Assessment of ultrasonography and computed tomography in the diagnostic strategy of suspected appendicitis

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"In most hospitals in the USA, even the tiny rural ones, high-tech CT images are much easier to obtain than a gourmet meal or even a cup of *real* coffee. And radiologists are always readily available to interpret the images online. No wonder that physicians confronted with suspected appendicitis feel compelled to get a CT, which is as easily procured as junk food"

MOSHE SCHEIN IN 'ACUTE ABDOMINAL PAIN - DIAGNOSTIC IMPACT OF IMMEDIATE CT SCANNING' , WORLD JOURNAL OF SURGERY 2007; 31: 2358

Improving the False-Negative Rate of CT in Acute Appendicitis: Reassessment of CT Images by Body Imaging Radiologists. A Blinded Prospective Study

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Abstract

PURPOSE To compare the accuracy of computed tomography (CT) analyzed by individual radiology staff members and body imaging radiologists in a non-academic teaching hospital for the diagnosis of acute appendicitis.

PATIENTS AND METHODS In a prospective study 199 patients with suspected acute appendicitis were examined with unenhanced CT. CT images were pre-operatively analyzed by one of the 12 members of the radiology staff. In a later stage two body imaging radiologist reassessed all CT images without knowledge of the surgical findings and without knowledge of the primary CT diagnosis. The results, independently reported, were correlated with surgical and histopathologic findings.

RESULTS In 132 patients (66%) acute appendicitis was found at surgery, in 67 patients (34%) a normal appendix was found. The sensitivity of the primary CT analysis and of the reassessment was 76% and 88%, respectively; the specificity was 84% and 87%; the positive predictive value was 90% and 93%; the negative predictive value was 64% and 78%; and the accuracy was 78% and 87%.

CONCLUSION Reassessment of CT images for acute appendicitis by body imaging radiologists results in a significant improvement of sensitivity, negative predictive value and accuracy. To prevent false-negative interpretation of CT images in acute appendicitis the expertise of the attending radiologist should be considered.

Introduction

In patients with suspected acute appendicitis computed tomography (CT) has proven to be an accurate imaging technique. CT has reported sensitivities of 70-100% and specificities of 91-100%.[1] However, the majority of these studies are performed in centres with dedicated expertise and in most of the cases expert interpretation of the images is provided.

Because most patients with acute appendicitis present at any time of the day in general community hospitals interpretation of CT scans is in the hands of in house staff. These health care professionals might have limited expertise in diagnosing appendicitis.

Few studies describe the influence of expertise of radiologists on the diagnostic accuracy of CT in acute appendicitis. Some authors describe no disagreement between resident and attending radiologists in the interpretation of CT scan in patients suspected of having appendicitis,[2-4] whereas others show interobserver variability in the evaluation of the CT images between radiologists with different levels of experience.[5,6]

Before the implementation of CT as the standard pre-operative imaging technique in our teaching hospital we decided to compare the results of the interpretation of CT images by the general radiology staff, published in a previous study,[7] by reassessing all the CT images by two body imaging radiologists. Results of this reassessment of CT images in acute appendicitis are presented in this study.

Patients and methods

Subjects

Because this study is a sequel to a previous study by Poortman et al.[7] we refer for the materials and methods used in this study to the mentioned previous study. All patients who were included in the previous study were included in the present study. In summary, all patients with suspected acute appendicitis underwent CT before surgery. When admitted between 10 pm and 8 am patients were clinically observed and underwent CT the next morning because of logistic considerations in the radiology department. One hundred and ninety-nine patients underwent surgery immediately or within 24 hours of observation after imaging.

Scanning technique

CT examinations were performed with a single-detector helical CT scanner (Tomoscan AV, Philips Medical Systems, Best, The Netherlands) by means of a rapid thin-scanning technique. A single breath-hold helical scan from the top of the L2 vertebral body to the pubic symphysis was obtained using 5 mm beam collimation and 5-mm/sec table speed (pitch of 1120 kV,100-250mA). Images were reconstructed and photographed at 3-mm intervals using different soft-tissue window settings (width: 400H; level: 40 H). In patients younger than 10 years old, the tube current was 100mA and reconstruction filter 5 was used. In patients between 10 and 15 years old, the tube current was 150 mA and reconstruction filter 5 was used. In patients 15 years or older, the tube current was 250 mA and reconstruction filter 4 was used. No oral, rectal, or IV contrast material was administered. A CT scan was read as positive for acute appendicitis if a distended appendix (≥ 6 mm in outer diameter) was visualized. The presence of the following ancillary signs were coded as being positive for appendicitis: periappendiceal inflammatory changes, cecal wall thickening, appendicoliths and abscess or phlegmon in the right iliac fossa. The presence of gas in the appendiceal lumen was considered as a possible negative criterion for appendicitis. An appendix less than 6 mm in outer diameter was also diagnosed as normal. If an appendix was not visualized and ancillary signs were or were not present, the findings were interpreted as negative.

Image analysis

CT scans were analyzed pre-operatively at a workstation by general radiology staff members who were alerted with the diagnosis “clinically possible appendicitis”. The CT examination was performed within 1 h by a general radiology staff member or by a resident radiologist supervised by a staff member. The ratio of the contributions to this study of body imaging radiologists (n=2) to the other members of the radiology staff (n=10) was 2:12, which is similar to daily practice. The CT diagnosis was pre-operatively established and registered. The reassessment of each individual CT image was performed by one of the two body imaging radiologists at a later date (after the study was finished). Both body imaging radiologists reassessed approximately the same amount of CT scans and no shared consultation took place. They were also only alerted to “clinically possible appendicitis” and unaware of the diagnosis made at surgery. The primary CT diagnosis nor the primary reader were known by the two body imaging radiologists. The results were correlated with surgical and histopathologic findings.

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 14.0. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of both the primary assessment and the reassessment were calculated.

Table 1: Acute appendicitis: alternative diagnoses made at surgery in 41 patients

Diagnosis	No. of patients	Therapy
Gynecologic		
Ovarian cyst	6	Conservative
Corpus luteum	6	Conservative
Adnexal teratoma	1	Resection
Epidermoid cyst	1	Resection
Cyst of Morgangi – torsion	2	Resection
Endometriosis/PID	6	Conservative
Total gynecologic diagnoses	**22**	
Gastro-intestinal diagnoses		
Diverticulitis	3	Sigmoid resection
Crohn's disease	2	Ileocoecal resection
Infarcted omentum	3	Resection
Cecal tumor (malignancy)	3	Hemicolectomy
Adhesions	2	Adhesiolysis
Cholecystitis	1	Cholecystectomy
Meckel's diverticulum	2	Diverticulectomy
Duodenal ulcer	1	Conservative
Mesenteric adenitis	2	Conservative
Total gastro-intestinal diagnoses	**19**	
Total	**41**	

Ninety-five per cent confidence intervals of the differences of sensitivity, specificity and accuracy were constructed using the CIA program (confidence interval analysis, BMJ group). The study protocol was approved by the hospital's ethical committee for human studies.

Results

Surgical findings

At surgery 132 of the 199 patients (66%) proved to have acute appendicitis and 67 patients (34%) did not have acute appendicitis. In 41 of these 199 patients (21%) another relevant

Table 2: Correlation of primary CT, reassessed CT and surgery for diagnosis of acute appendicitis in 199 patients

	Primary CT Analysis		
Surgery	Positive	Negative	Total
Positive	100	32	132
Negative	11	56	67
Total	111	88	199

	Reassessed CT Analysis		
Surgery	Positive	Negative	Total
Positive	116	16	132
Negative	9	58	67
Total	125	74	199

Table 3: Statistical data of primary CT and reassessed CT in 199 patients

	Sensitivity	Specificity	PPV*	NPV*	Accuracy
Primary CT	76%	84%	90%	64%	78%
Reassessed CT	88%	87%	93%	78%	87%
Difference	12%	3%	3%	14%	9%
95% CI difference	6%-18%	- 3%-10%	-5%-10%	6%-28%	5%-14%

*PPV, positive predictive value *NPV, negative predictive value

diagnosis was made. In most cases this diagnosis was gynecological. These diagnoses are listed in Table 1. In the other 26 patients without appendicitis (13%), no diagnosis was made and the appendix was left intact. One of these patients was re-admitted 4 months later and proved to have acute appendicitis at laparoscopy.

CT findings

The results of the primary CT findings and the CT findings after reassessment of all the CT images by two body imaging radiologists are listed in Table 2.

Statistical data

Statistical data are shown in Table 3. For sensitivity, negative predictive value and accuracy the differences are statistically significant in favour of the reassessment. The differences for specificity and positive predictive value are not statistically significant.

Histopathologic findings

During laparoscopy healthy-looking appendices were not removed. In two of these cases, the patients were re-admitted for acute lower abdominal pain in the right lower quadrant 1 year later. One of these patients underwent laparoscopy, and acute appendicitis was found. In three patients microscopic evidence of appendicitis was seen at histology after the surgeon removed a macroscopically normal appendix when performing a split-muscle incision. In one of the three patients both the primary CT and the reassessed CT showed appendicitis. In one patient the appendix was microscopically normal while the surgeon diagnosed an acute appendicitis. In this case both the primary CT analysis and the reassessment also did not suggest appendicitis.

Discussion

In this study the assessment of CT images for acute appendicitis in a non-academic community teaching hospital by two body imaging radiologists yields a significant higher sensitivity, negative predictive value and diagnostic accuracy than by individual members of the radiology staff.

In recent years the use of CT in the management of acute appendicitis has remarkably increased[8,9] and several researchers have concluded that CT should be performed routinely in all patients suspected of having appendicitis.[10-11] This point of view is comprehensible considering the high diagnostic performance of CT in these studies. Several authors emphasize that especially institutions without in house dedicated body imaging radiologists may not be able to duplicate high diagnostic accuracy rates of CT in acute appendicitis.[5-7,12,13]

In few studies the influence of expertise on the interpretation of CT images for acute appendicitis is described.[2-6] Lowe et al. prospectively compared resident and attending radiologic interpretations of unenhanced limited CT scans obtained in children suspected of having appendicitis and a high level of agreement was found.[2] Albano et al. compared the residents' preliminary written interpretations with both the final reports written by the faculty and the surgical findings and the results pointed out that both results closely match.[3] Keyzer et al. prospectively compared the diagnostic performance of appendiceal CT assessed by general radiologists and body imaging radiologists and no significant difference was found.[4] Contrary to this, Wise et al. showed a significant interobserver variability in the assessment of CT images for acute appendicitis.[5] In a retrospective analysis of CT scans in the diagnosis of acute appendicitis by Ceydeli et al. the data suggest that its specificity may change significantly depending on the level of the radiologist.[6]

Our study shows improved sensitivity, negative predictive value and accuracy of CT in acute appendicitis by reassessment of CT by body imaging radiologists, suggesting the influence of expertise on the assessment of CT images. The primary analysis by members of the radiology staff resulted in 32 (24%) false-negative CT interpretations, the reassessment by the two body imaging radiologists resulted in 16 (12%) false-negative CT scans. A possible explanation for this difference maybe the fact that appendiceal CT scans may be difficult to interpret at times and that experience is required to interpret the different diagnostic criteria which were established to diagnose appendicitis. One must be able to establish the true cecal position and scrutinize the entire appendix. Further interpretation is based on inflammatory changes, appendiceal size and the presence of an appendicolith and no one element is diagnostic, but rather, the whole radiologic image needs to be assessed. In a study of Daly et al. also experienced abdominal CT radiologists disagreed about the presence, absence and degree of isolated findings and the overall impression of appendicitis.[14] In this current study both members of the radiology staff and body imaging radiologists used the same criteria, but despite the use of the same protocol the false-negative rate among the members of the radiology staff was significant higher. Huyn et al. also suggested that in a community-based setting variations may still exist in the way each radiologist interpreted appendiceal CT scans and in the wording of their reads, resulting in a lower accuracy of CT than reported in protocol driven academic studies.[15] However, this pattern of CT usage in acute appendicitis probably more closely represent the common clinical setting in an average hospital. If the use of CT is implemented in the daily work up of acute appendicitis the surgeon should be aware of the accuracy of these tests in his/her particular hospital and the factors that could influence the CT results. Excessive interpretive variability may discourage the surgeon, which may result in discounting the efficacy of the imaging examination regardless of the accuracy reported in the literature. Each institution should examine their own results of CT scanning for the diagnosis of acute appendicitis and interpretation of CT images of patients with suspected appendicitis should be considered to be integrated into the early training of radiologists, surgeons and emergency medicine doctors. Another option is telesupervision of image interpretation, which is increasingly adapted and may become the standard of care in the near future.[16] Information technology allows and will oblige the medical community to provide the highest degree of expertise at any time and any place.

This study has limitations. Firstly, the reassessment was performed at a later date after the study was finished, which may introduce a certain bias. The reassessment was not part of the initial setup of the previous published study[7] but performed as a quality control and to determine whether the false-negative rate could be improved before the implementation of CT as the standard pre-operative imaging technique in our teaching hospital. The reassessment however was performed approximately 1 year after the primary study was finished which must have prevented that the body imaging radiologists could have remembered certain details of individual CT images. Secondly, the equipment used in the primary study was a single-detector helical CT. We realize that almost all facilities now have MDCT's which should have greater sensitivity. We also realize that oral and intravenous contrast material application, thin-collimation and, eventually, multiplanar reconstructions might improve the quality of interpretation. The aim of this study however was to determine the influence of expertise on the accuracy of appendiceal CT in an average teaching hospital by performing a reassessment within the original setup of the primary study.

Conclusion

In summary, reassessment of CT images for acute appendicitis by body imaging radiologists results in a significant improvement of sensitivity, negative predictive value and diagnostic accuracy. To prevent false-negative interpretation of CT images in acute appendicitis the expertise of the attending radiologist should be considered.

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