A different view of the sonographic classification of the appendix

Apendiksin ultrasonografik sınıflamasına farklı bir bakış açısı

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Abstract

Aim: We intended to detect various appendix localisations with a classification system different from those used in previous literature to facilitate the sonographic detection of the appendix.

Patients and methods: The study was performed on 362 consecutive patients who applied to our department for abdominal or pelvic US examination to our department. The sonographic criterion used to diagnose a normal appendix was visualization of the full extension of a compressible, blind-ending tubular structure with a maximum transverse diameter of 6 mm. Appendices were evaluated by US and localisations were recorded and classified according to the reference line passing through the iliac vessels in the right iliac fossa.

Results: Each appendix was classified as type 1 to 8 according to its location. Type 1 crossed the iliac vessels (85.5%), type 2 was medial to the iliac vessels (2.41%), type 3 was inferior and lateral to the cecum (1.93%), type 4 was in the right paracolic gutter (4.34%), type 5 was completely retrocecal (1.93%), type 6 was in front of the cecum (1.45%), type 7 extended to the umbilicus (0.97%) and type 8 was subhepatic with cecal malposition (1.45%).

Conclusion: The study demonstrated a new classification system (types 1–8) different from those described in previous literature. The most common position of the normal and abnormal appendices in our study was crossing the iliac vessels (type 1). The second most common position was the right paracolic gutter (type 4). Two interesting localisations extended to the umbilicus (type 7) and appeared in the subhepatic space (type 8).

Key words: Appendicitis, normal appendix, cecum-appendicular region, abdomen, sonography.

Öz

Amaç: Biz bu çalışmada farklı lokalizasyonlardaki apendiksleri inceleyerek önceki literatürden farklı bir sınıflama yapmayı ve böylece appendiksin sonografik incelemesini kolaylaştırmayı amaçladık.

Materyal ve metod: Çalışma bizim departmanımıza pelvik veya batın ultrasonografisi amacı ile başvuran 362 ardışık hasta üzerinde gerçekleştirildi. Normal sonografik apendiks kriterleri maksimum çapı 6 mm olan, komprese olan, kör sonlanan tübüler yapı olarak belirlendi. Appendiksler ultrasonografi ile incelendi ve kaydedildi, referans çizgisi olarak da sağ iliak fossadaki iliak damarlar alındı.

Bulgular: Apendiksler yerleşim yerine göre 1-8 sınıfa ayrıldı. Tip 1 iliak damarları geçen (85.5%),tip 2 iliak damarların hemen yanında (2.41%), tip 3 çekumun inferior ve lateralinde (1.93%), tip 4 sağ parakolik olukta (4.34%), tip 5 tamamen retroçekal (1.93%), tip 6 çekumun anteriorunda (1.45%), tip 7 umblikusa uzanan (0.97%) and tip 8 çekal malpozisyonla birlikte subhepatik yerleşim (1.45%).

Sonuç: Bu çalışmada literatürde daha önceden tanımlanandan farklı olarak yeni bir sınıflama sistemi (1-8) ortaya konulmuştur. Normal ve anormal apendikslerin en sık görülen yerleşimi iliak damarları geçen tip 1 olarak izlendi. İkinci en sık görülen yerleşim ise sağ parakolik olukta izlenen tip 4 idi. İki farklı ilginç yerleşim ise umblikusa uzanan tip 7 ile subhepatik alana uzanan tip8 idi.

Anahtar kelimeler: Apandisit, normal apendiks, çekum-periapendiküler bölge, abdomen, ultrasonografi.

Introduction

Cross-sectional imaging techniques, including US, computed tomography (CT), and more recently, magnetic resonance imaging (MRI), have been successfully used to examine patients suspected of having appendicitis [1-8]. Visualization of a normal-appearing appendix by cross-sectional imaging techniques in patients suspected of having acute appendicitis will prevent negative appendectomy and related complications, not only peroperative, but also late-stage complications such as chronic right-sided lower abdominal pain [7, 9-12].

Because of technical improvements, US has been reported to reach sensitivities and specificities up to 98% for the diagnosis of acute appendicitis, a ratio highly dependent on the experience of the sonographer [13, 14]. However, even to experienced sonographers, the normal vermiform appendix is not always visible sonographically. A US has a sensitivity of 81%, specificity of 88%, positive predictive value (PPV) of 92.6%, negative predictive value (NPV) of 71.6% and accuracy of 83% to detect acute appendicitis [15], similar results have been found in some other studies [16-18]. These ratios are higher in pathologic appendices [13]. When US is combined with CT in selected cases, sensitivity, specificity, PPV, NPV, and scanning accuracy increases even more [15, 16]. CT is being used with increasing frequency because it is less operator dependent than US and is more accurate for the diagnosis of acute appendicitis [12, 15, 19]. In addition, the normal appendix is reported to be more commonly visualized with CT. The normal appendix can be identified in 67–100% of patients without appendicitis who undergo CT. During sonography, the normal appendix is less frequently visualized, with results varying between 0% and 82%, reflecting the operator dependency of US [19, 20]. However, CT has the disadvantage of subjecting the patient to unnecessary doses of radiation [15, 21]. Any improvement in the detection of the appendix with US is therefore important for reducing the radiation dose. We believe that US examination of patients with clinically suspected appendicitis, knowledge of the most frequent locations of the appendix and using a systematic approach that searches from the most common to least common localisations will improve the appendix detection rate and decrease the radiation dose and time of imaging.

Different classification systems for appendix localisation were used in previous studies involving US, CT and MRI. Moreover, the classification varied between laparoscopic and radiological studies. In this study, we aimed to determine appendix localisations with a different classification system.

Patients and methods

This study was approved by the ethics committee of our institution. Consent was obtained from the legal guardians of all children.

The study was performed on 362 consecutive paediatric and adult patients who applied for abdominal or pelvic sonographic examination to our department with clinical findings of suspected acute appendicitis in 71 cases and with other reasons in 291 cases. Patients who were unwilling to participate, patients with general conditions not suitable for extra US examination, including emergency room or intensive care unit patients with trauma, severe dyspnea, or shock, and patients who needed immediate operation were excluded. All examinations were performed by the same ultrasound machine with a 9–14 MHz broadband matrix linear transducer. US examinations were performed using US equipment with a 9–14 MHz linear probe (Logic 9, GE Healthcare, Milwaukee, Wisconsin, USA).

At our hospital, the management of children with suspected appendicitis follows a protocol that requires the analysis of clinical and laboratory findings—abdominal pain with or without guarding and elevated white blood cell (WBC) count—and sonographic findings. If the sonographic findings are inconclusive and the patient has intense pain, the patient undergoes diagnostic or therapeutic laparoscopy.

Appendix classification in some studies [22, 23] is 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 appendiceal lumen was evaluated and classified as lumen without content or lumen with gas, faeces, fluid or fecalith. The appendix was classified according to the position of its tip as retrocecal (posterolateral or posterior to the cecum), abdominal (appendix in the abdomen, above anterior iliac crests), mid-pelvic (in the pelvis, proximal to the iliac vessels) and deep pelvic (in the pelvis, distal to the iliac vessels) in several studies [24-27]. On the other hand, we used the level of iliac vessels as a reference line to define the appendix position in the right iliac fossa (Figure 1).

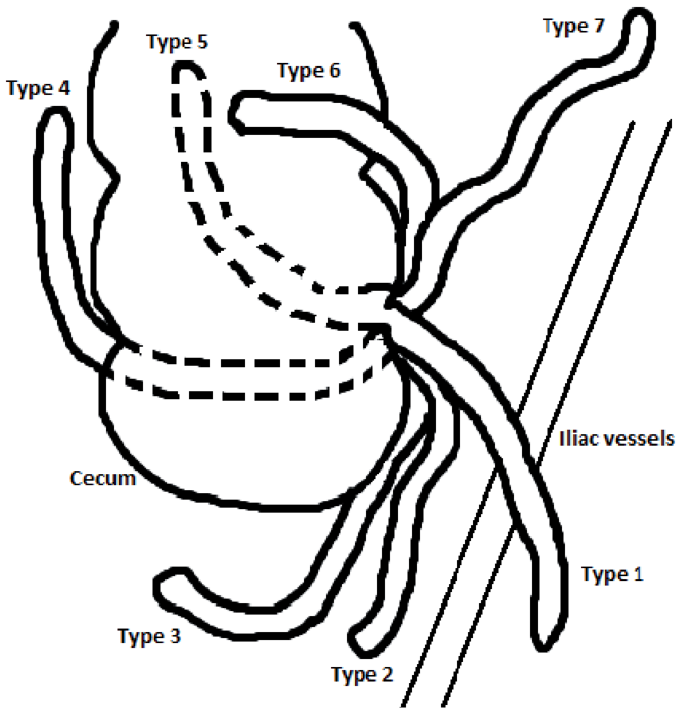

Figure 1. The level of iliac vessels used as a reference to define the appendix position in the right iliac fossa. Appendices were classified as types 1 to 8 according to the results of this study. Type 8 could not be shown in the figure.

US examinations were performed by the same radiologist (BU). The ascending colon was scanned transversally from the hepatic angle to the ileocecal valve and cecum. When the cecum was found, transverse, oblique and longitudinal scanning was performed by moving the transducer toward the pelvis to detect an appendix in the pelvic position, toward the abdomen to detect an appendix in the abdominal position, superolaterally, superomedially and toward the midline to detect an appendix in a different location and toward the right flank to detect a retrocecal appendix. Appendiceal diameter was the only criterion used to differentiate a normal from an abnormal appendix. The sonographic criterion used to diagnose a normal appendix was visualization of the full extension of a compressible, blind-ending tubular structure with a maximum transverse diameter of 6 mm (Figure 2). The sonographic criterion used to diagnose an abnormal appendix was the visualization of a blind-ending tubular structure with a maximum external diameter greater than 6 mm (Figure 3).

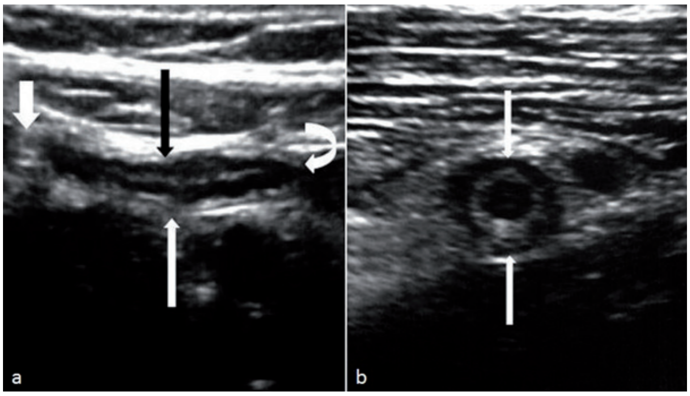

Figure 2. Sonograms of a normal appendix. a. Longitudinal section of a normal appendix (white and black arrows). Criteria for the visualization of a normal appendix include a continuing vermiform appendix from the cecum (white thick arrow) and a blind ending of the appendiceal tip (curved arrow). b. Round transverse section of a normal appendix (white arrows).

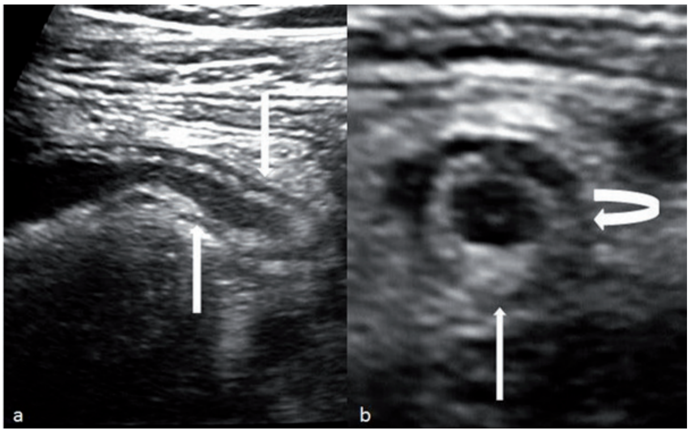

Figure 3. Longitudinally (right) and transverse (left) US images showing a pathological appendix. a. Longitudinal sonogram of an enlarged appendix (solid white arrows). The thick hypoechoic layer represents muscular propria and periappendicitis. b. Axial sonogram shows the ring appearance of enlarged appendix (solid straight and curved white arrows). The asymmetric hypoechoic region represents a muscular layer with periappendicitis.

Results

The appendix was not observed in 155 patients sonographically, and the appendix could be observed in 207 patients sonographically. For these 207 patients, the appendix was classified by location as type 1 to 8 according to the results of this research. The appendix was settled in the pelvis in 177 cases by crossing the iliac vessels (85.5%, type 1), medial to the iliac vessels in five cases (2.41%, type 2), inferior and lateral to the cecum in four cases (1.93%, type 3), in the right paracolic gutter in nine cases (4.34%, type 4), completely retrocecal in four cases (1.93%, type 5), localised in front of the cecum in three cases (1.45%, type 6), extending to the umbilicus in two cases (0.97%, type 7) and localised in subhepatic space in three cases (1.45%, type 8) with cecal malposition (Table I).

Table I. Distribution of sonographic anatomical location of the appendix (type 1 crossing the iliac vessels, type 2 medial to the iliac vessels, type 3 inferior and lateral to the cecum, type 4 in the right paracolic gutter, type 5 completely retrocecal, type 6 in front of the cecum, type 7 extending to the umbilicus, type 8 subhepatic with cecal malposition).

Types	N	%
Type 1	177	85.5%
Type 2	5	2.41%
Type 3	4	1.93%
Type 4	9	4.34%
Type 5	4	1.93%
Type 6	3	1.45%
Type 7	2	0.97%
Type 8	3	1.45%
Total	207	100%

A mobile appendix was observed in three patients with type 1 localisation, with the appendix location changing toward the lateral and medial to the iliac vessels in these patients. Also, a patient with type 1 localisation had a mucocele and an appendix diameter of 14 mm. There was cecal malposition with all three type 8 localisations.

Discussion

In early studies, the nonvisualization of the normal appendix during sonographic examination was interpreted as indicative of no appendicitis. Later studies showed that the normal appendix was seldom visualized by sonography [28]. In 1992, Rioux [13] used greyscale sonography to examine adults and children suspected of having acute appendicitis and detected a normal appendix in 82% of the patients without appendicitis. The Rioux study concluded that the detection of a normal appendix safely rules out appendicitis. Subsequent studies have shown a wide range of detection of a normal appendix (in 40% to 82% of patients) even though the same scanning technique was used with graded compression on the right lower abdominal quadrant and high-frequency transducers. The US scanning technique used to detect the abnormal appendix according to different appendiceal positions in children suspected of having appendicitis has been shown to be very accurate [28].

We understand that CT is a valuable and highly accurate method in the diagnosis of appendicitis and can be an invaluable diagnostic tool when patients are obese and when the sonographic results are inconclusive. However, we do not usually perform CT studies in these cases because the results of sonographic studies in our hospital are highly accurate. Such positive results can be achieved by radiologists with sound experience in US scanning. In the rare unclear case when intense abdominal pain persists, we refer the patient for laparoscopy. Although some institutions tend to adopt CT imaging as the only diagnostic test in the investigation of acute appendicitis, the use of sonography as the first imaging test is justified for a number of reasons. Current CT protocols have reduced the radiation doses to which patients are exposed; however, in a population of children with signs and symptoms suggestive of appendicitis or with an atypical clinical presentation, a substantial number of patients without the disease will be unnecessarily exposed to radiation if CT is the diagnostic test of choice. Also, in a population of patients suspected of having appendicitis, a considerable number of children present with recurrent abdominal pain of other origins. These children could be exposed to CT radiation at every recurrent episode of abdominal pain if the use of CT were the protocol suggested for such clinical presentation [18, 21, 29]. Moreover, the cost of sonography is lower than that of CT.

Transabdominal US has been performed as an imaging modality in patients with suspected appendicitis because sonography can rapidly help distinguish patients with appendicitis requiring computed tomography or surgery from those with a normal appendix. However, the diagnosis of appendicitis is often difficult to characterize from the normal appendix or acute appendicitis, even for the experienced examiner. In recent years, however, normal appendices have been detected with improved sonographic technology. The ability to make a differential diagnosis is important in patients with abdominal pain because a number of disorders can 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, haemorrhage and torsion. There has been little information available on the sonographic visualization of the normal adult appendix in a large series of asymptomatic subjects.

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According to results of another study, the anatomical positions were pelvic, subcecal, retroileal, retrocaecal, ectopic and preileal in 55.8%, 19%, 12.5%, 7%, 4.2% and 1.5% of cases, respectively. The base of the appendix is connected to the cecum, but its head can be placed in any of six locations: retrocecal, pelvic, subcecal, preileal, retroileal and ectopic [25]. There is controversial information about the most common location of the appendix; contrary to the common assumption that the retrocecal appendix is the most common position, the in vivo appendix is seen more often on multidetector computed tomography (MDCT) in the subcecal and deep pelvic positions [26]. According to other study, the retrocecal appendix is the most common position [27]. While in another study the least frequent location is the retrocecal position [24]. Retrocecal localisation is a position where the appendix is difficult to detect by US, which cautions against the method we used. The right-side sonographic examination was demonstrated to be advantageous in the detection of normal and abnormal retrocecal appendices, which confirmed previous findings [23].

Conclusions

Unlike previous work-ups, the most common position (type 1) in our study was crossing the iliac vessels (85.5%). Other findings were also contrary to findings in previous literature. In particular, the second largest number of appendices (4.34%) were detected in the right paracolic gutter (type 4), and the least frequent location (0.97%) was medial to the iliac vessels (type 7). A mobile appendix, mucocele and cecal malposition were observed in our study. The mobile appendix was changing toward the lateral and medial to the iliac vessels in three patients with type 1 localisation. In addition, a patient with type 1 localisation had a mucocele and an appendix diameter of 14 mm. Three patients with type 8 localisations had cecal malpositions, making their type 8 location new and interesting. The type 7 extending umbilicus was an interesting settlement. Also we assume that type 3-5 appendices in our study correspond to appendices defined as retrocecal in previous studies in the literature.

Patients who were general situation not suitable for sonographic study, bearing emergency room or intensive care unit patients with trauma, and patients who needed immediate operations were outside of this study. The aim of our study was to locate appendix localization sonographically without laparoscopic findings, moreover this was a limitation of the study. Ignoring differences in identification of the appendix between children and adults was a another limitation of this study.

In conclusion, the results of this study show that sonography can reliably depict appendices in different localisations in the adult and paediatric population. We classified appendices as types 1 to 8 according to their placement. This classification is new and different from that described in previous literature and facilitates the finding of the appendix sonographically. Localisation of the appendix is time consuming and knowing the possible location will shorten the time of the examination.

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