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Original Article

A new parameter in the diagnosis of acute appendicitis: Ileocolic artery and vein diameter measurements

Beyza Nur Kuzan[1], Taha Yusuf Kuzan[2], Rabia Ergelen[1]

[1] Marmara University Faculty of Medicine, Department of Radiology, Istanbul, Turkey
[2] Sancaktepe Sehit Prof. Dr. İlhan Varank Training and Research Hospital, Department of Radiology, Istanbul, Turkey

Abstract

Aim: To determine the ability of ileocolic artery (ICA) and ileocolic vein (ICV) diameter measurements in the diagnosis of acute appendicitis.

Material and Methods: ICA, ICV, abdominal aorta (AA) and inferior vena cava (IVC) diameters were recorded in 123 patients. Patients were grouped according to the presence of acute appendicitis clinically-radiologically. The receiver operating characteristic (ROC) curves were constructed to obtain the cutoff values in terms of differentiation of appendicitis and control groups.

Results: ICA, ICV, ICA/AA and ICV/IVC measurements differed significantly between the appendicitis (n=75) and control (n=48) groups (p <0.001, p <0.001, p =0.003, p =0.006). The best cutoff values for ICA and ICV to differentiate appendicitis from the control group were 2.92 mm and 4.28 mm, respectively. The ICA, with a cut-off point based on the ROC curve, of 2.92 mm provided a sensitivity of 70.7%, and a specificity of 70.8%. Applying the cut-off point of 4.28 mm for ICV, generated a sensitivity of 80%, and a specificity of 72.9%.

Conclusion: Measurements of the ICA and ICV diameter in computed tomography (CT) is a promising application for determining acute appendicitis. This preliminary study suggests ICA and ICV diameter measurements could contribute as an alternative parameter to major radiological evidence in the diagnosis of acute appendicitis.

Keywords: Ileocolic artery; ileocolic vein; acute appendicitis; abdominal; computed tomography.

INTRODUCTION

The appendix is a blind-ended tubular structure attached to the posteromedial end of the cecum in the lower right quadrant of the abdomen (1,2). The diameter of a healthy appendix is generally less than 6 mm, but it can measure up to 11 mm (3). While the blood supply to the appendix is provided by the appendicular artery, which is the terminal branch of the ileocolic artery, venous drainage of the appendix occurs via appendicular veins that flow into the ileocolic veins (4).

Acute appendicitis is one of the most common causes of acute abdominal pain. It is the most common condition that requires abdominal surgery. Although anamnesis, physical examination and laboratory findings are keys to diagnosing acute appendicitis, imaging modalities help in the determination of an accurate diagnosis and greatly reduce mortality and morbidity by eliminating unnecessary surgery in patients without acute appendicitis (5-8).

The computed tomography (CT) findings that indicate the presence of acute appendicitis include; increased appendix diameter (greater than 6mm outer-wall-to-outer-wall transverse diameter), thickening and contrast enhancement in the appendix wall and findings of periappendicular inflammation (periappendicular density increase, abscess and pericecal lymph nodes) (8-14).

In cases of acute appendicitis, hyperemia and vascular congestion in the periappendicular region, secondary to regional inflammation, can also be evaluated through CT examinations. Recent studies suggest that the demonstration of these changes by ileocolic artery and vein diameter measurements in CT may contribute to the diagnosis of acute appendicitis (15).

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Corresponding Author: Taha Yusuf Kuzan, Sancaktepe Sehit Prof. Dr. İlhan Varank Training and Research Hospital, Department of Radiology, Istanbul, Turkey **E-mail:** tykuzan@gmail.com

The purpose of this study is to quantitatively evaluate the local vasodilatation that occurs secondary to regional inflammation, by measuring the diameters of the ileocolic artery and vein and; calculating ICA/AA and ICV/IVC ratios radiologically in acute appendicitis cases using intravenous contrast-enhanced abdominal CT examinations.

MATERIAL and METHODS

Patient characteristics

Ethical approval for this retrospective study was obtained from Local Ethics Committee (protocol no. 09.2018.444). Contrast-enhanced abdominal CT examinations between January 2015 and January 2017 were retrospectively evaluated. Five major radiological findings, including appendix diameter ≥ 6 mm, appendix wall thickness ≥ 3 mm, contrast enhancement on appendix wall, periappendiceal density increase, and periceacal lymph nodes, were identified in the radiological diagnosis of acute appendicitis. Ninety-three adult patients, who were followed up with the findings described in the CT scan, participated in the study, constituting a radiological group of acute appendicitis. Seventy five of 93 patients participated in the study, while 18 patients with vascular variations, calcific plaques in vascular structures, hemodynamic instability (and other technical insufficiencies) were excluded. An age and gender matching group of 48 randomly selected, clinically-radiologically acute appendicitis negative, adult patients who visited the emergency department for abdominal pain during the same period also participated in the study as a control group. Acute appendicitis diagnosis was pathologically confirmed in 50 of 75 radiologically acute appendicitis cases. The remaining 25 patients had clinical and radiological diagnosis of acute appendicitis.

Equipment and computed tomography (CT) examination

All patients underwent CT examinations after the intravenous injection of 1 ml/kg of contrast medium, at a rate of 3-4 ml/s and portal venous phase images were obtained with a 60–70 ml/s delay after the initiation of the contrast injection. CT scans were obtained with a single breathhold multidetector scanner (Somatom Definition Flash, Siemens, Erlangen, Germany) from the hepatic dome to the pelvic floor using a 128x0.6 mm collimation, 5-mm slice thickness, a pitch of 1.0 and 120 or 140 kVp tube voltage using online dose modulation (CARE Dose4D, Siemens Healthcare).

Image interpretation

The data of all patients were evaluated on a PACS system (INFINITT Healthcare, Seoul, South Korea) by an abdominal radiologist with over 15 years of experience. The radiologist was blinded to clinical and pathological results. The CT findings of all patients were noted by the radiologist. In all cases, the appendix was simultaneously analyzed on axial and coronal CT sections and all measurement procedures were performed with an electronic ruler after the actual images were magnified. During the evaluation, five acute appendicitis findings previously determined in CT were noted (Figure 1). Measurements of ICA and ICV diameters were obtained from the proximal 2 cm segments of superior mesenteric artery (SMA), and superior mesenteric vein (SMV) in the axial plane, respectively. The abdominal aorta (AA) and inferior vena cava (IVC) diameters were measured at the same slice (Figure 2).

Statistical Analysis

Descriptive analyses were performed for the characteristics of the patients. For the ICA, ICV, ICA/AA and ICV/IVC, the receiver operating characteristic (ROC) was conducted to calculate the difference between the appendicitis and control groups, and to obtain the cutoff values in terms of differentiation of appendicitis and non-appendicitis. Statistical analysis was completed using SPSS software version 17.0.

RESULTS

The acute appendicitis group consisted of 75 adult patients (56 male and 19 female) aged between 18 and 66 (mean ± SD, 33.2±12.2 years). The control group consisted of 48 patients (34 men and 14 women) aged between 18 and 69 (mean ± SD, 32.9±13.3 years). The mean ICA diameter was 3.28±0.60 and 2.72±0.48 mm, and the mean ICV diameter was 5.12±1.03 and 4.02±1.05 mm, in the appendicitis and control groups, respectively. In the appendicitis group, the ICA and ICV diameters were significantly higher than in the control group ($p < 0.001$, $p < 0.001$, respectively). In comparison with the control group, the acute appendicitis group was significantly different with respect to ICA/AA and ICV/IVC ($p = 0.003$, $p = 0.006$, respectively). ROC analysis for the evaluation of acute appendicitis revealed an area under curve (AUC) for ICA as 0.759 (95% CI=0.67-0.84, $p < 0.001$) and for ICV as 0.795 (95% CI=0.71-0.88, $p < 0.001$). AUC for ICA/AA and ICV/IVC were 0.690 (95% CI=0.59-0.79, $p < 0.001$) and 0.671 (95% CI=0.57-0.77, $p = 0.001$), respectively. The best cutoff values of the ICA and the ICV in ROC analysis for the best differentiation between the acute appendicitis group and the control group were 2.92 mm and 4.28 mm, respectively. Using 2.92 mm as a cutoff for ICA differentiation between the acute appendicitis group and the control group, the sensitivity and specificity were founded as 70.7% and 70.8%, respectively. When the 4.28 mm cutoff value for ICV differentiation between the appendicitis group and the control group was used, the sensitivity and specificity were founded as 80% and 72.9%, respectively.

DISCUSSION

Delay in the diagnosis of acute appendicitis is placed at the top of emergencies that may cause major complications. Acute appendicitis can be diagnosed based on clinical and laboratory findings when the case presents with typical clinical findings, but scanning methods are needed to support the diagnosis in the presence of atypical clinical and examination evidence (10,16,17).

Ultrasonography is used as the first choice as a scanning method in the diagnosis of acute appendicitis, because of the absence of ionizing radiation and the lack of contrast material needed, but patient and operator-based limitations are the disadvantages of ultrasonography. On the other hand, CT examination is commonly used as a scanning method which allows the evaluation of other abdominal pathologies with high accuracy, especially in cases where ultrasonography is ineffective (12,16,18,19).

It has been reported that up to 94% of appendix CT scans that are applied on adults can visualize the appendix as a separate structure. In CT studies done of healthy children, the appendix can be selected as a separate structure in only 50% of the cases because of small size and low intra-abdominal fat tissue (20,22).

Acute appendicitis, one of the most common causes of acute abdomen, is a result of fluid in the obstruction of the appendix lumen, and luminal distention (9). The increase in the appendix diameter as a result of increased intraluminal pressure is the most common evidence in an acute appendicitis case. There are a variety of studies comparing acute appendicitis groups with healthy groups to evaluate appendix size. According to these studies, appendix diameter is variable in the range of 4.2-12.8 mm, in normal cases (9).

Because the range for a normal diameter of the appendix is wide, the appendix diameter threshold should not be determined without having evidence of other inflammation signs in the diagnosis of acute appendicitis [20]. In the case of acute appendicitis, the accuracy of a 6 mm diameter threshold for the diagnosis of appendicitis is high, and it is reported to have a sensitivity ranging from 52% to 59%, and a specificity ranging between 86% and 97%, in various studies (12,16).

Other major evidence in the diagnosis of acute appendicitis includes increased appendix wall thickness and wall enhancement, periappendiceal inflammatory changes (periappendiceal density enhancement, fluid collection, phlegmon-abscess form), and periceacal lymph nodes. Periceacal lymph nodes and increased density of mesenteric planes are sensitive but non-specific findings showing regional inflammation. In the literature, there are no definite sensitivity-specificity values defined for these findings in the diagnosis of appendicitis (9,16).

In acute appendicitis cases, venous and lymphatic drainage are blocked because of luminal distension in the appendix. Ischemia and bacterial invasion caused by the disturbance of venous drainage provide the basis for local inflammation. There are a variety of cytokines and chemokines that are responsible for the inflammatory response, there's a detected increase in their serum levels in acute appendicitis cases, and are associated with increased vascular permeability and local vasodilation. Also, regional inflammation secondary to vascular congestion and vasodilation can be evaluated in scanning methods. Recently, mesenteric vascular structures are evaluated by means of CT before laparoscopic surgery, and ICA diameter is almost always less than 7 mm when measured using CT (23,27).

In our study, ICA and ICV were used to evaluate local vasodilation as an alternative parameter in cases of acute appendicitis, with the five major radiological pieces of evidence previously described. In the literature, there are limited number of studies evaluating ICA and ICV changes secondary to inflammation in patients with acute appendicitis (15). In our study, the ICA diameter was found to be 3.28±0.60 mm in the acute appendicitis group, and 2.72±0.48 mm in the control group, and the difference between them was statistically significant ($p < 0.01$). Similarly, the ICV diameter was 5.12±1.03 mm in the acute appendicitis group, and 4.02±1.05 mm in the control group, and the difference between them was statistically significant ($p < 0.01$). In a study by Sirik et al. the mean diameter of the ileocolic artery in patients with acute appendicitis was 3.31±0.69 mm, while the mean diameter of ileocolic vein was 5.21±0.9 mm. In the control group, the mean diameter of the ileocolic artery was 2.75±0.31 mm and the mean diameter of ileocolic vein was 4.17±0.45 (15). Our results were consistent with the results of Sirik et al., and the ICA and ICV diameters increased in the appendicitis group compared to the control group.

In our study, contrary to the study conducted by Sirik et al., one's own ICA and ICV are divided by the AA and IVC diameter, respectively. A statistically significant difference was found between the acute appendicitis group and normal control group in terms of ICA/AA and ICV/IVC ratios, which were $p = 0.003$ and $p = 0.006$, respectively. While there was a statistically significant difference in ICA/AA and ICV/IVC ratios in appendicitis and control groups, AUC values for ICA/AA and ICV/IVC in ROC analysis was 0.690 and 0.671, respectively, and was found to be relatively lower than values obtained for ICA and ICV (0.759, 0.795, respectively) (Figure 4). We believe that the relatively low sensitivity and specificity for ICA / AA and ICV / IVC is due to individual differences in AA and IVC.

When a cutoff value of 2.92 mm was used for the ICA diameter in the appendicitis diagnosis, 70.7% sensitivity and 70.8% specificity were obtained. When a cutoff value of 4.28 mm was used for the ICV diameter, 80% sensitivity and 72.9% specificity were obtained. These results indicate that ICA and ICV diameters are useful for distinguishing an acute appendicitis group from a control group. We believe that these additional parameters may contribute to the diagnosis besides the major evidence present in acute appendicitis cases.

There are some limitations in our study. Firstly, since the BMI of the cases were unknown, it could have led to personal differences in the measurements. To prevent this, a proportional assessment was made between the vascular structures of the cases using ICA/AA and ICV/

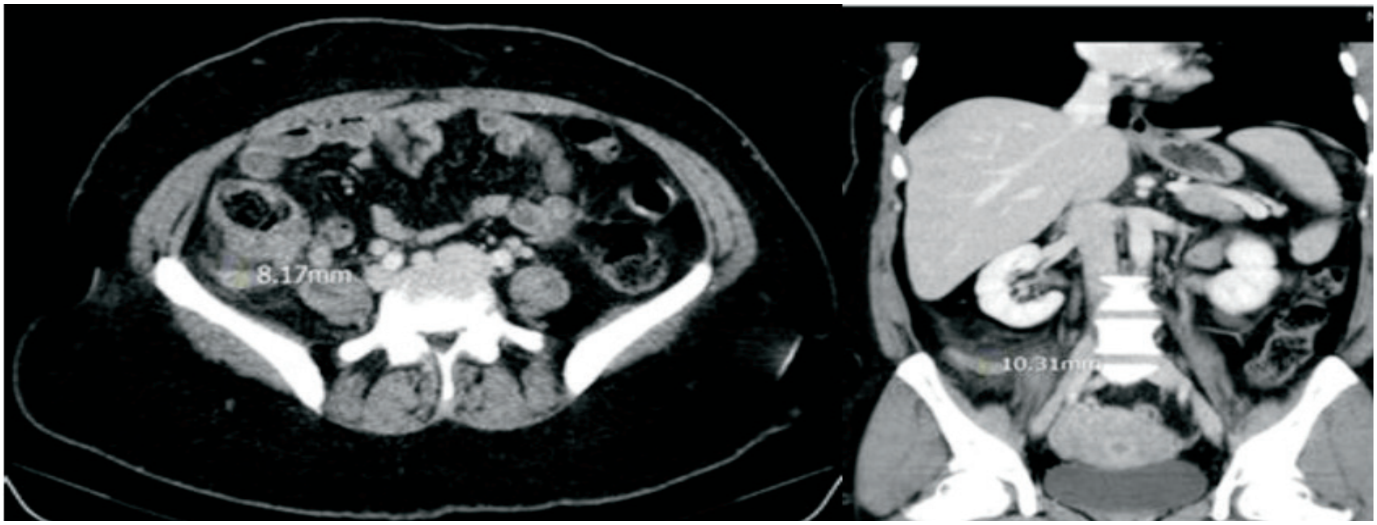

Figure 1. Five major radiological findings (increased appendix diameter and appendix wall thickness, contrast enhancement on appendix wall, increased periappendiceal density and periceacal lymph nodes) were identified in CT images.

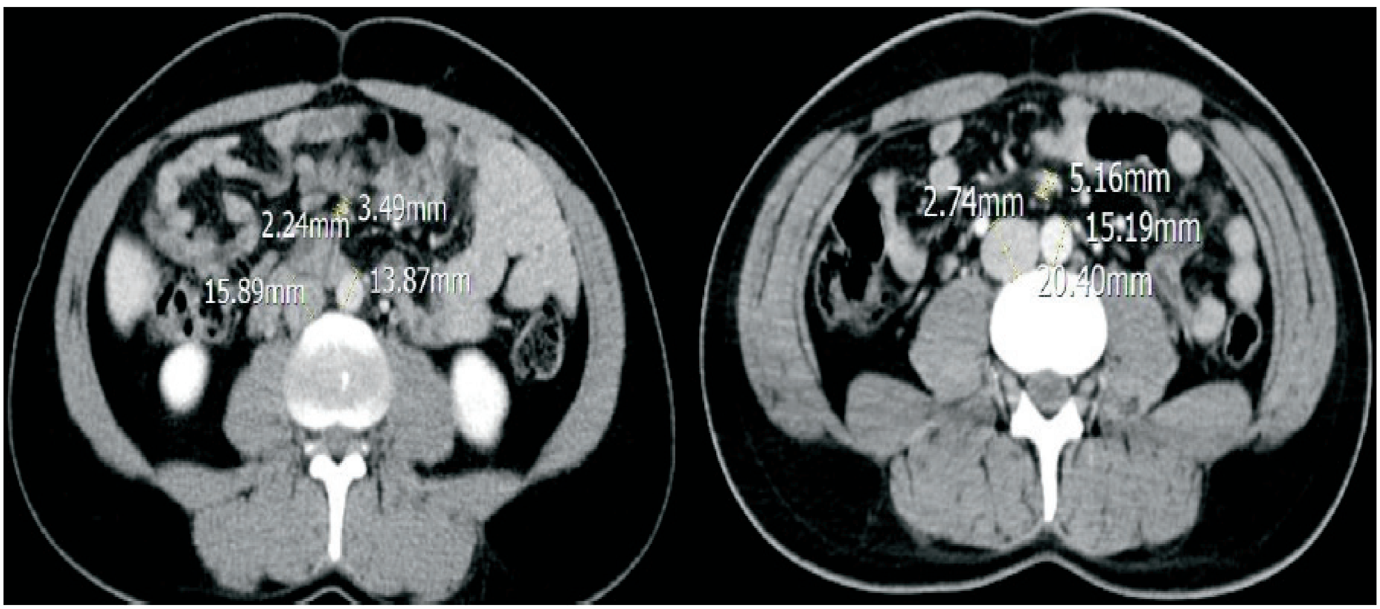

Figure 2. Measurements of ICA, ICV, AA and IVC diameter in the control group.
Ileocolic artery (ICA) and ileocolic vein (ICV), abdominal aorta (AA) and inferior vena cava (IVC)

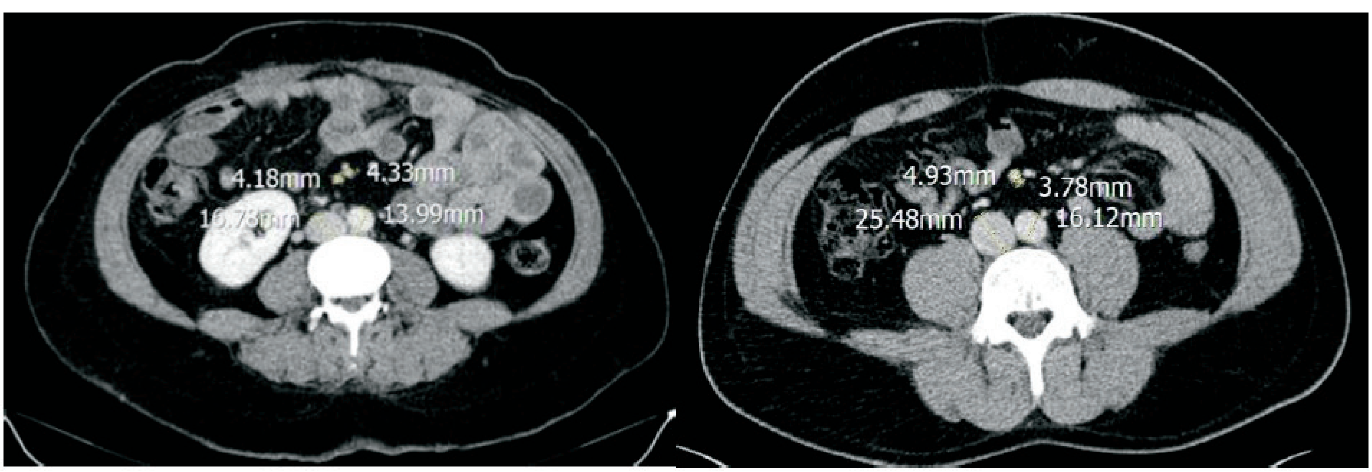

Figure 3. Measurements of ICA, ICV, AA and IVC diameter in the acute appendicitis group.
Ileocolic artery (ICA) and ileocolic vein (ICV), abdominal aorta (AA) and inferior vena cava (IVC)

Table 1. Demographic characteristics and vascular diameter measurements of the patients

	Acute appendicitis Group (n=75)	Control Group (n=48)	p value
Age	33.2 ± 12.2	32.9 ± 13.3	0.89
Gender (F/M)	19/56	14/34	0.64
ICA	3.28 ± 0.60	2.72 ± 0.48	<0.001
ICV	5.12 ± 1.03	4.02 ± 1.05	<0.001
AA	14.4 ± 2.18	13.6 ± 2.38	0.05
IVC	17.5 ± 3.21	16.0 ± 3.09	0.011
ICA/AA	0.23 ± 0.049	0.20 ± 0.045	0.003
ICV/IVC	0.29 ± 0.075	0.26 ± 0.079	0.006

Ileocolic artery (ICA) and ileocolic vein (ICV), abdominal aorta (AA) and inferior vena cava (IVC), Female (F), Male (M)

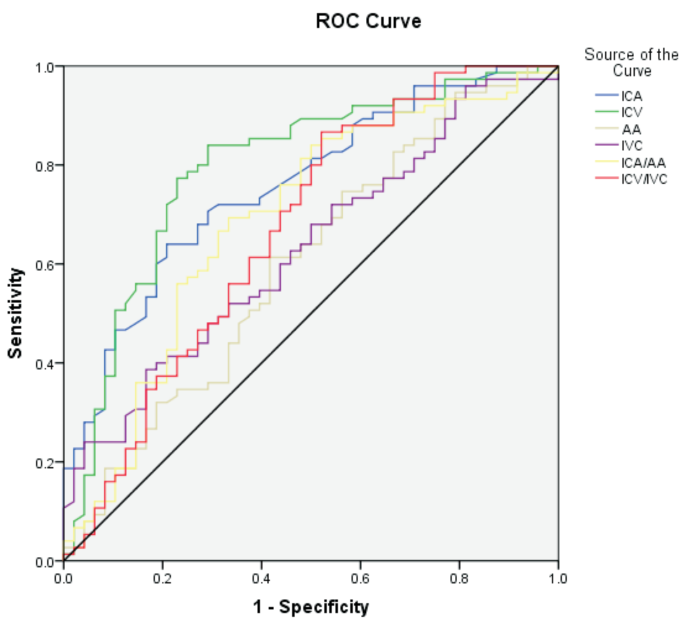

Figure 4. Diagnostic performance of diameter measurements in the diagnosis of appendicitis

IVC. The second is the absence of a pathological diagnosis of some cases followed by conservative treatment. These cases were accepted as acute appendicitis with clinical and laboratory data and scanning results and they recovered after medical treatment.

Additionally, the patients who were treated with less than five major pieces of radiological evidence and were considered as suspicious in terms of "radiological acute appendicitis" and were therefore not included in the study.

The final limitation of the study is that interobserver variability was not assessed.

CONCLUSION

According to our study, ICA and ICV diameter measurements can be used as an additional parameter to major radiological evidence in the diagnosis of an acute appendicitis case.

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Beyza Nur Kuzan: ORCID:0000-0002-5001-3649
Taha Yusuf Kuzan: ORCID:0000-0002-5420-8507
Rabia Ergelen: ORCID:0000-0002-9647-4125

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