

## Can appendix bending angle be an additional finding to detect acute appendicitis on MDCT?

Akut appendisitın ÇKBT tanısında appendiks bükülme açısı ek bir tanısal bulgu olabilir mi?

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### ABSTRACT

**Aim:** Computed tomography (CT) is frequently used as an imaging modality in the evaluation of acute appendicitis. The most frequently used measurement to detect acute appendicitis is maximal outer diameter of appendix on CT and several studies have reported other CT findings of acute appendicitis, such as thickness of the appendiceal wall, appendiceal wall enhancement, peri-appendiceal free fluid, peri-appendiceal inflammation, peri-appendiceal lymph node, appendicolith and cecal wall thickening. We investigated the value of the appendix bending angle (ABA) as an additional and novel finding in the diagnosis of acute appendicitis.

**Methods:** This retrospective study was conducted after the local ethics committee's approval. 52 consecutive patients who underwent appendectomies were assigned to the study group. The patients, who underwent abdominopelvic CT for any other reason than acute abdomen, were included as control group.

**Results:** The mean age of the appendicitis group was 41.9±16.0; male predominance was present (n=32, 61.5%). Peri-appendiceal inflammation was seen in 65.4%, peri-appendiceal lymph node was seen in 73.1% and appendicolith was present in 9.6% of the appendicitis group. The mean ABA was 103.0±15.9 degree in study group and 118.8±23.8 degree in control group respectively (p<0.001). The sensitivity of ABA was calculated as 76.9% and the specificity was 58.3% at 113.15 degree which is the best cut-off point calculated by ROC curve. There was no appendicitis over 142.3 degrees.

**Conclusion:** ABA can be used as an additional finding which is decreased in acute appendicitis.

Key words: acute, appendicitis, angle, multidetector computed tomography

### ÖZ

**Amaç:** Bilgisayarlı tomografi (BT), akut apandisit tanısında sık kullanılan bir görüntüleme yöntemidir. Akut apandisiti saptamak için BT'de en sık kullanılan ölçüm; apandiks en geniş dış çapının transvers düzlemde ölçümüdür. Birçok çalışma apandiks duvar kalınlığı, apandiks duvar kontrastlanması, peri-apandiküler serbest sıvısı, peri-apandiküler enflamasyon, peri-apandiküler lenf nodu, apendikolit ve çekum duvar kalınlaşması gibi akut apandisit için diğer BT bulgularını bildirmiştir. Biz çalışmamızda akut apandisit tanısında apandiks bükülme açısının (ABA) tanıya ek ve yeni bir bulgu olarak katkısını araştırdık.

**Yöntemler:** Bu retrospektif çalışma enstitüden etik kurul onayı alındıktan sonra yapıldı. Çalışma grubuna ardışık tarihlerde apandektomi yapılan 52 hasta alındı. Akut batin dışı nedenlerle abdominal BT çekilen hastalardan da kontrol grubu oluşturuldu.

**Bulgular:** Akut apandisit grubunun yaş ortalaması 41.9 ± 16.0 idi. Erkek hastalar çoğunlukta idi (n = 32, %61.5). Akut apandisit grubunda peri-apandiküler inflamasyon %65.4, peri-apandiküler lenf nodu %73.1 ve apendikolit %9.6 oranlarında pozitif bulundu. Ortalama ABA, çalışma grubunda 103.0 ± 15.9 derece, kontrol grubunda ise 118.8 ± 23.8 derece idi (p < 0.001). ABA'nın duyarlılığı % 76.9 olarak hesaplandı ve özgüllüğü ROC eğrisi ile hesaplanan en iyi kesme noktası olan 113.15 derecede % 58.3 idi. 142.3 derecenin üzerinde akut apandisit saptanmadı.

**Sonuç:** ABA'nın azalmış olması akut apandisit tanısında ek bir bulgu olarak kullanılabilir.

Anahtar Kelimeler: akut, apandisit, açı, çok kesitli bilgisayarlı tomografi

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## INTRODUCTION

**A**cute appendicitis is the most common cause of acute abdomen that requires surgery, with an estimated lifelong risk of 8.6% in men and 6.7% in women [1]. It is often regarded as a disease of the young population with a peak incidence in the second and third decades of life [1]. Appendectomy is generally accepted as a first-line treatment for non-complicated acute appendicitis [2]. Plain radiography, ultrasonography and computed tomography and even magnetic resonance imaging have all been used in diagnosis.

Computed tomography (CT) has been frequently used as an imaging modality in the evaluation of acute appendicitis and has improved the diagnostic ability, leading to a significant reduction in the number of negative appendectomies [3]. The use of CT has led not only to a substantial decrease in the rate of unnecessary appendectomies, but also to a concomitant decrease in the perforation rate [4]. With reported sensitivities of up to 83–99% and specificities of 92–99%, CT plays a major role in the clinical decision-making process in acute appendicitis and is considered as a first-line and rapid imaging modality in the diagnostic workup for suspected acute appendicitis [5,6]. A normal appendix can be identified in 73-82% of patients with thin-section axial CT abdomen; also, it can be increased to 93% by using 16-slice CT and multiplanar reformation images [7]. Additionally, using a 64-slice multi-detector CT (MDCT) with coronal reformations can increase the identification rate up to 98.5% [8].

Several studies have reported CT findings of acute appendicitis [9-12]. However, there are no reported conflicting results about the appendix bending angle (ABA) and no available data as to whether a cut-off point influence ABA in adults, with or without acute appendicitis. In this study we hypothesized that as an empty small intestinal segment; the appendix gets rigid and bends towards the cecum at an acute angle. However, a non-inflamed appendix has a relax lining and positioned across the cecum at an obtuse angle. Establishing normal and abnormal parameters for ABA is important because in subtle cases this angle can be helpful for the correct diagnosis. Furthermore, we believe ABA measures can be

a precursor for an inflamed appendix and thus, in this study, we investigated signs of inflamed and noninflamed appendix on MDCT and reference values for ABA in symptomatic and asymptomatic adults, using reformatted CT imaging.

## MATERIAL AND METHODS

This retrospective study was approved by the local ethics committee of Diskapi Yildirim Beyazit Training and Research Hospital (approval date: 16.01.2017, no: 34/26). From January 2016 to October 2016, 63 patients who underwent appendectomy (laparoscopic or open) for suspected acute appendicitis and diagnosed as acute appendicitis surgically, were included the study. Of these, 11 patients were excluded for the following reasons: preoperative CT was not performed (n=4), CT scanning without using intravenous contrast media (2), complicated appendicitis (abscess, phlegmon, and focal defect in the appendiceal wall, n=3) and poor CT image quality (n=2). In total, 52 consecutive patients were included in the study group. For the aim of the control group, patients who underwent contrast enhanced abdominopelvic CT for causes other than acute abdomen were enrolled consecutively between the same dates of the study group.

### MDCT imaging

MDCT examinations were performed with a 128-detector row CT machine (GE Optima 660 SE 64 Detector 128-slice CT, General Electric Medical Systems, Milwaukee, WI). CT protocols were based on the following: effective level of 140–175 mAs, 120 kVp, 0.625 collimation, 5-mm thickness reconstruction at 5-mm intervals, 0.5-second rotation time. 100–120ml iodinated contrast medium was injected via the antecubital vein at a rate of 3mL/second, with a delay of 60 seconds between contrast administration and data acquisition given at a rate of 3-3.5 mL/s. We did not use enteric contrast material, as the need for it is questionable according to recent studies [13,14]. Images were acquired from the dome of the diaphragm through the pubic symphysis. Both transverse, sagittal and coronal reconstruction images were obtained. Soft tissue kernel was used and the reconstruction increment was 0.625-mm.

Image analyses: Two abdominal radiologists who were blinded to the histopathologic and surgical findings evaluated in consensus all images retrospectively. They evaluated the following features: transverse diameter of the appendix, thickness of the appendiceal wall, appendiceal wall enhancement, peri appendiceal free fluid, peri appendiceal inflammation, existence of peri-appendiceal lymph node, appendicolith and cecal wall thickening [15]. The transverse diameter of the appendix and thickness of the appendiceal wall were measured at maximal short-axis diameter and maximal wall thickness of the inflamed appendix, respectively. Appendiceal wall enhancement was compared to that of the cecal wall and divided into two groups: increased or un-increased [15]. Images were evaluated for ABA on coronal reformat images. ABA was defined as the wide angle between long axis of cecum and long axis of proximal appendix. Figure 1 showed ABA measurement on normal and inflamed appendix. Each observer measured ABA on the same day in separated computers to assess interobserver variation. Additionally, to detect intraobserver variations, observers measured the ABA for the second time in two-week interval. Observers were blinded to their previous measurements. The final measurement of continuous variables were calculated as follows: The mean of the two measurement of the first observer was added to the second observers result and divided into two again [Result=  $0.5 \times ((\text{First look of Observer1} + \text{Second look of Observer1}) \times 0.5 + \text{Observer2})$ ].

#### Statistical Analyses:

The statistical calculations were performed by "IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.". The continuous variables were expressed as mean $\pm$ sd, categorical data was expressed as n (%). The normal distribution was determined by histogram and Kolmogorov-Smirnov test. To compare the mean of two groups that were normally distributed, Student's t Test was used. The categorical parameters were compared by Chi Square test. ROC analysis was used to determine the cut-off points; sensitivity and specificity values were calculated. Correlation of the same raters two judgments was calculated by Pearson Correlation Coefficient and correlation between two radiologists by Kendall's Coefficient

of Concordance (the mean value of the first observer compared with the second observer's measurement). All tests was applied as two tailed and the statistical significance level was  $p < 0.05$ .



Figure 1: (a) Normal appendix. Appendix bending angle measurement technique in coronal plane (the angle between the vertical line of cecum and appendix) (b) Acute appendicitis. Measurement of ABA in coronal plane.

## RESULTS

The mean age of the appendicitis group was  $41.9 \pm 16.0$  (range 18-77) versus the control group was  $45.4 \pm 15.2$  (range 18-80). Male predominance was present in the appendicitis group ( $n=32$ , 61.5%) whereas female dominance was present in the control group ( $n=27$ , 56.3%).

The frequency of peri appendiceal inflammation, peri appendiceal lymph node, appendicolith, as well as the means of appendix wall thickness, cecum wall thickness, appendix diameter and ABA and comparison of appendicitis and control group, were given in Table 1.

Peri appendiceal inflammation was present in 65.4% of the appendicitis group but also in 4.2% of the control group. It is more frequently observed in appendicitis, but the sensitivity was 65.38% and the specificity was 95.83%; positive predictive value (PPV) was 94.44% (81.19% - 98.53%), negative predictive value (NPV) was 71.88% (63.65% to 78.86%).

Peri appendiceal lymph node was present in 73.1% of the appendicitis group but also in 14.6% of the control group. It was more frequently

observed in appendicitis, but the sensitivity was 73.08% and the specificity was 85.42%; positive predictive value (PPV) was 84.44% (72.86% - 91.65%), negative predictive value (NPV) was 74.55% (64.83% to 82.31%).

Table 1. Frequency of appendicitis findings and measurements of appendix in appendicitis and control group

	Appendicitis Group		Control Group		P
	n	%	n	%	
Periappendiceal inflammation	34	65,40%	2	4,20%	<0,001
Periappendiceal lymph node	38	73,10%	7	14,60%	<0,001
Appendicolith	5	9,60%	-	-	<0,028
	mean±sd	(min-max)		(min-max)	
Bending angle (degree)	103,0±15,9	(69,5-142,3)	118,8±23,8	(75,8-160,0)	<0.001
Appendix diameter (mm)	10,14±1,53	(5,0-13,0)	4,66±0,46	(3,5-5,3)	<0.001
Appendix wall thickness (mm)	3,87±0,68	(2,23-5,43)	2,42±0,29	(1,88-3,18)	<0.001
Cecum wall thickness (mm)	4,35±0,84	(2,48-6,38)	2,65±0,40	(2,00-3,90)	<0.001

Appendicolith was present in 9.6% of the appendicitis group but in none of the control group. It was observed in appendicitis, but the sensitivity was 96.2% and the specificity was 100%; positive predictive value (PPV) was 100%, negative predictive value (NPV) was 50.53% (48.31% to 52.74%).

The mean of appendix wall thickness, cecum wall thickness and appendix diameter were greater in appendicitis group as expressed in Table 2, ROC curve and best cut-off points of these measurements were given in Figure 2. The mean ABA was 103.0±15.9 in acute appendicitis group and 118.8±23.8 in control group, respectively. The ROC curve of appendix bending angle was showed in Figure 3. Area under curve in ROC analysis was 0.695 (0.588-0.801; 95%CI). Two cut-off points with sensitivity and specificity values were given in Table 2. According to ROC curve the best cut-off of point was 113.15 degrees; at this point the sensitivity was 76.9% and the specificity was 58.3% (PPV 66.67% and NPV 70.00%). When we got the cut-off of point as 110 degrees the sensitivity would be 69.2% and the specificity would be 60.4% (PPV 65.5% and NPV 63.6%).

As we saw in Table 1, there were no appendicitis cases over the bending angle 142.3 degrees.

Table 2. AUC and cut-off points determined by ROC curve and sensitivity and specificity of these points

	AUC* of ROC** Curve (Upper-Lower Bound with 95% CI***)	Cut-off Point	Sensitivity (%)	Specificity (%)
Appendix diameter (mm)	0,994 (0,981 - 1,000)	6,3	98,1	100,0
Appendix wall thickness (mm)	0,982 (0,953 - 1,000)	3,08 3,20	96,2 88,5	97,9 100,0
Cecum wall thickness (mm)	0,970 (0,937 - 1,000)	3,27 3,94	96,2 63,5	95,8 100,0
Bending angle (degrees)	0,695 (0,588-0,801)	113,15 110,00	76,9 69,2	58,3 60,4

\*AUC: Area under curve, \*\*ROC: Receiver operating characteristic, \*\*\*CI: Confidence interval

There was a high correlation between two measurements of the same observer (p<0.001, r=0.884). However, interobserver reliability was lower compared to intraobserver rates (p=<0.001, r=0.262).

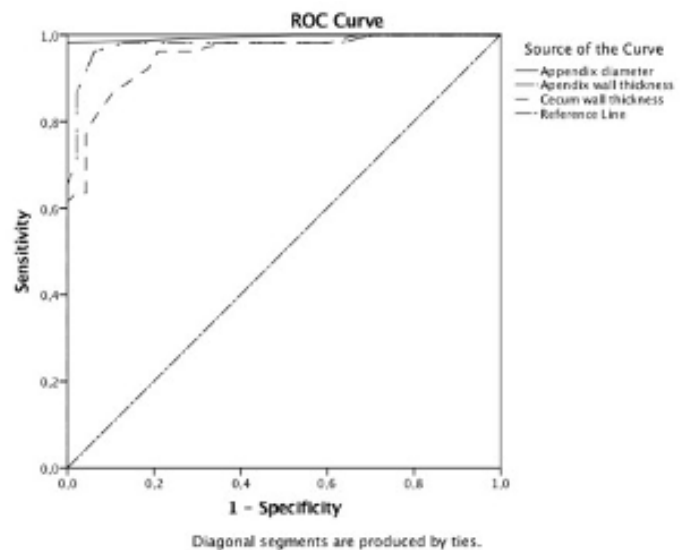


Figure 2. ROC curve of appendix wall thickness, cecum wall thickness and appendix diameter

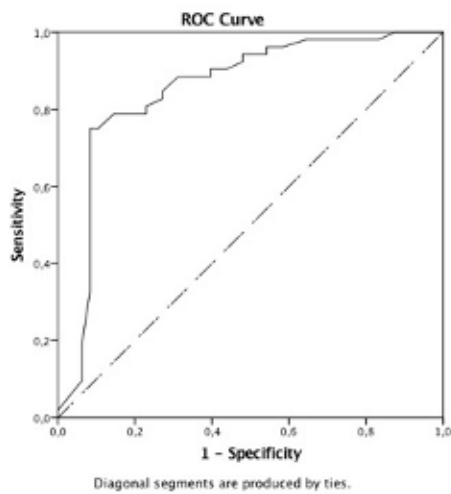


Figure 3. ROC curve of appendix bending angle

## DISCUSSION

Diagnosis of acute appendicitis can be determined by observing the increased diameter of the appendix, the presence of appendicolith, peri appendiceal inflammation and free fluid on the CT [15]. Except those on MDCT, as in our hypothesis, ABA can be measured as an additional and a new solution in the diagnosis of acute appendicitis.

Firstly, if we evaluate at the classic CT findings of appendicitis, we find in our study results that are similar to previous studies, such as an increased diameter and wall thickness of the appendix, increased cecum wall thickness, the presence of appendicolith, peri appendiceal inflammation and lymph node all highly indicate the presence of appendicitis. The inflamed appendix is distended with a diameter measuring between 6-40 mm and a wall thickness of 1–3mm [16]. Our study revealed that the mean appendix diameter was  $10,14 \pm 1,53$  mm in acute appendicitis group. Besides over 6.3 mm of appendix diameter the sensitivity was 98.1% and specificity was 100%. Several studies report that the diameters of normal appendices do not exceed 6 mm [17,18], while others reported diameters greater than 6 mm even up to 10mm [19,20]. We did not detect an appendix diameter over 6mm in our control group. Additionally, we measured the mean wall thickness of appendix as  $3.87 \pm 0.68$  (range 2.23-5.43) in the acute

appendicitis group and  $2.42 \pm 0.29$  (range 1.88-3.18) in the control group.

Appendicoliths is a rare finding of the acute appendicitis but it is associated with severe appendicitis, appendiceal perforation, recurrent appendicitis after conservative therapy or failure of antibiotic therapy [21]. The presence of appendicoliths and the location of an appendicolith at the root of the appendix were significantly associated with gangrenous appendicitis [22]. As described, appendicolith is very rare, it was observed in 9.6% of the appendicitis group and not at all in the control group. Another study has reported the frequency of appendicolith as 33.3% in acute appendicitis and never observed in their control group [23]. Peri appendiceal inflammation is one of the positive findings of acute appendicitis [24]. Tatar et al. reported that in the patients with normal appendix mild to moderate peri appendiceal inflammation frequency was 12.8% and severe peri appendiceal inflammation was 3.8%; in the patients with acute appendicitis, mild to moderate peri appendiceal inflammation was observed in 30.8% of the patients and severe peri appendiceal inflammation was observed in 48.7% of the patients [23]. Our study results were similar with the previous literature: we observed peri appendiceal inflammation in 73.1% of the appendicitis group and 14.6% of the control group.

In this study, we hypothesized that ABA decreases in cases of acute appendicitis and we could not find a similar study about this angle and its association with acute appendicitis. The mean ABA in acute appendicitis was significantly lower than in the control group, which supports our hypothesis that when we come up with as an empty small intestinal segment, an inflamed appendix forms an acute angle throughout the cecum. The sensitivity of ABA was calculated as 76.9% and the specificity was 58.3% at the point of 113.15 degrees which is the best cut-off point and the specificity was 59.6% at the point of 110 degrees. There was no appendicitis case over the bending angle of 142.3 degrees. With these results, we determined that ABA can be used as a novel and additional finding which can exclude acute appendicitis over 142.5 degrees and which additionally, has acceptable sensitivity and specificity values at 113.15 or 110 degrees. Furthermore, we explained the predictive

value of ABA in acute appendicitis, which is significantly high to be used as a diagnostic tool.

Having been designed retrospectively, a limitation of this study is the low number of patients included and lack of knowledge whether the patients were in the early phases of inflammation or not. Our results should be further validated with a higher number of patients and with the addition of follow-up periods, in order to build more solid recommendations after a standardized explanation of measurement method to the observers.

In conclusion, CT is an accurate imaging modality for the diagnosis of acute appendicitis. The main purpose of our study was to determine the diagnostic value of ABA, which can be used as a new diagnostic finding that was found to be lower in patients with acute appendicitis. There were no cases with acute appendicitis over 142.3 degrees. But further prospective studies with patients that are conservatively followed will provide better results that can be used in clinical practice.

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