,25] or air-fluid levels.[26]

RESULTS

Results obtained by comparison of CT diagnosis with surgical findings and pathological exams are as illustrated in Tables 1 and 2. Categories 1 and 3 were used as criteria for a positive CT diagnosis of acute appendicitis and categories 2 and 4 were considered a negative diagnosis of appendicitis, which allowed assessment of global efficacy of the method.

Pericecal fat: Pericecal fat was homogeneous in 11 of 52 cases (21.15%) and heterogeneous in 41 of 52 cases (78.85%). It showed hyperdense lines in 28 cases, diffuse shadowing in 16, presence of a fluid collection in 20, and presence of gas in 7 cases (Fig. 4). Frequently, different signs of heterogeneity were found in the same patient. The retroperitoneal fascias were thickened in 34 of 52 patients (65.38%), of which 21 (40.38%) had lateral conal fascial thickening and 26 (52%) had pararenal fascial thickening. The prevalence of heterogeneity of paracecal fat detected by CT in patients with acute appendicitis was 84.09% (37 of 44).

Abscess: Fourteen of 52 cases (26.9%) presented with loculated intrabdominal fluid identified as an appendicular abscess due to its association with appendiceal calculi (6 of 14 cases) and/or an abnormal appendix (10 of 14). One case presented as an abscess associated with thickening of the terminal ileum. Thirty patients did not present any abscesses and 7 cases did not have any particular signs. Abscess diameter varied from 2 to 8 cm (mean=4.25). Ten of 14 cases (71.42%) showed the presence of gas within the collection. Abscess sites were located medially to the cecum in 6 of 14 cases (42.85%), in 5 cases (35.71%) laterally to the cecum, in one case (7.14%) in the retrouterine pouch, and in 1 case (7.14%) anterior to the cecum. Prevalence of the abscesses was 31.81% in patients with acute appendicitis (14 of 44). Two of the 15 cases with identified abscesses presented false-positive results. Eleven of the forty-two remaining cases were false-negative results, which indicated a 73.07% efficacy for the diagnosis of pericecal appendicular abscess.

Appendix: We identified the appendix in 35 cases, among which 33 were considered abnormal. Non-identification of the appendix occurred in 25% of the cases with appendicitis (11 of 44). Transverse diameter of abnormal appendices varied from 10 to 30 mm (mean: 17.3 mm), wall thickness varied from 1 to 15 mm (mean: 6.4 mm). In patients with wall thickness under 3 mm (2 cases) the appendices was considered abnormal due to its transverse diameter. The thickest walls were in those with collapsed appendices with no content (Fig. 5). Twenty patients showed collapsed appendices and 13 showed distended appendices due to gas (3 of 13), calculi (10 of 13) and/or fluid (6 of 13). Thirty-two patients presented with symmetrical circumferential thickening and one case (3%) presented with asymmetrical circumferencial thickening. Retrocecal appendices occurred in 14 of 35 cases (40%), medial anterior appendices occurred in 19 cases (54.28%), and pelvic appendices occurred in only 2 of the 35 cases (5.72%). Abnormal appendix prevalence was 75% in patients with acute appendicitis (33 of 44).

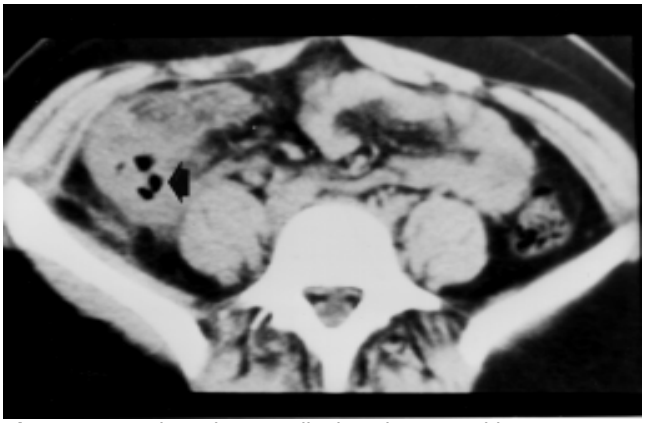

Figure 4 - Pericecal appendicular abscess with gas content (arrow).

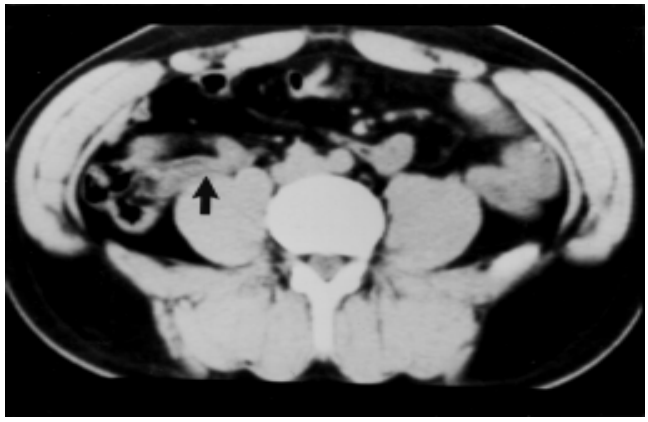

Figure 5 - Collapsed medial anterior appendix (arrow). Thickened walls and diameter over 10mm.

Table 1
Overall accuracy of unenhanced CT in the diagnosis of acute appendicitis.

	Surgery or Pathological Results		
CT	**Appendicitis**	**Normal**	**Total**
Appendicitis	40	0	40
Normal	4	8	12
Total	44	8	52

True positive = 40
True negative = 8
False positive = zero
False negative = 4

Accuracy = 92.3%, 95% CI 99.5% to 85.1%
Sensitivity = 90.9%, 95% CI 78.3% to 97.5%
Specificity = 100.0%, 95% CI 63.1% to 100%
Positive predictive value = 100.0%, 95% CI 91.2% to 100%
Negative predictive value = 66.66%, 95% CI 34.9% to 90.1%

Table 2
Efficacy of parameter used in unenhanced CT in the diagnosis of acute appendicitis.

CT parameter	ACUR	SENS	SPEC	PPV	NPV	PREV
Pericecal fat	78.84%	84.09%	50.00%	90.24%	36.36%	84.09%
Abscesses	40.38%	31.81%	87.50%	93.33%	18.92%	31.81%
Appendix	100.00%	100.00%	100.00%	100.00%	100.00%	75.00%
Appendiceal Calculi	38.46%	27.27%	100.00%	100.00%	20.00%	27.27%
Cecum	59.61%	61.36%	50.00%	87.10%	19.05%	61.36%
Musculature	–*	–*	–*	–*	–*	4.54%
Small Bowel	36.54%	34.09%	50.00%	78.95%	12.12%	34.09%

ACUR - Accuracy
SPEC - Specificity
SENS - Sensitivity
PPV - Positive predictive value
NPV - Negative predictive value
CT - Computerized tomography
* The small number of cases did not allow a statistical analysis.

Appendiceal calculi: We observed appendiceal calculi in 12 of 52 CT examination (23.07%), all of which had a definite diagnosis of acute appendicitis. The frequency of appendiceal calculi varied from 1 to 4 per patient (mean: 1.5); 9 patients had 1 appendiceal calculi, each of the other patients had 2, 3, and 4 appendiceal calculi respectively. Eight of 12 patients had homogeneous calcification (66.6%) and four had ring-shaped calcification (33.3%). All appendiceal calculi were associated with other CT signs, such as pericecal appendicular fat heterogeneity (100%); appendicular abscesses (50%); abnormal appendices (100%) and an abnormal cecum (75%). The prevalence of this sign in patients with acute appendicitis was 27.7% (12 of 44).

Cecum: Thirty-one patients, of which 27 (87.10%) were diagnosed with acute appendicitis, presented an abnormal cecum. Four of these patients had an abnormal cecum due to other inflammation (terminal ileitis, salpingitis, ruptured adnexal cyst) and acute lymphocytic leukemia. A spastic cecum was observed in 17 of 52 patients (32.69%) and thirty-five patients (67.30%) had a distended cecum with the presence of gas, feces, and/or fluid. Thirty-nine of 52 patients (75%) had an abdominal cecum and thirteen (25%) a pelvic cecum. The cecal wall was thickened (over 5 mm) in 26 of 52 patients (50%), with the same number of patients with symmetrical and asymmetrical involvement (Fig. 6). Cecal concavities were observed in 25 of 52 patients (48.01%), of which 17 (68%) occurred in the medial wall, 9 (36%) in the posterior wall, and one in the anterior wall. In some patients the cecal contour was concave medially and posteriorly. There were no cases with a lateral concave contour. Five of these 25

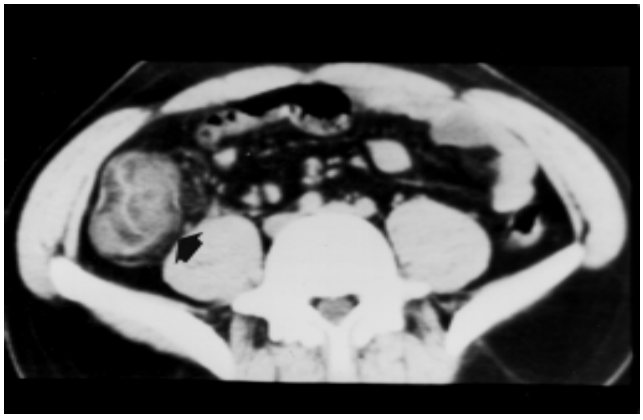

Figure 6 - Asymmetric thickening of cecal wall (arrow)

patients had a concave cecal contour due to compression by a paravertebral or anterior iliac muscle (physiological compression). Prevalence of an abnormal cecum in patients with acute appendicitis was 61.36% (27 of 44).

Muscles: The anterior abdominal musculature was symmetrical in all examinations. The psoas and iliopsoas were considered abnormal (asymmetric due to heterogeneity and thickening) in two of 52 cases (3.85%). These were patients with acute appendicitis, one with a pericecal appendicular abscess. The prevalence of abnormal musculature in patients with acute appendicitis was 4.54% (2 of 44). This low prevalence did not allow calculation of the efficacy of the method.

Small bowel: Nineteen of 52 patients (36.54%) had a distended small bowel (transverse diameter over 2.5 cm), in thirteen of these patients (68.42%) the bowel contained fluid and eight (42.10%) had air-fluid levels. Fifteen of these nineteen patients (78.94%) were diagnosed with acute appendicitis. The other four patients were diagnosed as: recurrent acute lymphocytic leukemia (1 case), endometritis and salpingitis (1 case), local enteritis (1 case), and nephrotic syndrome (there were no abnormalities on laparotomy in this patient). Twenty-nine of 44 patients (65.90%) with acute appendicitis had a normal small bowel on CT. Three of the 19 patients with a distended small bowel (15.79%) presented with a collapsed colon with intestinal obstruction with a 5.76% prevalence for this sign. Prevalence of an abnormal small bowel in patients with acute appendicitis was 34.09%(15 of 44).

DISCUSSION

Acute appendicitis is usually diagnosed on a clinical examination and confirmed by routine laboratorial tests. However, the incidence of negative laparotomy is high, especially among young women.[27] Elderly patients have a higher morbidity and mortality due to the silent progress of the disease.[21] The risk of false positive results leading to unnecessary laparotomies and misdiagnosed complications (false negative results) may be reduced by imaging techniques in selected cases.

Computerized tomography, although expensive when compared with other methods, has high accuracy in: assessing the extension of the appendicular inflammation; distinguishing phlegmon from an abscess, diagnosing pneumoperitoneum and other intra-abdominal complications.[12,14] Therefore, CT provides a better guide towards adequate treatment.[5,28]

Most authors believe that oral and intravenous administration of contrast is essential for CT diagnosis of appendicitis.[4,8,10,12,14,15,20,23] Malone et al.[13] recently suggested the use of unenhanced CT to assess patients with clinical manifestations of acute appendicitis. They obtained results that were similar to those obtained with enhanced CT (accuracy = 93%; sensitivity = 87%; specificity = 97%). Several authors have criticized unenhanced CT by claiming that difficulties in identifying appendiceal and inflammatory changes worsens the sensitivity and specificity of the method.[14,15] However, CT signs that indicate appendicitis, such as: heterogeneous pericecal fat, abnormal cecum, thickened appendix, and appendiceal calculi,[8,12,15] depend on precise identification of these structures and not on the use of contrast.[11]

In our previous study, which compared unenhanced and enhanced CT,[18] there was no significant difference ($X^2 = 1.68$; critical $X^2 = 3.84$) in visualization of the normal appendix in CT with (63.3%) and without (46.7%) oral or intravenous contrast; however, visualization was better in contrast enhanced CT. In that same study, six of 19 identified appendices (31.58%) were not filled by oral or intravenous contrast. These results and the low cost, speed, and patient approval of unenhanced CT were responsible for this subsequent study.

Our results confirm those of other authors that have used a similar method.[13,16] The study showed 4 false negatives and no false positives. The four patients with mistaken CT diagnoses were young (20 years old), and three of these patients were women. All were thin and 75% had a pelvic cecum, one of whom was retropubic. After reviewing the examination, we maintained our former opinion, which suggests that unenhanced CT has some limitations related to the position of cecum and the quantity of pericecal fat, which has already been reported by other authors.[10,16]

We also tried to relate the amount of fat present with the CT diagnosis of appendicitis. We measured subcutaneous tissue in women and transverse diameters of retrocecal fat in men. We noted that these measurements are not compatible with body fat and with pelvic cecal fat. Therefore, we did not find an adequate method for assessing the amount of pericecal fat, which supported our decision not to use this parameter. Some authors who had used the amount of pericecal fat in acute appendicitis diagnosis and appendix visualization did not report the parameters adopted.[10,11]

Analysis of the pericecal fat, cecal characteristics, and the presence of appendiceal calculi was not altered by the lack of contrast. Identification of an abnormal appendix, which in our study was 75% (33/44), is similar to that found by other authors who have used enhanced

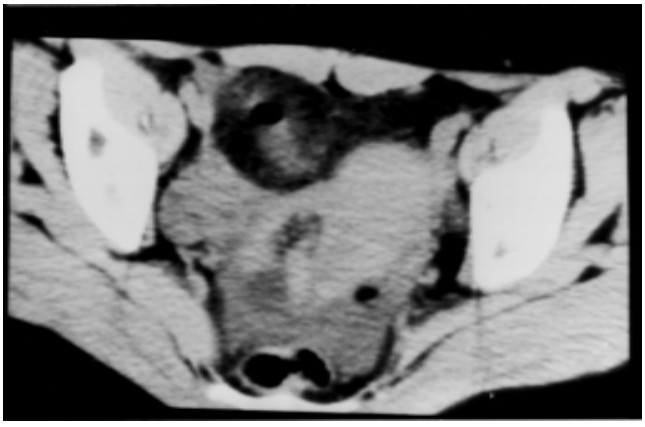

Figure 7 - Periappendicular lipomatosis with compression of abdominal musculature.

CT.[12] These authors raised abnormal appendix identification rates from 18%[8] to 94%[14] as they became more experienced. Identification of the appendix in CT is easier due to its retrocecal position, which occurs in up to 65% of the cases.[29] Appendix position is also influenced by the degree of cecal distention, and may become retrocecal when the cecum is empty and contracted.[23]

Inflammatory involvement of abdominal musculature is rare in acute appendicitis. We observed two cases of muscle abnormalities. One patient presented thickening of the right iliopsoas muscle due to hypertrophy caused by dysplasia of the opposite hip joint. The other patient presented heterogeneity and thickening of the iliopsoas muscle associated with a retrocecal abscess.

Small bowel obstruction is diagnosed by distention (transverse diameter over 2.5 cm) and a collapsed colon.[30,31] Its occurrence rate in patients with acute appendicitis varies from 8 to 20%[8,9] and it is usually caused by inflammatory adhesions or compression of the terminal ileum.[23] Thirty-six percent of the patients in our study presented distention of the small bowel and three presented obstruction, all of which were diagnosed as acute appendicitis and alteration of intestinal function.

CT signs other than those already mentioned were found in our study: one patient presented with mesenteric lipomatosis (Fig. 7) similar to that found in Crohn's disease, and was considered to be reactional inflammatory dystrophy.[32]

Another patient with a diagnosis of perforated acute appendicitis and periappendicular abscess presented distention of the transverse colon and collapse of the descending colon, which was similar to the colon cut-off sign normally used in roentgenogram diagnosis of appendicular perforation.[33] We also found pneumo-peritoneum in a patient with perforated appendicitis and a periappendicular abscess with free liquid in the peritoneal cavity. One of the main advantages of unenhanced CT is the brevity of the examination. Even using axial mode (non-helical CT) the entire examination can be performed in less than 10 minutes. In addition, because no oral or IV contrast material is needed, the examination does not interfere with following imaging studies. When the unenhanced CT results are questionable, oral or IV contrast material can be given and the examination repeated, without extracost for the patient.

In spite of the fact that some authors affirm that the helical CT technique is more accurate than conventional CT for imaging patients with suspected appendicitis, they have not compared both techniques in the same group of patients.[34] We strongly believe that for an adequate appendiceal study, even conventional CT is quite accurate.

Another important point for discussion is cost. In Brazil, the contrast material is responsible for more than fifty percent of the abdominal CT charge. For this reason, unenhanced CT could have an important impact on the management of patients with acute abdominal illness

In summary, the efficacy of unenhanced CT during preoperative diagnosis of appendicitis is high (92.30%) and similar to other reports in the literature using contrasted CT. The most reliable CT sign in diagnosis was the identification of an abnormal appendix. Method limitations occur especially in young, thin patients with a pelvic cecum and depend on the experience of the examiner. Low cost, good patient acceptance, and high efficacy make the unenhanced CT a good complementary test in patients with atypical clinical manifestations of appendicitis or those for whom ultrasound is inconclusive.

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RESUMO

Objetivo: Estabelecer a eficácia da TC sem contraste EV ou VO no diagnóstico pré-operatório da apendicite aguda. **Tipo de Estudo:** estudo de acurácia prospectivo, independente. **Local:** hospital-escola de atenção terciária (instituição mista). **Pacientes:** 52 pacientes com suspeita clínico-laboratorial de apendicite aguda. **Método Diagnóstico:** Os exames tomográficos foram realizados sem contraste EV ou VO. O diagnóstico tomográfico de apendicite aguda foi feito na presença de apêndice anormal, apendicolito com flegmão pericecal ou alterações na região apendicular, sem sinais que indicassem um diagnóstico alternativo. **Variáveis Estudadas:** eficácia, sensibilidade, especificidade, valor preditivo positivo e negativo, comparando os aspectos tomográficos com os achados intra-operatórios e laudos anatomopatológicos (padrão ouro). **Resultados:** O diagnóstico definitivo de apendicite aguda foi observado em 44 casos. A eficácia do método foi de 92%; sensibilidade de 91%; especificidade de 100%; o valor preditivo positivo foi de 100% e o valor preditivo negativo de 67%. **Conclusão:** A TC sem contraste EV e VO apresenta eficácia global semelhantre à TC com contraste relatada por outros autores, no diagnóstico da apendicite aguda.