ORIGINAL ARTICLE

Can peritoneal thickening and enhancement be used to determine perforation in patients with acute appendicitis?

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ABSTRACT

BACKGROUND: Acute appendicitis (AA) is a common cause of abdominal pain in developed countries. In patients with suspected AA, computed tomography (CT) is considered as the gold standard with the highest sensitivity and specificity, and it is also an important modality, especially in patients with complicated AA. In this study, we aimed to evaluate age and laboratory findings, as well as specific CT findings in differentiating between perforated and non-perforated appendicitis.

METHODS: We retrospectively analyzed 252 patients diagnosed with AA and underwent appendectomy between November 2015 and December 2019 in Somalia Mogadishu Recep Tayyip Erdogan Education and Research Hospital. Patients under 18 years of age and those with no pre-operative CT scans were excluded from the study. The demographic, laboratory, CT findings, and pathological data of all patients were evaluated.

RESULTS: This study included 80 patients, 32 (40%) classified as perforated appendicitis (Group-1) and 48 (60%) as non-perforated appendicitis (Group-2). The C-reactive protein value was found to be statistically higher in Group-1 than in Group-2 (177.5±118.9 and 100.2±87.3 mg / L, respectively; p=0.001). The appendix lumen diameter (p=0.002), appendix wall defect (p<0.001), peritoneal thickening and enhancement (p<0.001), ascites (p=0.031), intra-abdominal abscess (p=0.003), jejunal thickening (p=0.019), ileal thickening (p=0.008), and ileus (p=0.035) values were significantly higher in Group-1. In the binominal logistic regression analysis performed with statistically significant data, an appendiceal wall defect (OR: 0.069, 95% CI=0.014–0.327, p=0.001) and peritoneal thickening and enhancement (OR: 0.131, 95% CI=0.024–0.714, p=0.019) were identified as independent variables for perforated appendicitis.

CONCLUSION: Among CT findings, appendix wall defects and peritoneal thickening and enhancement play an important role in detecting perforation.

Keywords: Acute appendicitis; computed tomography; perforation; peritoneal thickening and enhancement.

INTRODUCTION

Acute appendicitis (AA) is a common cause of abdominal pain with prevalence of approximately 1/1000 per year and lifetime prevalence of 7–9% in developed countries.[1] It has been suggested that genetic and environmental factors play an important role in appendicitis.[2]

In characteristic medical history, the main symptom is abdominal pain, associated with nausea and vomiting, which then migrates to the right iliac fossa. The clinical and laboratory findings include mild fever, pain exacerbated by coughing, increased sensitivity in the right lower quadrant, elevated white blood cell count, and C-reactive protein (CRP) concentration.[3] However, according to the literature, peritoneal irritation

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findings may not be present in 70% of patients with suspected appendicitis.[4] In one study, it was shown that computed tomography (CT) had more sensitivity and specificity in distinguishing perforated appendicitis from non-perforated appendicitis and in detecting other intra-abdominal pathologies. In another study, it was emphasized that CT played a key role in differentiating perforated and non-perforated appendicitis.[5] In patients with suspected AA, CT is considered as the gold standard with the highest sensitivity and specificity.[6] However, despite early diagnosis and treatment, perforation still occurs in 16–39% of AA cases. It has been shown that this condition can lead to serious life-threatening complications.[7] Although physical examination, laboratory, and imaging findings form the basis of the diagnosis of AA, CT is an important modality, especially in patients with complicated AA. In this study, we aimed to evaluate age and laboratory findings, as well as specific CT findings in differentiating between perforated and non-perforated appendicitis.

MATERIALS AND METHODS

Study Population

In this study, we retrospectively analyzed 252 patients diagnosed with AA and underwent appendectomy between November 2015 and December 2019 in Somali Turkey Recep Tayyip Erdogan Education and Research Hospital Education and Research Hospital. Eighty patients with pre-operative abdominal CT images were included in the study. The data of the patients were obtained from electronic records. The demographic, laboratory, CT findings, and pathological data of all patients were evaluated. Patients under 18 years of age, those with abnormal renal function, and those with no pre-operative CT scans were excluded from the study. For the study, approval was obtained from the local ethics committee (dated December 27, 2019, and numbered 2731).

CT Protocol

All CT examinations were performed with a 16-slice multidetector CT system (Sensation 16; Siemens, Forchheim, Germany). A standard 120 kVp was used for the injured patients with normal weight. Real-time Anatomic Exposure Control (CARE) dose 4D automatic exposure was used to optimize current (mA) according to body attenuation. Contrast material injection was applied using only 16- or 18-gauge peripheral intravenous (IV) catheters. All reconstructed images were archived in the hospital's picture archiving and communication system (PACS, Fonet Information Technologies, Istanbul, Turkey) for further image analysis and documentary purposes. All contrast-enhanced images were obtained using an automatic pump injector (CT motion™, Ulrich, Germany). The injection protocol consisted of 100 ml iso-osmolar, non-ionic iodinated contrast agent (iohexol, Omnipaque, 300 mg of iodine per milliliter; Amersham, Ireland), followed by 30 ml saline rapidly administered through the peripheral vein at 3 mL/s. The abdominal image was acquired 60 s after the beginning of contrast injection. We did not use enteric contrast material. Images were acquired from the dome of the diaphragm through the pubic symphysis. Both transverse and coronal reconstruction images were obtained.

Imaging Evaluation

All CT images were retrospectively reviewed at a PACS workstation by a radiologist (8 years of experience in emergency imaging), without prior knowledge of the patients' surgical or pathology results. Coronal and sagittal reconstructions were obtained and reviewed, when required, using computer software that was incorporated directly into the PACS. This configuration enabled immediate image reconstruction at the primary interpreting workstation without the imaging data having to be transferred to a separate 3D workstation. These reconstructions were not performed in all cases but rather as a problem-solving tool in some cases. The images were analyzed for the presence of an appendix, signs of inflammation, and any associated complications. The following findings pertaining to the presence or absence of perforation were recorded: (a) Appendicolith, (b) cecal wall thickening, (c) peritoneal thickening and contrast enhancement, (d) free fluid, (e) appendiceal wall defect, (f) ileus, (g) extraluminal free air, (h) abscess, and (i) appendix diameter. Appendicolith was defined as a well-defined, radiopaque, round, or oval structure within the appendix that was well separated from any contrast material that may have been present within the cecum. Cecal wall thickening was determined subjectively to be thickening of the cecal wall such that this wall was thicker than the ascending colon wall. Free fluid referred to extraluminal fluid attenuation in the abdomen or the pelvis, with no enhancing rim.[8] Focal wall enhancement defect referred to a discontinuity in the ring enhancement of the appendiceal wall after IV contrast material administration. Ileus was defined as a fluid-filled dilatation of the small bowel of 3.0 cm or larger. Extraluminal free air referred to focal areas of free gas outside of the bowel lumen. Abscess was defined as a well-defined focal fluid collection with a thick wall that enhanced with IV contrast material administration. The appendiceal diameter was the maximal short-axis diameter of the appendix measured using electronic calipers.[7,8]

Statistical Analysis

All analyses were performed using SPSS v. 20.0 (SPSS for Windows 17.0, Chicago, IL, USA). The variables with normal distribution were shown by mean and standard deviation values. Continuous variables that showed normal distribution were compared using Student's t-test, whereas those without normal distribution were compared with the Mann-Whitney U test. Categorical variables and frequencies were compared by conducting a Chi-square (χ^2) test. The statistical significance was defined as a $p<0.05$ (two-sided). A binominal logistic regression analysis was performed with significant variables. The sensitivity and specificity of the independent variables were also calculated.

RESULTS

The patients included in the study were 24 (30%) females and 56 (70%) males. The mean age of the patients was 37.4±16.2 years. Of the 80 patients, 32 (40%) were classified as having perforated appendicitis (Group-1) and 48 (60%) as non-perforated appendicitis (Group-2). The demographic data of Group-1 and Group-2 were similar. When the laboratory findings were compared, the CRP value was found to be statistically higher in the perforated appendicitis group than in the non-perforated appendicitis group (177.5±118.9 and 100.2±87.3 mg/L, respectively; p=0.001) while the remaining laboratory findings were similar in both groups. When the CT findings were compared, the appendix lumen diameter (p=0.002), appendiceal wall defect (p<0.001), peritoneal thickening and enhancement (p<0.001), ascites (p=0.031), intra-abdominal abscess (p=0.003), jejunal thickening (p=0.019), ileal thickening (p=0.008), and ileus (p=0.035) values were significantly higher in Group-1. Other CT findings were similar (Table 1). In the binominal logistic regression analysis performed with statistically significant data, an appendiceal wall defect (OR: 0.069, 95% CI=0.014–0.327, p=0.001) and peritoneal thickening and enhancement (OR: 0.131, 95% CI=0.024–0.714, p=0.019) were identified as independent variables for perforated appendicitis (Table 2 and Figs. 1–3). The selectivity and specificity appendiceal wall defect were found to be 81.3% and 83.3%, respectively, and those of peri-

Table 2. Binominal logistic regression analysis of the data found significant in the univariate analysis

	OR	%95 CI	p-value
Diameter of appendix (mm)	1.109	0.871–1.411	0.402
C-reactive protein (mg/L)	1.003	0.995–1.011	0.419
Appendiceal wall defect	0.069	0.014–0.327	0.001*
Peritoneal thickening and enhancement	0.131	0.024–0.714	0.019*
Ascites	1.988	0.328–12.059	0.455
Intraabdominal abscess	1.438	0.251–8.238	0.684
Jejunal wall thickening	0.769	0.052–11.354	0.848
Ileal wall thickening	0.981	0.093–10.392	0.987
Ileus	1.165	0.180–7.537	0.873

*P<0.05. OR: Odds ratio; CI: Confidence interval.

Table 3. Sensitivity and specificity of independent variables

	Sensitivity	Specificity
Appendiceal wall defect (%)	81.3	83.3
Peritoneal thickening and enhancement (%)	87.5	64.6

Table 1. Evaluation of patients' demographic, laboratory and radiological findings

	Group-1 (Perforated appendicitis) n=32	Group-2 (Non-perforated appendicitis) n=48	p-value
Age (years)	40.9±17.1	35.1±15.5	0.117
Male, n (%)	21 (65.6)	35 (72.9)	0.486
Transverse diameter of appendix (mm)	15.3±3.3	11.1±3.0	0.002*
Thickness of appendiceal wall (mm)	2.8±1.0	2.5±0.7	0.228
C-reactive protein (mg/L)	177.5±118.9	100.2±87.3	0.001*
White blood cell (x1000/mm^3)	14.4±5.9	12.3±4.8	0.085
Appendiceal wall defect	26 (81.3)	8 (16.7)	<0.001*
Extraluminal free air	4 (12.5)	3 (6.3)	0.332
Extraluminal free appendicolith	3 (9.4)	2 (4.2)	0.346
Peri-appendicular fluid	26 (81.3)	28 (58.3)	0.032*
Peritoneal thickening and enhancement	28 (87.5)	17 (35.4)	<0.001*
Ascites	17 (53.1)	14 (29.2)	0.031*
Intraabdominal abscess	20 (62.5)	14 (29.2)	0.003*
Thickening of lateroconal fascia	26 (81.3)	30 (62.5)	0.073
Thickening of cecum wall	5 (15.6)	3 (6.3)	0.256
Jejunal wall thickening	10 (31.3)	5 (10.4)	0.019*
Ileal wall thickening	13 (40.6)	7 (14.6)	0.008*
Ileus	12 (37.5)	8 (16.7)	0.035*

*P<0.05.

toneal thickening and enhancement were 87.5% and 64.6%, respectively (Table 3).

DISCUSSION

In this study, among the findings showing perforated appendicitis detected by CT, the presence of a defect in the appendix wall and peritoneal thickening and enhancement were found to be independent variables. The most important step in the treatment of patients with AA is to make a quick decision on the rapid diagnosis and surgical intervention in cases with perforated appendicitis. In addition, perforated appendicitis is a more advanced stage of AA and ultimately has less morbidity and mortality when accurately diagnosed and treated early.[9]

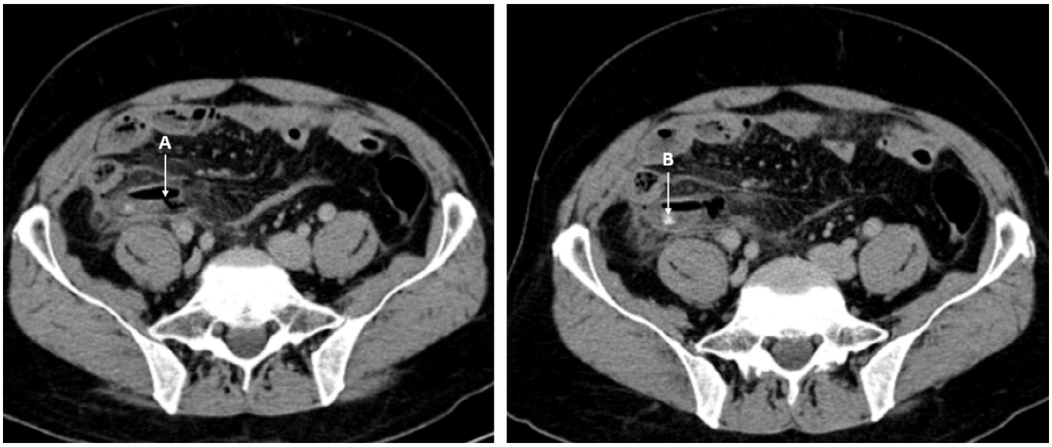

Figure 1. The axial computed tomography images of a 46-year-old male patient diagnosed with perforated appendicitis based on pathological findings, revealing an appendiceal wall defect (a) and an intraluminal appendicolith (b).

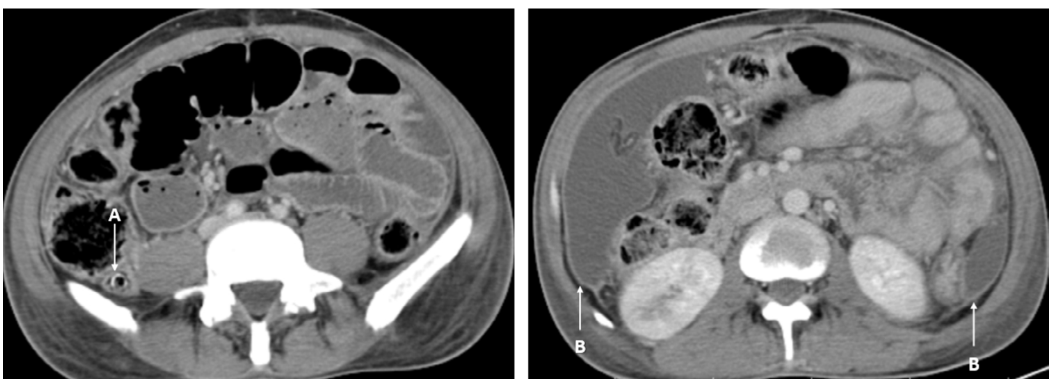

Figure 2. The axial contrast-enhanced computed tomography images of a 42-year-old female with perforated acute appendicitis, showing an intraluminal appendicolith (a), intraperitoneal ascites, diffuse abdomino-pelvic smooth peritoneal thickening, and peritoneal enhancement (b).

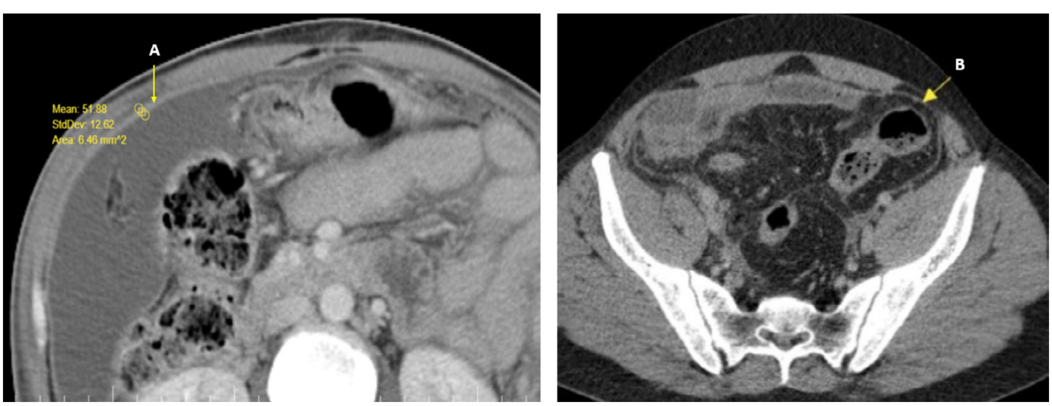

Figure 3. Axial contrast-enhanced computed tomography images show diffuse peritoneal enhancement (a) and peritoneal thickening (a and b).

In a study by Ruess et al.,[10] the presence of peritoneal thickening and enhancement was associated with perforation whereas Yeung et al.[11] reported that peritoneal thickening and enhancement did not indicate perforation. In another study,[12] it was emphasized that the presence of free fluid and peritoneal thickening and contrast enhancement in acute abdominal inflammatory conditions, such as appendicitis, diverticulitis, and Crohn's disease indicated peritonitis and was associated with gastrointestinal system perforation in advanced cases.

When the literature is examined, it is seen that there are only a limited number of studies on the presence of peritoneal thickening and enhancement. Although controversial in the literature, the presence of peritoneal thickening and enhancement in perforated appendicitis was found to be an independent variable in the current study. In the current study population, this may have been associated with the late presentation of the patients in Somalia to the hospital. In the literature, it has been emphasized that CT imaging is the routine imaging method in cases suspected to have AA, excluding children and young women.[13] Not surprisingly, it was also previously reported that perforated appendicitis cases had a longer hospital stay, almost twice as long as non-perforated appendicitis cases.[14] A perforated appendicitis and peritonitis in particular can be diagnosed by clinical and laboratory methods. However, CT can serve as a guide by providing a better explanation of the patient's current condition and even assisting in the decision regarding the preferred incision. As highlighted in the majority of studies, the majority of CT-positive patients underwent surgery, but CT-negative patients were usually kept under observation since it is considered unethical to expose the latter to surgery that may be unnecessary.[15] Horrow et al.[16] investigated the sensitivity and specificity of five findings, namely abscess, phlegmon, extraluminal air, extraluminal appendicolith, and appendiceal wall defect in the diagnosis of perforation and reported their sensitivity as 36%, 46%, 36%, 21%, and 64%, respectively. In another study, Tsuboi et al.[17] determined that 38 of 40 patients with perforated appendicitis had focal wall defects, and the sensitivity of this finding was 95% independent of other findings. In the present study, the sensitivity and specificity of an appendiceal wall defect were 81.3% and 83.3%, respectively. It was considered that the cross-sectional thickness being 5–10 mm and the use of oral contrast material in some studies might be the reason why sensitivity differed between the studies. While perforated appendicitis with abscess, gangrene or diffuse peritonitis is observed in 20% of the general population, the incidence of perforation in complicated AA patients (>65 years) varies between 40 and 70%.[18] High sensitivity and insufficient anti-inflammatory response have been proposed as the reasons for a higher rate of perforation in the elderly population.[19] These patients present with atypical clinical findings due to the insufficient immune response. Based on these findings, it is suggested that perforation is more common among the elderly.[19] The previous studies have also shown that patients in rural areas have a higher rate of perforated appendicitis.[20] As a progressive disease, complications, such as perforation in AA are primarily affected by the time from the onset of symptoms to hospitalization. This duration being longer than 72 h is often associated with perforated AA.[21] In this study, no significant relationship was found between perforated and non-perforated appendicitis in terms of age. This can be attributed to the effect of socioeconomic development or public health measures on life expectancy in underdeveloped countries such as Somalia. In addition, in our hospital located in Somalia, cases with the symptom of acute abdominal pain often present to the emergency room late, which may be related to the lack of social security, transportation problems, and sociocultural characteristics. Panagiotopoulou et al.[22] concluded that the increase in the CRP level had a high diagnostic value in detecting perforation in AA, but did not provide a cutoff value in separating perforation from AA. In the current study, CRP was significant in detecting perforation according to the univariate analysis, but the regression analysis did not reveal any statistical significance.

A major limitations of this study were its retrospective nature and the relatively small sample size. Furthermore, it was difficult to determine the time from the onset of symptoms to surgery.

Conclusion

CT can accurately distinguish between perforated and non-perforated appendicitis. In our study, among the CT findings, direct findings such as appendiceal wall defect and indirect findings; for example, peritoneal thickening and peritoneal enhancement were detected to be independent variables for perforated appendicitis. Therefore, it is important and very useful to perform CT in the pre-operative stage to develop appropriate therapeutic strategies in the diagnosis of perforated appendicitis.

Ethics Committee Approval: This study was approved by the Mogadişu Somali-Türkiye Recep Tayyip Erdoğan Training and Research Hospital Ethics Committee (Date: 05.12.2019, Decision No: MSTH/2731).

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Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Akut apandisitli hastalarda perforasyonu belirlemek için periton kalınlaşması ve kontrastlanması kullanılabilir mi?

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AMAÇ: Akut apandisit (AA) gelişmiş ülkelerde karın ağrısının en sık nedenlerinden biridir. Bu çalışmada, perfore olan ve perfore olmayan apandisitin ayrımında yaş, laboratuvar ve spesifik bilgisayarlı tomografi (BT) bulgularının değerlendirilmesi amaçlandı.
GEREÇ VE YÖNTEM: Somali Türkiye Recep Tayyip Erdoğan Eğitim ve Araştırma Hastanesinde, Kasım 2015 ile Aralık 2019 tarihleri arasında, AA tanısı alan ve apendektomi ameliyatı yapılan 252 hastayı geriye dönük olarak inceledik. Ameliyat öncesi uygun protokolle çekilmiş BT'si bulunmayanlar ve 18 yaş altı hastalar çalışma dışı bırakıldı. Hastalar histopatoloji sonucuna göre; perfore apandisit (Grup-1) ve perfore olmayan apandisit (Grup-2) olmak üzere ikiye ayrıldı. Tüm hastaların demografik, laboratuvar, BT bulguları ve patoloji verileri değerlendirildi.
BULGULAR: Bu çalışmaya 80 hasta dahil edildi. Hastaların %40'ı (n=32) perfore apandisit (Grup-1) ve %60'ı (n=48) perfore olmayan apandisit (Grup-2) olarak sınıflandırıldı. Grup-1'de C-reaktif protein değeri Grup-2'ye kıyasla istatistiksel olarak daha yüksek bulundu (sırasıyla; 177.5±118.9 ve 100.2±87.3 mg/L; p=0.001). Tek değişkenli analizde; apendiks lümen çapı (p=0.002), apendiks duvar defekti (p<0.001), peritoneal kalınlaşma ve kontrastlanma (p<0.001), asit (p=0.031), intraabdominal apse (p=0.003), jejunal kalınlaşma (p=0.019), ileal kalınlaşma (p=0.008) ve ileus (p=0.035) Grup-1'de Grup-2'ye kıyasla istatistiksel olarak daha yüksek bulundu. Tek değişkenli analizde istatistiksel olarak anlamlı verilerle yapılan binominal lojistik regresyon analizinde; apendiks duvar defekti (OR: 0.069, %95 CI=0.014–0.327, p=0.001), peritoneal kalınlaşma ve kontrastlanma (OR: 0.131, %95 CI=0.024–0.714, p=0.019) perfore apandisit için bağımsız değişkenler olarak belirlendi.
TARTIŞMA: Bilgisayarlı tomografi bulguları arasında apendiks duvar defekti, peritoneal kalınlaşma ve kontrastlanma perforasyonun saptanmasında önemli bir role sahiptir.
Anahtar sözcükler: Akut apandisit; bilgisayarlı tomografi; perforasyon; peritoneal kalınlaşma ve kontrastlanma.

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