

Appendix Vermiformis Morphology in the Adult Age Group: What we've learned from more than 250 Patients on Computer Tomography

Erişkin Yaş Grubunda Apendiks Vermiformis Morfolojisi: Bilgisayarlı Tomografide 250'den fazla Hastadan Öğrendiklerimiz

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ABSTRACT

Objective: This article assesses normal appendix vermiformis morphology in the adult age group by computed tomography (CT).

Material and Methods: A total amount of 256 cases who had a clinical suspicion of urolithiasis and underwent abdominal- pelvic non- enhanced CT were enrolled in the study. Appendiceal diameter, wall thickness, intraluminal content, and the presence of an appendicolith were evaluated. Variables summarized by descriptive statistics. Groups were compared using the chi-square test and student *t*-test.

Results: The mean diameter of the appendix was 6.5 ± 1.2 mm (range, 3.1-9.7 mm) in all cases. Intraluminal air content detected in 199 (77.7%) cases. In 57 (22.3%) cases without air within the lumen, the appendix was evaluated as collapsed or isodense. Mean appendix diameter was 6.7 ± 1.1 mm in cases with air in the lumen and the mean appendix diameter was 5.8 ± 1.3 mm in cases with isodense or collapsed appearances ($p < 0.001$). Mean wall thickness of appendix determined as 1.7 ± 0.3 mm (range, 0.9-3.1 mm). Appendicolith was detected in seven (2.7%) cases.

Conclusion: In the presence of air in the appendiceal lumen, the increase in diameter can be interpreted normal unless not accompanied by inflammatory findings. It should be kept in mind that normal appendix diameter may be 6 mm or above when the intraluminal content of the appendix could not be distinguished.

Keywords: Appendix morphology; Computed Tomography; Appendix Diameter; Acute Appendicitis

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ÖZET

Amaç: Bu makale erişkin yaş grubunda bilgisayarlı tomografi (BT) ile normal apendiks vermiformis morfolojisini değerlendirmektedir.

Yöntem: Çalışmaya klinik olarak ürolitiazis şüphesi olan ve kontrastsız abdomen-pelvik BT incelemesi yapılan toplam 256 olgu dahil edildi. Apendiks çapı, duvar kalınlığı, lümen içeriği ve apendikolit varlığı değerlendirildi. Değişkenler tanımlayıcı istatistikler kullanılarak sunuldu. Gruplar ki-kare testi ve student *t*-testi kullanılarak karşılaştırıldı.

Bulgular: Tüm olguların ortalama apendiks çapı 6.5 ± 1.2 mm (dağılım aralığı, 3.1-9.7 mm) idi. Lümen içi hava 199 (%77.7) olguda tespit edildi. Lümen içinde hava olmayan 57 (%22.3) olguda apendiks kollabe veya izodens olarak değerlendirildi. Ortalama apendiks çapı lümen içinde hava bulunan olgularda 6.7 ± 1.1 mm, izodens veya kollabe olan olgularda 5.8 ± 1.3 mm idi ($p < 0.001$). Ortalama apendiks duvar kalınlığı 1.7 ± 0.3 mm (dağılım aralığı, 0.9-3.1 mm) olarak belirlendi. Yedi olguda (%2,7) apendikolit saptandı.

Sonuç: Apendiks lümeninde hava mevcut ise inflamatuvar bulgular eşlik etmedikçe çap artışı normal olarak kabul edilebilir. Apendiks lümen içeriğinin ayırt edilemediği durumlarda normal apendiks çapının 6 mm veya üzerinde olabileceği akılda tutulmalıdır.

Anahtar Sözcükler: Apendiks morfolojisi; Bilgisayarlı tomografi, Apendiks çapı, Akut apandisit

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INTRODUCTION

Acute appendicitis is the most common cause of right lower quadrant pain in patients admitted to the emergency department (1, 2). Early surgical intervention is preferred due to the high risk of perforation and abdominal sepsis in patients with acute appendicitis (2, 3). In adult patients who are suspected of acute appendicitis, computed tomography (CT) has become the preferred imaging method in addition to clinical and physical examination findings (4-6). In most studies, sensitivity and specificity of CT have been reported as 90-100% (3-11). With the increasing and widespread use of CT, negative appendectomy and post-appendectomy complication rates have decreased (6, 7). However, since negative appendectomy rates which are still high reveals the necessity for better identification of normal appendix CT findings.

The increased diameter and wall thickening of the appendix with periappendiceal inflammation, including stranding of the adjacent fat planes are necessary imaging findings for the diagnosis of acute appendicitis. Most common view is that the appendix can be considered abnormal if the diameter of the appendix is above 6 mm and the wall thickness is above 3 mm (12-14). Although these values play a critical role in the diagnosis of acute appendicitis, their determination is based on compression ultrasonography (US) and do not completely meet the CT criteria (15-18). Isolated enlargement of appendiceal diameter (> 6 mm) not accompanied by inflammatory changes, may be the only finding for acute appendicitis. However, in the presence of air within the appendiceal lumen, the increase in diameter can be interpreted normal unless secondary inflammatory findings are accompanied (13). In particular, when the intraluminal content of the appendix could not be distinguished; the evaluation becomes more confusing.

Knowing the normal appendix CT findings is important for the diagnosis of acute appendicitis. Therefore, this article assesses normal appendix vermiformis morphology in the adult age group.

MATERIALS and METHODS

Patient Population

Between May 2018 and December 2018, patients who had a clinical suspicion of urolithiasis and underwent abdominal- pelvic non- enhanced CT were assessed retrospectively. CT scans were accessed via the Picture Archiving and Communication System (PACS), and patient clinical information was obtained from hospital electronic medical records. The patients who were excluded from the study are as follows: (1) Pediatric patients (< 18 years), (2) with a history of abdominal surgery and systemic disease, (3) with radiological and clinical bowel pathology, (4) whose appendices could not be visualized and patients whose medical records could not be reached. The rest 256 consecutive cases (140 males, 116 females; range 18-82 years) were included in the study. Corporate ethics committee gave approval to this study (2021/500).

CT technique

CT scans were performed with a 128-slice CT system (Somatom Definition Flash, Erlangen, Germany, Siemens Healthineers). CT scans were taken in the supine position, from top of the kidneys to the base of the bladder, during 4.98-second breath-hold. Intravenous and oral contrast agents were not used during the scanning.

Scanning and reconstruction parameters for CT images were as follows: 38.4 × 0.6 mm collimation, 1 mm reconstruction thickness, 1 mm reconstruction interval, 0.8 pitch, 100 kVp and 100 mA.

Image interpretation

CT images were assessed at dedicated the workstation by multiplanar reformat (MPR) and by two radiologists with 7 years of abdominal CT experience.

Appendiceal diameter, wall thickness, intraluminal content, the presence of an appendicolith and periappendiceal fat planes were assessed in each case. Images were magnified and the maximum diameter of the appendix was measured at the widest point, by two radiologists in consensus. Measurements were taken from the outer wall to the opposite outer wall. Each measurement was taken 3 times and the average of these measurements was calculated.

Wall thickness of appendix was measured in cases with intraluminal air content. In cases with indiscernible appendix wall due to lack of intraluminal content, measurements were not performed.

Wall thickness of appendix measurement was performed on the sections where the appendix was observed axially. Two opposite wall thicknesses were measured, and the mean values were noted.

Cases were evaluated by dividing groups according to appendix diameter (< 6 mm or ≥ 6 mm), intraluminal air (with or without air), gender and age (≤ 50 years or ≥ 51 years). Cases without intraluminal air were identified as collapsed or isodense.

Statistical analysis

Continuous numerical variables were shown as mean ± standard deviation (SD) and categorical variables were shown as a number of cases (percent) by using descriptive statistics. In addition, groups were compared using the chi-square test (categorical variables) and student *t*-test (continuous numerical variables). The results for *p* < 0.05 were considered statistically significant unless otherwise stated. Data were analysed via "Statistical Package for Social Sciences (SPSS) for Windows Version 21.0 Statistics" package.

RESULTS

The distribution of some sociodemographic characteristics and imaging findings of the cases are given in Table 1.

The mean diameter of the appendix was 6.5 ± 1.2 mm (range, 3.1-9.7 mm) in all cases. The appendix diameter was found to be 6 mm and above in 176 (68.3%) cases. None of the cases had a maximum diameter more than 10 mm.

There was air content in the appendiceal lumen in 199 (77.7%) cases. In 57 (22.3%) cases without air within the appendiceal lumen, the appendix was evaluated as collapsed or isodense (Figure 1).

Mean appendix diameter was 6.7 ± 1.1 mm (range, 4.1-9.7 mm) in cases with air in the appendiceal lumen and the mean appendix diameter was 5.8 ± 1.3 mm (range, 3.1-9.3 mm) in cases with isodense or collapsed appearances. The mean diameter was higher in cases with air in the appendiceal lumen and this difference was statistically significant (*p* < 0.001) (Figure 2).

Appendix diameter was determined as 6 mm and above in 148 (57.8%) patients with air in the appendiceal lumen and in 28 (10.9%) cases whose intraluminal content was indistinguishable. The difference between the groups was significant (*p* = 0.001) (Table 2).

In the assessment according to the gender, the appendix diameter and wall thickness were detected higher in males. However, this difference was not statistically significant (*p* = 0.073). There was no difference in assessment according to age groups (*p* = 0.713).

Wall thickness of appendix was evaluated in patients with luminal air content and mean wall thickness of appendix determined as 1.7 ± 0.3 mm (range, 0.9-3.1 mm). The wall thickness of the appendix was more than 3 mm in one case.

Appendicolith was detected in seven (2.7%) cases (Figure 3).

Table 1. Demographic characteristics and imaging findings of patients (n = 256)

	Number	Percentage
Gender		
Male	140	45.3
Female	116	54.7
Age (year)		
	Mean ± SD: 45.6 ± 15.6, Median: 46 Minimum: 18, Maximum: 82	
Intraluminal contents		
Air	199	77.7
Collapsed/isodense	57	22.3
Appendicolith		
Presence	7	2.7
Absence	249	97.3
Periappendiceal fat stranding		
Yes	-	-
No	256	100
Appendix diameter (mm)		
	Mean ± SD: 6.5 ± 1.2, Median: 6.6 Minimum: 3.1, Maximum: 9.7	
Wall thickness (mm) (n=199)		
	Mean ± SD: 1.7 ± 0.3, Median: 1.7 Minimum: 0.9, Maximum: 3.1	

SD: Standard deviation

Table 2. Cross table between appendix diameter and intraluminal content

	Appendix diameter				χ ²	p**
	< 6 mm		≥ 6 mm			
Intraluminal contents	n	%*	n	%*		
Air	51	19.9	148	57.8	13.148	0.001
Collapsed/isodense	29	11.3	28	10.9		

* Total percent ** Chi-square Test



Figure 1. Non-enhanced axial image demonstrates normal appendix vermiform with thin wall thickness (mm) and containing intraluminal air content (a). Intraluminal content of normal appendix vermiformis could not be distinguished (b).

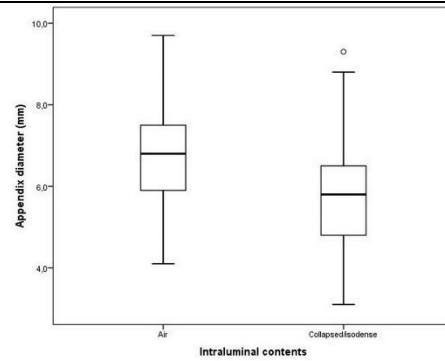


Figure 2. Box plot showing the comparison of appendix diameter (mm) according to intraluminal contents. Box lengths represent the interquartile range, the horizontal lines within the boxes the median value, and ° represents outlier value. Appendix was visualized isodense and enlarged (9.3 mm, outlier) in one case who had no radiologic and laboratory findings that were compatible with acute appendicitis in the medical records.



Figure 3. Non-enhanced coronal image demonstrates appendicolith within the appendiceal lumen.

DISCUSSION

CT is a commonly used imaging method for the diagnosis of acute appendicitis in adult patients, and its sensitivity and specificity were found to be over 90% (3-9). The increased diameter and wall thickening of the appendix with periappendiceal inflammation are typical and most common CT findings for the diagnosis of acute appendicitis (3-9). In 15% of patients with acute appendicitis, isolated enlargement of appendiceal diameter may be the only finding and may not be accompanied by signs of inflammation. In such cases, the interpretation of CT becomes more confusing (13). In our study, we showed that the normal appendiceal diameter may be larger than commonly known values. We also showed that the appendiceal diameter may vary depending on the luminal content. Therefore, we concluded that we need to know the normal appendix vermiformis morphology on CT to better evaluate acute appendicitis.

It is a common mistake to consider the appendix diameter increased over 6 mm. Although these values play a critical role in the diagnosis of acute appendicitis, their determination is based on compression ultrasonography (US) and do not completely meet the CT criteria (11, 17-20). Previous studies have reported that the mean normal appendix diameter is 5.6 mm to 8.1 mm (14, 15, 21, 22). These differences can be explained by variations in measurement techniques. In our study, mean appendix diameter was 6.5 ± 1.2 mm and measured as 6 mm and above in 68% of the cases, similarly to previous studies (14, 15, 21).

The content of the normal appendix lumen is often distinguishable. Approximately 77% of the patients had air content within the lumen of appendix similarly to previous studies (14, 15, 22).

The mean appendix diameter was found to be higher in cases with air in the appendiceal lumen. Previous studies have also demonstrated that intraluminal content may increase the appendix diameter slightly (14, 15). However, 28 (10.9%) cases whose intraluminal content was indistinguishable had a diameter 6 mm or more. In a study conducted by Webb et al, this rate was reported as 6.6% (14). In the literature, there is not a normal appendix whose intraluminal content cannot be distinguished and with a diameter above 10 mm (14, 15, 22). In our study, the findings were similar to the literature (14, 15, 22). The maximum diameter of the appendix was determined as 9.3 mm in these cases whose intraluminal content was indistinguishable. Therefore, the threshold value for normal appendix diameter can be accepted as 10 mm in cases with indistinguishable intraluminal content and without findings of accompanying inflammation (14, 15, 22, 23).

The increase in thickness of the appendix wall is accepted as an imaging finding of acute appendicitis (2, 4, 11, 13, 14, 17-22). In a study by Simianu et al, 62% of patients with acute appendicitis had a wall thickness of more than 3 mm in CT scans (9). In our study, the wall thickness of the normal appendix was 1.7 ± 0.3 mm and showed similarity between previous studies (3, 15, 22). Previous studies have demonstrated that the normal appendix wall thickness can be over 3 mm (3, 15, 22). However, in our study, there was only one case whose wall thickness is above 3 mm.

Although there is a significant correlation between appendicolith and acute appendicitis, this finding is not specific. Appendicolith can also be found in normal cases. In our study, appendicolith was detected within the appendiceal lumen in 2.7% of normal cases and this rate was similar to previous studies (24, 25).

The most important limitations of our study are the use of clinical information as a standard reference and the lack of pathological diagnosis of patients. Another limitation is the fact that our study was retrospective. In addition, even if the patients with the appendix or ileocecal region diseases were excluded in the study, the sample did not represent a healthy population.

In conclusion, knowing the normal appendix morphology in CT is important for diagnosis of acute appendicitis. In the adult age group, the normal appendix diameter frequently detected as 6 mm or above. Depending on the intraluminal content, the diameter of the normal appendix varies and the mean appendix diameter was higher in the patients with air in the appendiceal lumen. In the presence of air in the appendiceal lumen, the increase in diameter can be interpreted as normal unless it is accompanied by inflammatory findings. It should be kept in mind that normal appendix diameter may be 6 mm or above when the intraluminal content of the appendix cannot be distinguished. However, this can be confusing often times in acute appendicitis cases with lacking signs of inflammation. Therefore, clinical correlation and follow-up imagines should be recommended in these cases.

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