What is the thickness of the normal appendix on MDCT?

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Abstract

Objective. To determine the wall thickness and external diameter values of the normal appendix on multidetector computed tomography (MDCT).

Materials and methods. A senior radiologist with no knowledge of the patient’s surgical history prospectively examined the abdominal-pelvic CT scans of 57 consecutive adult patients with no suspicion for appendicitis. Most of the patients (50/57) received an intravenous iodinated contrast material injection, but none had gastrointestinal studies. All slices (1 and 5 mm) and multiplanar reconstructions were analyzed on a treatment console. The external diameter of the appendix, the thickness of the two appendicular walls, and the presence or absence of intraluminal gas were noted.

Results. The appendix was visualized in 82% of the cases (47/57). The mean external diameter was 6.7 mm±1.2 (range, 5.0–11.0 mm). The mean thickness of the two walls was 4.8 mm±1.0 (range, 2.6–6.4 mm). Intraluminal air was visualized in 87% of cases (41/47).

Conclusion. Contrary to external diameter, the normal thickness of the appendix’s two walls does not go beyond the threshold of 6 mm and therefore seems to be a reliable measurement for identifying a normal appendix using MDCT.

Key words: Appendicitis. Appendix. Appendix, CT.

S onography and computed tomography (CT) are both validated methods for diagnosing acute appendicitis (1-14). When the clinical examination and the classical biological results are insufficient to establish the diagnosis, sonography is the first-line method in children and in young women, but CT is useful either in second intention in difficult cases or in first intention in other subjects (15-19). Moreover, the normal appendix is more often visualized on CT (3, 4, 7-9, 20, 21), nearly excluding the diagnosis of acute appendicitis.

The diagnosis of appendicitis on CT is based notably on wall thickness, the presence of a stercolith, and infiltration of periappendicular fat. However, despite the widespread use of CT in diagnosing acute appendicitis, few CT studies have investigated the appendix with normal characteristics (20, 22-24).

The reported thickness of a normal appendix on CT is based on sonographic results (7-9, 25), with a 6-mm diameter as the higher value of the normal range (1-4, 19, 26). This extrapolation of the sonographic results for a normal appendix diameter is based on the size of the collapsed and compressed appendix without measuring the lumen content and therefore cannot be applied to CT. As shown by Benjaminov et al. (23), a visible lumen content is required to measure the appendix wall on CT without IV injection of iodinated contrast material. If the lumen content cannot be individualized, a collapsed appendix cannot be differentiated from an appendix that has a content with the same attenuation as the wall. Consequently, the IV injection of contrast material seems valuable to measure the wall thickness of the normal appendix.

The objective of this study was to determine the values of the wall thickness and of the external diameter of the normal appendix, and from this information to determine which of these two measurements is the most reliable to exclude acute appendicitis on multidetector CT.

Materials and methods

Study of the population

We conducted a prospective study of abdominal-pelvic CT images between March and April 2004 on a series of 85 consecutive patients who did not have clinical suspicion of acute appendicitis: 53 men and
32 women; mean age, 55 years ± 18 (standard deviation) (range, 16-91 years). Patients were included whether they received an appendectomy or not. Several exclusion criteria were applied: absence of 1-mm reconstructions, intestinal opacification, and presence of symptoms suggesting acute or spontaneously resolving appendicitis. Finally, this series included no patients with a diagnosis of chronic inflammatory disease to prevent any confusion with possible wall anomalies of the ileocolic region. The diagnoses established in these 85 patients were the following: malignant tumors in 17 cases, left renal colic in four cases, multiple injury in two cases, left diverticulitis in five cases, acute pancreatitis in four cases, acute cholecystitis in two cases, cirrhotic decompensation in five cases, acute pyelonephritis in three cases, postoperative liver abscess in one case, and catheter infection in one case. The 41 remaining patients presented vague abdominal symptoms that did not require additional abdominal exploration. The reference diagnosis was based on the CT and the clinical and biological results. None of these patients developed symptoms suggesting appendicitis during their entire hospital stay. As stipulated by legislation on the protection of research subjects, during the study period, our institution did not request approval from the ethics committee for the prospective study of the medical records nor consent from the patients because our study did not modify patient management in any way.

MDCT protocol

All examinations were acquired on a 16-row multidetector spiral CT (Aquilion 16, Toshiba, Otawara, Japan). The protocol was the following: abdominal-pelvic volume acquisition from the hepatic dome to the pubis; 0.5-s rotation time (120 kV, 200 maS, pitch 1.4); 16x1-mm collimation. Acquisition was followed by two reconstructions based on raw data, the first in 5-mm-thick slices in the axial plane and the second in 1-mm-thick slices also in the axial plane. The sagittal and coronal planes were reconstructed on the processing workstation (Vitrea®, Vital Images, Minnetonka, MN, USA). Of the 85 patients, 70 had an IV injection of nonionic contrast material (iohexol at a concentration of 300 mg/mL iodine). The dose injected was 120 mL with a flow rate of 3 mL/s and a delay of 90 s (portal time). None of the patients underwent oral or rectal gastrointestinal opacification. The images were examined on a Vitrea® processing workstation.

Data collection

This study, centered on the signs and patterns of appendix wall thickness and external diameter, was conducted within a larger study on the CT measurement of the normal appendix. A senior radiologist who was unaware of the possible history of appendicitis prospectively read the images on the workstation. The appendix was interpreted as visualized or not visualized.

On the multiplanar reconstructions for each appendix visualized, the radiologist measured the following:

- the maximum thickness of the two appendicular walls on each side of the intraluminal content, with exclusion of this content, independently of whether it was fluid or air;
- the maximum external diameter.

In addition, the radiologist indicated the presence or absence of intraluminal air. A third person who did not participate in the reading of the images questioned patients on whether they had had an appendectomy before the examination. The overall results of this study are presented elsewhere.

The radiologist’s error rate for identification of the appendix was also determined.

Results

Visualization of the appendix

Even though this study is not based on CT’s performance in detecting the normal appendix, we recall here the overall results to show the frequency of false-positive and false-negative results in the identification of the normal appendix in this population.

The prevalence of appendectomy in this cohort was 32.9% (28/85), which means that 57 had their appendix and 28 no longer had an appendix. Fifty of these 57 patients who had not undergone appendectomy had an IV injection of iodinated contrast material. The presence or absence of appendectomy was confirmed by information provided by the patient.

The reader’s performance in identifying the appendix was as follows: sensitivity, 82% (47/57); specificity, 93% (26/28), positive predictive value, 96% (47/49), negative predictive value, 72% (26/36). Forty-one of the 47 patients whose appendix was visualized had an iodinated contrast material injection. The radiologist’s error rate was 14.1% (12 errors out of 85).

Internal diameter, external diameter, and other characteristics of the appendix

The mean external diameter of the normal appendix was 6.7 mm ± 1.2 (standard deviation) (range, 5.0-11.0 mm). In 70% of the cases, the external diameter of the appendix was 6.0 mm or greater. On all the appendices, the intraluminal content could always be differentiated from the appendicular wall, which made it possible to systematically measure the wall itself (fig. 1-2).

The mean thickness of the two appendix walls was 4.8 mm ± 1.0 (SD) (range, 2.6-6.4 mm). Only two were greater than 6.0 mm (6.1 mm and 6.4 mm).

Intraluminal air was visualized in 41 of 47 (87%) appendices (fig. 1 and 3).

Discussion

Acute appendicitis is the most frequent cause of acute abdominal pain requiring surgery. However, the overall rate of negative appendectomy (or the rate of normal appendix on pathological examination) is high (up to 35%) before use of CT imaging (27-29). With more widespread use of sonography and CT, there has been improvement in preoperative diagnosis of appendicitis. The results described by Balthazar et al. indicate that the rate of negative appendectomy has been reduced to 4% (17). Identification of the normal appendix therefore seems essential because it provides a nearly definite exclusion criterion for acute appendicitis.

The CT signs (1-4, 6, 16, 30-32) of appendicitis include a thickened appendix, calcified stercolith, and infiltration of periappendicular fat. The wall thickness criterion in the diagnosis of acute appendicitis is essential in the absence of periappendicular...
fat infiltration. In the study conducted by Jacobs et al. (33), in 15% of the cases of acute appendicitis, there was indeed no periappendicular inflammatory infiltration on the CT with contrast material injection.

The currently used values for normal and abnormal thicknesses of the appendix wall stem from sonographic studies (7, 9, 25, 34). However, on sonography, the appendix can be compressed (when using Puylaert’s technique) (21). Here, compression serves to prevent fluid from being included in the appendix lumen. The true thickness of the wall excluding the content can then be measured. Precise sonographic criteria were thus applied to the normal appendix with a maximum external diameter less than 6 mm and a maximum wall thickness less than 3 mm. For CT diagnosis of acute appendicitis, a CT protocol with IV injection of iodinated contrast material is increasingly recommended (33, 35-39). Despite the risk for allergy (40), IV injection of iodinated contrast material seems to improve the efficacy of the CT exam looking for acute appendicitis by showing enhancement and thickening of the appendix wall. Previously, some authors advised administering contrast medium both orally and rectally, others preferred no administration of contrast material (1-4).

Without IV injection of iodinated contrast material, the true thickness of the appendix wall can only be measured if the intraluminal content of the appendix can be individualized. In their CT study where no contrast material was administered, Benjaminov et al. (23) encountered this problem. On a normal appendix, the content may not be individualizable from the wall depending on the density of the contents. Consequently, if the contents are not visualized and in the absence of periappendicular inflammatory involvement, it is not possible to differentiate a noncollapsed appendix filled with a fluid of the same density as the wall from a thickened and inflamed appendix. In our study where none of the examinations included digestive tract opacification, the intraluminal contents were always differentiated from the appendix wall because of the IV injection of iodinated contrast material in 41 of 47 cases (87%) of appendices seen by the radiologist. The iodinated injection seems useful to enhance the wall as well as to distinguish the wall from the intraluminal contents. Multiplanar reconstructions and the presence of intraluminal air in 87% of cases also undoubtedly helped in this differentiation between the appendix wall and the intraluminal contents.

In the study by Benjaminov et al. (23), the radiologists were asked to measure, on CT without contrast material injection, the maximum thickness of the two appendix walls on each side of the content (with exclusion of the content) if the wall could be individualized from the content. If the walls could not be individualized from the content, the maximum external diameter of the appendix was measured. When the content was individualizable, the mean thickness of the two appendix walls was 3.6 mm ± 0.8 (range, 2.6-6.4 mm), which is comparable with the values reported on sonography. Consequently, they concluded that the upper limit of 6 mm for the sum of the normal thicknesses of the two appendix walls could be used reliably on CT only if the intraluminal content was individualized. In our study, the mean thickness of the two appendix walls was 4.8 mm ± 1.0 (SD) (range, 2.6-6.4 mm). Of the 47 appendices studied, only two measured more than 6.0 mm.

The mean diameter of the normal appendix in the series of Benjaminov et al. (23) was 6.6 mm ± 1.0 (range, 4.0-11.0 mm) when the intraluminal content was not individualized. Benjaminov et al. (23) suggested a diameter of 10 mm (mean ± 3 SD) for the upper limit of normal if the content was not individualized and there was no periappendicular inflammation. Of the 117 appendices seen by the three radiologists in this study, only one was thicker than 10 mm. This 10-mm threshold value proposed for the maximum external diameter of the normal appendix corresponds to the data found in the literature (20, 22, 41-43). Consequently, the diagnosis of appendicitis could not be determined on CT in the group whose appendix thickness was between 6.0 and 10.0 mm. These patients should have an additional examination with rectal or IV administration of contrast material or an ultrasound to visualize the wall and thus prevent a false-positive diagnosis of acute appendicitis.
appendicitis. We obtained results that were quite similar to those found by Benjaminov et al. (23) for diameter: the mean diameter of the normal appendix was 6.7 mm ± 1.2 (SD) (range, 5.0-11.0 mm). In 70% of cases, the mean external diameter of the appendix was 6.0 mm or greater. As a result, since we were always able to differentiate the intraluminal content from the appendix wall, it seemed more useful in clinical practice to measure the thickness of the two walls so as to exclude the diagnosis of acute appendicitis.

The presence of intraluminal gas was visualized in 41 of 47 (87%) cases in our study. In the study conducted by Rao et al. (44), of 100 cases with a normal appendix, the air present in 57 cases (57%) was always intramural and, as in our study, was never intramural or extralateral (in their study, intramural and extraluminal air were correlated with perforation in 60% and 100% of cases, respectively). However, intraluminal air of the appendix was often seen in their series of 100 patients with appendicitis (19% of cases). Rao et al. also showed that the presence of intraluminal air should not lead to concluding in a 19% of cases). Rao et al. also seen in their series of 100 patients with appendicitis (19% of cases). Rao et al. also showed that the presence of intraluminal air should not lead to concluding in a normal appendix. The theory that intraluminal air designates a healthy appendix was dismantled by Rao et al. (44).

Our study has a certain number of limitations. The main limitation was the small sample. Another was the absence of a standard reference as proof of a normal appendix. However, it is impossible to conduct a study of the normal appendix with pathological comparison. Although it is theoretically possible that some of the cases in our study had spontaneously resolved appendicitis, this is highly unlikely because none of them presented symptoms suggesting acute appendicitis. Our study also carried the potential limitation of verification and memory bias, since we relied on patient questioning to obtain their history of appendectomy. It is possible that some patients had a normal appendix removed during pelvic or other surgery and did not remember this information. It is also theoretically possible that certain patients had a congenitally missing appendix. However, given that the reported estimated incidence of appendix agenesis is 1/100,000 laparotomies for patients suspected of having acute appendicitis (45), agenesis of the appendix was highly unlikely in our cohort.

**Conclusion**

Contrary to the external diameter, the thickness of the two walls of the normal appendix very rarely goes beyond the threshold of 6 mm, the value usually accepted for CT diagnosis of appendicitis, which in clinical practice could more easily exclude the diagnosis of acute appendicitis and thus reduce the negative appendectomy rate. This information should motivate the use of CT protocols for the systematic measurement of the two walls of the appendix, which was done in our study using 1-mm slices with multiplanar reconstructions and IV injection of iodinated contrast material.

**Références**

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