Sonographic Appearance of the Normal Appendix in Adults

Koichi Yabunaka, MS, Toshizo Katsuda, PhD, Shigeru Sanada, PhD, Tsunemasa Fukutomi, MD

Objective. To evaluate the sonographic visualization of the normal adult appendix, a large series of sonographic images from consecutive asymptomatic patients was analyzed. Methods. A total of 788 consecutive adult patients (402 male and 386 female; median age ± SD, 51.1 ± 17.2 years; range, 16–91 years) were examined by appendiceal transabdominal sonography with tissue harmonic imaging. The detection rate, outer appendiceal diameter, intraluminal content, and location of the appendix were estimated. The overall normal appendix was separated into appendix-visualized and appendix-not-visualized groups, which were then examined for the relationship with abdominal wall thickness, body mass index (in kilograms per square meter), age, and sex. Results. The normal appendix was detected in 388 (49.2%) of 788 patients. The outer appendiceal diameter ± SD was 4.27 ± 1.2 mm (range, 1.0–11.1 mm). In 291 (75%) of the 388 patients, appendices could be depicted in the intraluminal gas during sonography. The location of the appendix was classified according to the appendiceal tip, which was found to be abdominal in 37 (9.5%), pelvic in 291 (75%), retrocecal in 23 (6.0%), and a midline extension in 37 (9.5%). In both body mass index and abdominal wall thickness, significant differences were found between appendix-visualized and appendix-not-visualized cases (P < .05). There was no significant difference in age (P = .37) or sex (P = .23) between appendix-visualized and appendix-not-visualized cases. Conclusions. The results show that the normal adult appendix can be revealed by sonographic visualization in a large series of asymptomatic patients. Key words: appendicitis; normal appendix; tissue harmonic image; sonography.

Abbreviations
BMI, body mass index; THI, tissue harmonic imaging
mimic the clinical signs of acute appendicitis, including gallbladder disease, acute pyelonephritis, urinary tract stone disease, infectious/inflammatory conditions of the cecum/ascending colon, and abnormal diseases such as complicated ovarian cysts, hemorrhage, and torsion.

There has been little information available on the sonographic visualization of the normal adult appendix in large series of asymptomatic subjects. The purpose of this prospective randomized study was therefore to assess, with the use of sonography with THI, the detection rate of the normal appendix, to classify appendices by location, to determine their appearance (size, location, and intraluminal content), and to assess the body mass index (BMI; in kilograms per square meter), abdominal wall thickness, age, and sex. The influence of these parameters on the visibility of the normal appendix was then evaluated.

Materials and Methods

Patients
A total of 788 consecutive adult patients (402 male and 386 female; median age ± SD, 51.1 ± 17.2 years; range, 16–91 years; weight, 58.8 ± 12.8 kg; height, 161.2 ± 9.1 cm; BMI, 22.4 ± 3.8), who were asymptomatic with no surgical history and who were undergoing routine health examinations, were examined by appendiceal sonography for a prospective randomized study conducted at Ishikiri Seiki Hospital. Informed consent for the study was obtained from all patients or their guardians as approved by the Ethics Committee of Ishikiri Seiki Hospital. All sonographic examinations in this study were performed by 2 certified sonographers (with >10 years of experience each), and interpretation was based on static images by 2 gastroenterologists experienced in gastrointestinal sonography.

Methods
Appendiceal sonography was performed after abdominal sonography. The criteria of a normal appendix were as follows: a clear structure originating from the cecum, a distal appendiceal tip with a blind ending, and consistent observation by compression (Figure 1). In addition, positions of the terminal ileum and ileocecal valve were confirmed. The terminal ileum showed peristaltic activity and changed to an oval shape in cross section by compression. The detection rate of sonography and visualization of gas in the appendices were estimated. All outer appendiceal diameters were measured as the distance between the outer wall and the opposite outer wall (muscle coat) in a transverse section. This measurement was performed by the investigating sonographers during sonography by setting the electronic calipers in millimeters. Appendix-not-visualized cases were compared with appendix-visualized cases for the effects of patient age, sex, BMI, and abdominal wall thickness (as measured at the point where the iliac crest crosses over the right psoas major muscle without compression to the abdominal wall).

The location of the normal appendix was classified into 4 groups by site on the appendiceal tip according to the classification of Wakeley and Baldisserotto and Marchiori, as follows: area A (abdominal), tip in the abdominal cavity; area B (pelvic), extending to the pelvis; area C (retrocecal), posterior to the cecum; and area D (midline extension), extending to the midline without extending to the pelvis. The appendix locations were classified on the basis of a horizontal line defined by the iliac crests (Figure 2). Curved array (3.5– to 5.0-MHz) and linear array (7.5– to 10.0-MHz) transducers were used (Aplio 50 and 80 sonography systems; Toshiba Medical Systems Co, Ltd, Tochigi, Japan).

Statistical Analysis
χ² tests were used to compare the frequencies of appendix-visualized and appendix-not-visualized cases between male and female patients. The means of appendix-visualized and appendix-not-visualized cases were compared by 2-tailed Student t tests for BMIs, abdominal wall thicknesses, and ages. P < .05 was considered statistically significant. Statistical analyses were performed with SPSS version 10.0 software (SPSS Inc, Chicago, IL).

Sonographic Scanning Technique
Patients were instructed to refrain from eating and drinking for 4 hours before the examination and to maintain an adequate urinary bladder volume for 2 hours before the examination. All sonographic studies were performed with graded compression.
to obtain transverse and longitudinal scans. The appendix was scanned by our new technique based on systematic scanning as described below. The right major psoas muscle and iliac vessels were visualized with a transverse axial scan. Using the above image as a guide, visualized appendices were identified as the location of the ileocecal valve and distal border of the ileum. The psoas muscle and iliac vessels are the anatomic landmarks for identifying the appendix, which is usually localized between these structures and the abdominal wall.\textsuperscript{12} If the appendix was recognized, the cecum continued with the appendix as a blind-ending structure. When the appendix was difficult to identify, transverse and longitudinal scans from the cecal portion to the hepatic flexure were added, and a search for the peripheral ascending colon was attempted. Appendiceal sonography was performed within 5 minutes, on average, after abdominal sonographic screening.

Results

Detection of the Normal Appendix

Normal appendices were detected in 388 (49.2%) of 788 patients but not in the remaining 400 (50.8%). The outer appendiceal diameter ranged from 1.0 to 11.1 mm (in 14/388 patients, the appendiceal diameter was >6 mm), with a mean ± SD of 4.27 ± 1.2 mm. In 291 (75%) of the 388 appendices depicted in the appendix-visualized cases, intraluminal gas was visualized during sonography.

Figure 1. Sonograms of a normal appendix. A, Longitudinal section of a normal appendix (arrows). Criteria for visualization of a normal appendix include a continuing vermiform appendix from the cecum (arrowhead) and a blind ending of the appendiceal tip (curved arrow). B, Round transverse section of a normal appendix (arrows).

Figure 2. Classification of appendiceal positions during sonography. Four divisions were decided on the basis of the standard position of the appendicular root, as follows: area A (abdominal), tip in the abdominal cavity; area B (pelvic), in the area extending to the pelvis; area C (retrocecal), posterior to the cecum; and area D (midline extension), extending to the midline without extending to the pelvis.
Location of the Normal Appendix

Numbers of appendiceal tips in areas A, B, C, and D were found to be 37 (9.5%), 291 (75%), 23 (6%), and 37 (9.5%) of the 388 appendix-visualized cases, respectively. In 61 (7.7%) of 788 patients, the cecum was located in the deep pelvis, and accordingly, the appendix was not depicted at all in any of these 61 patients.

Investigation of Appendix-Not-Visualized Cases

The mean abdominal wall thicknesses in appendix-visualized and appendix-not-visualized cases were 14.5 ± 5.2 mm (range, 5.0–30.1 mm) and 21.0 ± 9.4 mm (range, 5.3–51 mm) (Figure 3). A significant ($P < .05$) difference was found in abdominal wall thickness between appendix-visualized and appendix-not-visualized cases.

The mean BMIs in appendix-visualized and appendix-not-visualized cases were 21.3 ± 3.0 (range, 7.6–33.9) and 23.5 ± 4.2 (range, 14.3–46.3) (Figure 4). A significant ($P < .05$) difference was found in BMI between appendix-visualized and appendix-not-visualized cases.

The mean ages in appendix-visualized and appendix-not-visualized cases were 51.7 years (range, 16–91 years) and 50.6 years (range, 16–88 years), with no significant difference in age between these cases ($P = .37$). In the appendix-visualized and appendix-not-visualized cases, the sex ratios were 189 male/199 female (total 388) and 213 male/187 female (total 400), respectively. There was no significant difference in sex between these cases ($P = .23$). A significant ($P < .05$) difference was found in BMI between the male and female patients in appendix-visualized cases.

Discussion

Tissue harmonic imaging may have assisted in visualization of the normal appendix because THI is characterized by a reduction of artifacts.7,8,13,14 In this study, sonography with THI detected a normal adult appendix in 49.2% of healthy subjects (asymptomatic patients), which is a rate close to the 45.9% observed without THI by Simonovsky.15 However, Rioux16 reported a detection rate of 82%, whereas other studies have reported rates of 62% and higher.17–20 One of the reasons for the low detection rate in this study may have been the strict diagnostic criteria we applied. It is also relatively easy to misinterpret a bowel loop or the terminal ileum as the appendix.21,22 Appendiceal sonography thus requires investigation of the distal part of the cecum and location of the ileocecal valve by an experienced examiner.

Another probable reason for the high detection rate in previous reports is that sonography was performed only in patients with abdominal pain16,20 and not in healthy subjects. Rettenbacher et al19 reported that the detection rate in symptomatic patients without appendicitis (77%) was higher than that in subjects with a normal appendix (68%). Patients with digestive problems (such as enteritis and diverticulitis), for example, often have decreased intestinal gas (due to dilatation or edema of the bowel, a fluid collection, or a hyperplastic mesentery), whereas
patients with constipation or any other relevant condition have accumulation of intestinal gas. In many cases, therefore, changes associated with abdominal pain may facilitate visualization of the appendix. Wiersma et al. found that in pediatric subjects, a normal appendix was depicted more frequently than in adults, possibly because there is less attenuation of the ultrasonic beam by subcutaneous fat and muscle, which are thinner in pediatric subjects.

In evaluating the appendiceal wall, some studies have measured the outer appendiceal diameter rather than appendiceal wall thickness. A few factors that may affect the outer appendiceal diameter are as follows: first, in the normal appendix with a thin wall, it may be difficult to identify the intraluminal limit of the mucosal layer; second, the shape of the normal appendix greatly changes depending on the intensity of pressure applied during examination, especially with the presence of loose feces in the lumen; and third, several studies, including this one, have reported outer appendiceal diameters of greater than 6 mm in healthy subjects, thus, the diameter of the appendix alone may not be a parameter for diagnosing appendicitis. In this study, intraluminal gas in the appendiceal lumen was revealed with sonography in 75% of cases, which is a rate close to the 86% reported for a control group in a previous study. The presence of intraluminal gas in the normal adult appendix was used as a diagnostic criterion, although there are difficulties in differentiating the gas-filled appendix from intestinal gas.

Area B, located between the psoas muscle and the abdominal wall, was the most depicted location in the normal appendix (75%), which can be explained by the fact that it is located closest to the transducer, where intestinal gas has the least influence. In 788 patients, the sonographic detection rate was lowest for area C (3%), as based on the classification of Wakeley (Figure 6). However, when the classification of Wakeley was adjusted to show the position of the normal appendix, the results suggested that many of the appendix-not-visualized cases (50.8%) were indeed included in area C.

In this study, the cecum was located in the deep pelvis in 7.7% of appendix-not-visualized patients. Important reasons for nondetectability of the appendix were the location of the cecum in the true pelvis, which is atypical. In such cases, intraluminal gas in the appendiceal lumen was revealed with sonography in 75% of cases, which is a rate close to the 86% reported for a control group in a previous study.

Figure 5. Longitudinal (A) and round transverse (B) sonograms show a normal appendix (arrows). Sonography could not visualize behind the appendiceal wall because of the intraluminal gas-filled appendix (asterisks).
patients, it is difficult to depict a normal appendix because of bowel gas, ultrasound attenuation, or both. An abdominal wall thickness measuring greater than 20 mm in diameter decreased the detection rate in this study. An increased BMI rapidly decreased the detection rate of the appendix from greater than 25 (overweight). Tissue harmonic imaging resolution of the body surface is superior to that of conventional sonography, although it does not suitably depict deep positions. It has been reported that a low-frequency convex transducer is preferable when searching for a normal appendix in a deep location or in obese patients.

The design of this study had some obvious limitations: first, it was not possible to obtain pathologic evidence of a normal appendix; second, the sonographic location of a normal appendix could not be compared with that on computed tomography or that found during an operation, for the obvious reason that surgery or invasive examination, such as the use of an ionized contrast medium or radiation exposure, is not possible in healthy subjects; and third, sonography is dependent on operator skill and technique. In this study, all scans were performed by expert sonographers, who were able to provide useful interpretive information.

In conclusion, the results of this study show that sonography with THI can depict approximately 50% of normal appendices in the healthy adult. Area B (75%) was the most depicted location for the normal appendix. In contrast, area C (retrocecal) was the least frequent location for depiction of the normal appendix. This study has identified a relationship among abdominal wall thickness, BMI, and detection rate. The limiting factors in the use of sonography were location C and obesity of patients. Finally, this study has shown that the normal adult appendix can be revealed by sonographic visualization in a large series of asymptomatic patients.

References


