

THE VALUE OF CT SCAN IN ACUTE APPENDICITIS⁺

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Abstract

To determine the accuracy of nonenhanced nonfocused (abdomino-pelvic) computed tomography (CT) in the diagnosis of clinically equivocal cases of acute appendicitis, a prospective study was performed of 95 patients with clinically equivocal signs of acute appendicitis who were referred from the department of surgery. The study was performed using thin section nonenhanced helical CT of the abdomin-opelvic region. All the scans were obtained in a single breath-hold using 5 mm beam collimation and a pitch of 1.6. Criteria for diagnosing acute appendicitis included an enlarged appendix (> 6 mm) and periappendiceal inflammation. Final diagnoses were established based on the results of surgical or clinical follow up, or both. There were 33 true positive diagnoses, 53 true negative diagnoses (18 of which had an alternative diagnosis established at CT), 4 false positive, and 5 false negative diagnoses, yielding a sensitivity of 87 %, a specificity of 93 %, a positive predictive value (PPV) of 89 %, a negative predictive value (NPP) of 91%, and an accuracy of 91 %.

We conclude that nonenhanced, nonfocused (abdomin-opelvic) helical CT is a highly accurate technique for diagnosis or exclusion of acute appendicitis.

المستخلص

لغرض دراسة فائدة المفراس الحلزوني الغير معزز والغير محدد (أي لمنطقة البطن والحوض) في تشخيص التهاب الزائدة الدودية المشتبه به سريرياً ، تم إجراء هذه الدراسة التي تضمنت خمسا وتسعون مريضاً ومريضة لديهم أعراض التهاب الزائدة الدودية المشتبه به سريرياً كانوا قد ارسلوا من قسم الجراحة. تم فحص المرضى باستخدام المقاطع الرقيقة للمفراس الحلزوني الغير معزز بالتلوين . تم استخدام مقاطع بسمك خمس ملمترات وأجري الفحص خلال قطع التنفس من قبل المريض. اشتملت العلامات التي اعتمدت للتشخيص على تشنخ الزائدة الدودية الى اكثر من ست ملمترات ، و التهاب ما حول الزائدة الدودية . اعتمد التشخيص النهائي على نتائج الجراحة أو المتابعة السريرية. كان هنالك ثلاث وثلاثون حالة بتشخيص ايجابي صائب ، وثلاث وخمسون حالة بتشخيص سلبي صائب (من ضمنهم ثمانية عشر حالة حملت تشخيصاً بديلاً شخّصت بواسطة المفراس الحلزوني) ، وأربع حالات بتشخيص ايجابي خطأ وخمس حالات بتشخيص سلبي خطأ . بلغت حساسية الفحص في التشخيص ٨٧ % ، والقيمة التخصيصية ٩٣ % ، و القيمة التوقعية الايجابية ٨٩ % ، والقيمة التوقعية السلبية ٩١ % ، أما الدقة التشخيصية فقد بلغت ٩١ %.

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نستنتج من هذا إن المفراس الحلزوني الغير معزز بالتلوين لمنطقة البطن والحوض هي تقنية عالية الدقة في تشخيص أو استثناء التهاب الزائدة الدودية .

Introduction:

Acute appendicitis remains one of the most difficult diagnoses to make clinically. Much of the difficulty stems from the variability in its presentation. The classical presentation; including periumbilical pain localizing to the right iliac fossa, nausea, vomiting, anorexia, fever, and leukocytosis ; is generally seen in less than 50% of patients[1]. The erroneous diagnosis of acute appendicitis has led to a high rate of inappropriate removal of a normal appendix of 8% -30% [2].

Removal of a normal appendix is not necessarily a benign procedure. In a study of 39,901 adult and pediatric patients, Flum and Koepsell [3], reported that the nonincidental removal of a normal appendix is associated with a significantly longer hospital stay, higher hospital costs, higher patient fatality rate, and higher rate of infectious complications compared with surgical results in patients with appendicitis.

To reduce the error rate in the diagnosis of this potentially life threatening condition; conventional radiography, barium studies, and ultrasonography; have been used with limited success[4-7]. While ultrasound is generally available and relatively inexpensive and safe, its biggest drawback is that negative findings at US do not exclude appendicitis unless a normal appendix is visualized with a high degree of confidence. Visualization rates of a normal appendix by US in the published literature ranges from a high of 98% [8] to a low of 22% [9].

After initial reports by Rao et al in 1997 [10], CT quickly became the preferred technique for the imaging of suspected appendicitis in adults. Pediatric applications soon followed. As with US; CT is also generally available, reproducible, accurate, and safe. However, ionizing radiation and the use of intravenous and gastrointestinal contrast material make it a relatively more invasive test.

Accuracy rates with a variety of CT techniques that use different combinations of oral, rectal, and intravenous contrast agents have ranged from 93% to 98%[10,11,12] for patients suspected to have acute appendicitis.

Aim of study

To determine the diagnostic accuracy of nonenhanced helical CT of the entire abdomen in the diagnosis of clinically equivocal cases of acute appendicitis.

Methods

Study Design

A prospective study was performed through a period of 20 months to determine the diagnostic accuracy of nonenhanced helical CT of the entire abdomen in the evaluation of clinically equivocal cases of acute appendicitis.

Ninety five Patients were referred from the department of surgery. Each patient was evaluated by a surgical resident. Only patients in whom the clinical diagnosis was uncertain were included in the study.

Two radiologists interpreted all CT scans in consensus and CT findings were reported as positive or negative for appendicitis. Surgical management included an operation or observation for 24 hours, respectively. Further follow up included the operation room (OR) and pathology reports to confirm the diagnosis and follow up to rule out readmission for acute appendicitis. A consensus retrospective review was performed in those cases in which the radiology reports did not agree with the surgical and pathology results.

CT Technique

In all patients, a single breath- hold helical scan from the top of the T12 vertebral body to the pubic symphysis was obtained using 5mm beam collimation and 8mm/sec table speed (pitch, 1.6; 120 KVp; 240-270 mAs). No oral, rectal, or intravenous contrast material was administered. Images were reconstructed and photographed at 5mm intervals by using standered soft tissue windows (width, 400 HU; level, 40 HU). Total examination time was approximately 10 minutes.

Image interpretation

The primary criterion used to diagnose acute appendicitis on nonenhanced helical CT scans was a dilated appendix with periappendiceal inflammatory changes. An appendix larger than 6 mm in transverse diameter was considered potentially abnormal; however, periappendiceal inflammatory changes were also required to be present for diagnosis of acute appendicitis. The presence of an appendicolith was also noted prospectively.

Results

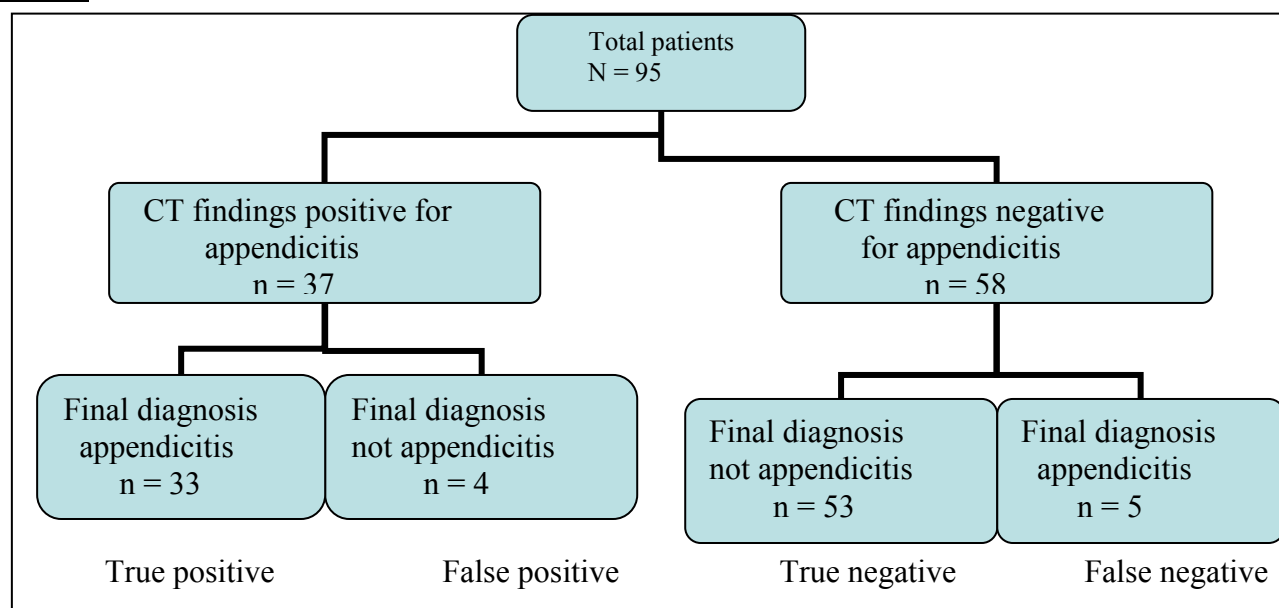


Fig. 1 demonstrates CT scan interpretations in the study population.

Ninety five patients participated in the study, (55 female and 40 male), ranging in age from 7- 66 years.

Of the 95 patients, 37 patients (35%) had CT findings positive for appendicitis, and 58 patients (56%) had CT findings negative for appendicitis.

Of the 37 patients with positive CT findings for appendicitis, 33 patients had true positive and 4 patients had false positive findings.

In the 33 patients with true positive CT diagnoses, an enlarged appendix (> 6 mm) was visualized in 30 patients, together with inflammatory changes in the periappendiceal fat. The appendix was not visualized in the other 3 patients. These 3 patients had ruptured appendices. In each of these 3 patients, an abscess in the right iliac fossa suggested a ruptured appendix and hence a correct diagnosis of appendicitis.

Of the 4 false positive interpretations ; two had appendiceal diameters of 8 mm and 10 mm respectively, with an appendicolith in each. However, on retrospective review, periappendiceal inflammation was not present in either of these two cases. In the third patient with false positive examination, the base of the appendix measured 7mm on CT with minimal periappendiceal stranding. However, it was histologically normal. The fourth false positive diagnosis occurred in a patient with perforated cecal diverticulitis and secondary inflammation of the appendix .

Of the 58 patients with negative CT findings, 53 patients did not show any aggravation of their clinical picture on further follow up and their final diagnosis on discharge was not appendicitis . hence, they were considered true negative cases at statistical analysis.

The other 5 patients with negative CT interpretations underwent laparotomy despite having negative CT findings for appendicitis, because they continued to have symptoms that were suggestive of appendicitis. appendicitis was proved at surgery and histopathology in these 5 patients who , therefore, were considered false negative at statistical analysis. On retrospective review of these 5 false negative CT scan interpretations, in one patient a 10 mm dilated appendix was found within the pelvis of a young man. This was not seen in the initial prospective interpretation because of its pelvic location . In another patient, a young thin female, although the enlarged appendix was visualized the inflammatory changes were not seen because of the lack of Intraperitoneal fat. The remaining three patients with false negative interpretations were encountered very early in our study protocol and , in retrospect, had obvious CT findings of acute appendicitis which were missed on the initial prospective interpretations.

In the 53 patients with true negative CT diagnoses, a normal appendix was seen in 45 patients(89 %), including those with an alternative diagnosis established at nonenhanced CT. Non visualization of the appendix in the other 8 patients was not associated with any other inflammatory changes suggestive of appendicitis. The examination, thus, was interpreted as negative in these patients.

Identification of an appendicolith on non enhanced CT scans was considered a secondary finding. Appendicitis was not diagnosed without the presence of an enlarged appendix and periappendiceal inflammation. An appendicolith was identified in 16 (48%) of the 33 true positive diagnoses, in two of the 4 false Positive diagnoses, and in 2 patients with true negative diagnoses (one with an alternative diagnosis of a hemorrhagic right ovarian cyst correctly diagnosed at CT and one with true negative CT interpretation without an alternative diagnosis). In both patients with true negative diagnoses with an identified appendicolith, the appendix was less than 6 mm in diameter and there was no periappendiceal inflammation

Eighteen (31 %) of the 58 patients with true negative diagnoses, an alternative diagnosis was correctly established at CT. these alternative diagnoses included renal or ureteric calculi in 6 patients, gynecological disorders in 5 patients, sigmoid diverticulitis in 2 patients, cholelithiasis in 2 patients, ascending colon diverticulitis in one patient, , abscess in one patient, and inguinal hernia in one patient.

This analysis corresponds to an overall sensitivity of 87 %, specificity of 93 %, PPV of 89 %, NPV of 91 %, and accuracy of 91 %.

Discussion

Helical CT has become a valuable means of evaluating suspected appendicitis and is now accepted by several institutions as the method of first choice in the adult and pediatric populations [9,13]. In routine imaging, different techniques are sometimes used at the same diagnostic center as reported in a descriptive article from a large teaching hospital [13]. The major subjects of discussion are the use of, and the method of administration of contrast material, and possible limitation of the scanning field with regard to reduction of the radiation dose.

Rectal contrast media are recommended in children by several authors[14,15] to improve identification of the cecum and appendix. Others, however, believe that rectal contrast material is unnecessary and the procedure is too time consuming because the colon and cecum are usually clearly identified at CT on the basis of location and content [16].

The use of intravenous contrast agents in appendiceal CT has been recommended by several authors [13,17]. Jacob et al [18] demonstrated a significant improvement in diagnostic accuracy with the use of intravenous contrast- enhanced nonfocused CT compared with nonenhanced focused CT in adolescent and adult patients.

The ability to scan the abdomen and pelvis rapidly without any bowel preparation or contrast medium administration has made nonenhanced helical CT the study of choice at some institutions for the evaluation of patients suspected to have acute appendicitis. Furthermore; since rectal, oral, and intravenous contrast materials are not used; other imaging studies are not precluded if no abnormality is detected on the non enhanced CT scan. The examination is not operator dependant, and can be performed in very ill patients.

Understanding the anatomy of the ascending colon, cecum, and appendix is of great value in improving visualization of both the normal and abnormal appendix. The cecum is a highly mobile structure that can vary in position due to variations in its posterior peritoneal attachment. Furthermore, when the cecum is unusually large, it may extend downwards, overlap the psoas muscle, and drape into the true pelvis. In these instances, identification of the appendix arising from the postero-medial base of the cecum may be difficult and may result in false negative interpretations. One of our 5 false negative interpretations occurred in the setting of a pelvic appendix.

The primary imaging findings of acute appendicitis at non-enhanced CT include an appendix that measures greater than 6 mm in transverse diameter and periappendiceal inflammation [10,11,12].

In this study, an enlarged appendix was found in 30 of 33 true positive cases. An enlarged appendix was also found, although only retrospectively, in the 5 false negative cases. On the other hand, a review of our false positive interpretations showed that a dilated appendix > 6 mm occurred in 2 of 4 patients. However, on retrospective review, periappendiceal inflammation was not present in either of these patients, indicating that an enlarged appendix without periappendiceal inflammatory changes should be interpreted cautiously.

The results of a recent study by Rao et al [19] evaluating the sensitivity and specificity of several CT signs associated with acute appendicitis showed that an enlarged appendix of greater than 6 mm transverse diameter was 93% sensitive and 100% specific for acute appendicitis.

Additional CT findings in acute appendicitis include cecal or appendiceal wall thickening, appendicoliths and periappendiceal fluid collections [17,18]. Visualization of an appendicolith may aid in identifying the appendix, although this sign is not specific for acute appendicitis.

The appendix was not always depicted in this study. It was seen in 45 (89%) of 53 true negative CT interpretations, and was not seen in 9 patients. Nonvisualization of the appendix with absence of any other inflammatory sign was interpreted as negative for appendicitis in accordance with other literature [20,21,22]. This is the main point of divergence between CT interpretations in this study and that of Rao et al [10] in which the appendix was depicted in every true negative case. Their improved results may be attributed to the use of bowel opacification with both oral and rectal contrast materials.

Intraperitoneal fat is the intrinsic contrast medium in non-enhanced CT examination. Therefore, identification of inflammatory changes in thin pediatric patients with little intraperitoneal fat may be difficult. Three of five false negative CT scans in the Lane et al study [19] were obtained in thin young women with little intraperitoneal fat.

Evaluation of our 5 false negative interpretations shows, similarly, that one false negative interpretation occurred in a thin young woman with little intraperitoneal fat. The lack of intraperitoneal fat in this patient resulted in obscuration of the inflammatory process in the periappendiceal fat, even though the appendix was visualized prospectively. One false negative interpretation in this series

was in a patient with appendix low in the pelvis. The lack of an inflammatory process in the right lower quadrant in this patient resulted in misinterpretation of the findings, as the appendix was not seen prospectively.

The CT interpretations used by us was based on the positive and negative criteria described by Rao et al [10,23]. In our interpretation of the CT scans we required the presence of two or more signs to diagnose appendicitis. we chose these signs because they were the most frequently seen signs in the true positive cases in the Rao et al study.

Correctly identifying disorders that mimic acute appendicitis is as important as accurately establishing the diagnosis of appendicitis. Determination of an alternative diagnosis by CT in patients without appendicitis has been reported [21].

In this study we have found a high frequency (18 of 58 patients) of disease processes correctly diagnosed at non enhanced CT that clinically simulate acute appendicitis. Many of these cases were related to renal or ureteric calculi. The findings of renal or ureteric calculi at non enhanced helical CT have been well documented in the recent imaging literature [24]. Because the entire urinary tract should be visualized from the top of the kidneys to the pelvis [11], we believe that in cases of suspected acute appendicitis, images should not be limited to the pelvis. Gynecological disorders were the next most common set of conditions that mimicked acute appendicitis in this study. Ovarian processes commonly mimic acute appendicitis clinically. Therefore thin women with acute right lower quadrant pain must undergo pelvic ultrasonography because of the clinically important overlap with gynecological disorders that mimic acute appendicitis [11]. In this study we did not perform pelvic ultrasound to exclude gynecological abnormalities prior to CT because we believed that this would result in a high pre-set probability that appendicitis would be found with whatever test was used next.

In a recent study, Kamel et al [22] also examined the value of non focused (abdomino-pelvic) appendiceal CT in 100 consecutive patients with right lower quadrant pain who were clinically equivocal for acute appendicitis. They achieved a sensitivity of 98%, a specificity of 100%, and an accuracy of 99%.

Lane et al [20] examined 300 consecutive patients prospectively by using non enhanced thin section non focused helical CT for the detection of suspected acute appendicitis. Their study yielded a sensitivity of 96%, a specificity of 99%, and an accuracy of 97%. An alternative diagnosis was established in 35% of patients in whom CT results were negative for appendicitis.

The slightly lower sensitivity and accuracy achieved in this study compared with those of Lane et al [20] may be due to our exclusion of clinically straight forward cases, and our inclusion of gynecological cases by non performing a pelvic US prior to the CT examination. Furthermore, Lane et al study included cases clinically suspected of having acute appendicitis, while we examined only those patients who presented with equivocal symptoms and signs of acute appendicitis. In this study, whenever the diagnosis of appendicitis was clinically obvious, CT was not performed because the referring surgeons did not believe that there was any advantage of

scanning clinically typical cases, as this would have delayed diagnosis and increased complications as well as costs.

The reduced dose of ionizing radiation has been postulated as a major reason for limitation of the scanning field especially in children. However it has been shown that limitation of the scanning field may result in failure to include the appendix and may adversely affect the ability to diagnose alternative conditions [18].

In conclusion, we consider that the use of non enhanced non focused (entire abdominal) helical CT for confirmation of acute appendicitis is highly accurate examination in adult patients with a normal or obese body habitus and may decrease delays in appropriate medical or surgical therapy. US, on the other hand, remains the primary imaging modality for pediatric patients, pregnant patients, and very thin patients of either sex with suspected acute appendicitis.

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