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Point-of-Care Ultrasonography for Appendicitis Uncovers Two Alternate Diagnoses

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Abstract: We present two cases of pediatric patients initially presenting with a clinical suspicion of acute appendicitis. In these cases, point-of-care ultrasonography was performed early in the patient's emergency department course, leading to alternate diagnoses. This article highlights a role for point-of-care ultrasound in the diagnoses of two alternate conditions that clinically mimic appendicitis: Meckel diverticulitis and acute ileocecitis. We offer a brief overview of terminology, relevant literature, and ultrasound scanning technique for the right-lower-quadrant point-of-care ultrasound evaluation.

Key Words: acute abdominal pain, appendicitis, appendix, bowel, Elizabethan ruff, "bowel signature", Elizabethan ruff, emergency ultrasound, ileocecitis, Meckel diverticulitis, point-of-care ultrasound, right lower quadrant

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PATIENTS

Patient 1

A 3-year-old healthy Hispanic boy was brought into the pediatric emergency department (ED) after several hours of abdominal pain and subjective fevers. Earlier in the afternoon, the patient was noted to be in his usual state of health, other than a decrease in appetite. On waking from a nap, the child complained of an acute onset of severe abdominal pain that localized to his umbilicus and right lower quadrant. His parents grew concerned for the worsening pain, tactile fevers, and 1 episode of nonbloody, nonbilious emesis. On physical examination, he was febrile to 38.7°C and tachycardic at 146 beats/min. He was non–toxic appearing but in visible pain. The remainder of the examination was notable only for right-lower-quadrant tenderness to palpation with mild guarding, but no rebound. Prior to laboratory evaluation, he was given intranasal fentanyl, and a point-of-care ultrasound was performed to evaluate for appendicitis.

A point-of-care ultrasound examination was performed of the right lower quadrant. A normal appendix was visualized as a compressible tubular structure measuring 4 mm (Fig. 1). An additional fluid-filled cystic structure was visualized just cephalad and anterior to the bladder (Fig. 2) measuring 15 × 14 × 18 mm. This structure demonstrated no peristalsis and an increased blood flow within the walls on power Doppler evaluation. The wall demonstrated a "bowel signature," which has been used to describe the 5-layer sonographic appearance of bowel (Fig. 3). The mural thickening of the wall suggested an inflammatory reaction.

A pediatric surgical consultation recommended performing a computed tomography, which revealed the same rounded structure, which had been visualized by point-of-care ultrasound (Fig. 4). This structure was attached via a narrow neck to a loop of small bowel adjacent to the cecum, with marked adjacent bowel wall thickening and fat stranding. These findings were highly suggestive of an inflamed and infected Meckel diverticulum. A laparoscopic diverticulectomy and appendectomy were performed. Surgical pathology later revealed an inflamed Meckel diverticulum with gastric mucosa and a normal appendix.

Patient 2

A 15-year-old Caucasian boy presented to the ED for abdominal pain, fevers, and vomiting. The abdominal pain began in the periumbilical region and over the course of 1 day migrated to the right lower quadrant. He had a significant increase in the severity of his pain and developed a loss of appetite and a subjective fever. He had no significant travel or exposure history. On physical examination, he was febrile to 39.4°C, but otherwise had age-appropriate vital signs. He was non–toxic appearing, but in visible pain. His physical examination was notable for right-lower-quadrant tenderness with guarding, but no rebound tenderness. Intravenous access was obtained, and laboratory evaluation was remarkable for a leukocytosis of 8.8×10^3 cells/uL^2 with a neutrophil predominance of 88%. He received morphine for analgesia, which made him significantly more comfortable prior to performing the point-of-care ultrasound evaluation.

A point-of-care ultrasound examination revealed a normal-appearing, compressible appendix. While evaluating the suprapubic region, a small amount of free fluid was noted between the posterior bladder and small bowel. While interrogating the cecum and terminal ileum, the bowel wall was noted to be greater than 3 mm, suggesting mural thickening (Fig. 5); this finding is often present in inflamed bowel.[1]

The patient was given a presumptive diagnosis of infectious acute ileocecitis. Stool cultures were performed, which ultimately grew *Campylobacter* species. He recovered uneventfully.

ULTRASOUND TECHNIQUE

An 8- to 10-MHz linear transducer is used in order to visualize the appendix. As illustrated in both cases, pain control is recommended prior to performing the point-of-care ultrasound evaluation for appendicitis. The transducer is placed in a transverse orientation, with the indicator directed toward the patient's right. In children who are able to point to the region of maximal tenderness, the ultrasound evaluation begins at that location. Otherwise, the transducer is placed at McBurney point, and the landmarks of the psoas muscle and adjacent iliac vessels are identified. In order to locate the appendix, the regions above, medial, and lateral to the psoas muscle should be interrogated. Finally, the terminal ilium can be identified and traced laterally to the right lower quadrant by identifying iliocecal transition. The distal ileum can be identified by maintaining the transducer in transverse orientation (with the indicator toward the patient's right) and scanning from the middle abdomen toward the right lower quadrant. While interrogating the ascending colon, large intestine can be identified

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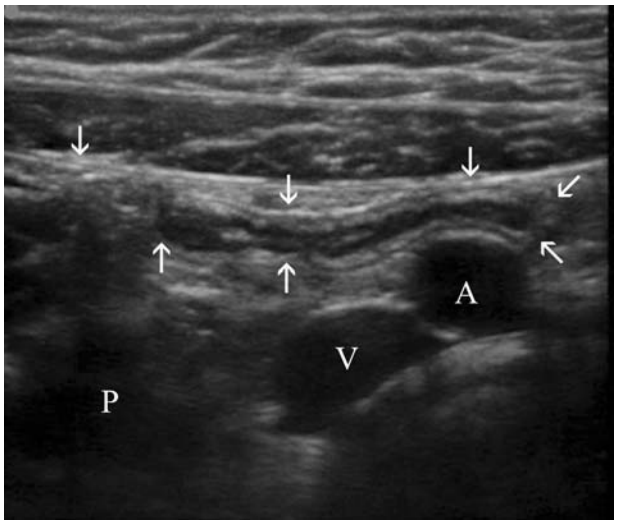

FIGURE 1. Patient 1. Ultrasound image shows a normal-appearing appendix. The appendix (arrows) is a tubular structure without peristalsis that attaches to the cecum. The appendix can often be located superior to the landmarks of the psoas muscle (P) and iliac artery (A) and vein (V). A normal appendix measures less than 6 mm in diameter and is compressible on graded compression.

by the presence of haustra. As the cecum is encountered, it appears as a blind-ending loop of large intestine.

Graded compression is utilized, a technique in which gentle, constant pressure is placed with the transducer in order to displace soft tissue and bowel gas.[2] In order to make the diagnosis of appendicitis, a blind-ending, noncompressible tubular structure should be visualized in its entirety and measure greater than 6 mm.

In contrast, an inflamed Meckel diverticulum may be easily distinguished from an abnormal appendix. Sonographically, it appears as a hyperemic cyst-like structure with a perimeter of "bowel signature."[3] The "bowel signature" pattern is created from a small echogenic layer that reflects the superficial mucosal interface. The deep mucosa, including the muscularis mucosa, is seen as a second hyperechoic layer. A third hyperechoic layer is produced by the submucosa and the muscularis propria interface. The muscularis propria is seen as a fourth hypoechoic layer. Finally, the marginal interface to the serosa is seen as the fifth small hyperechoic layer.[4] Because a Meckel diverticulum may be misdiagnosed as appendicitis in as high as 11% of cases,[5–7] the evaluation should be

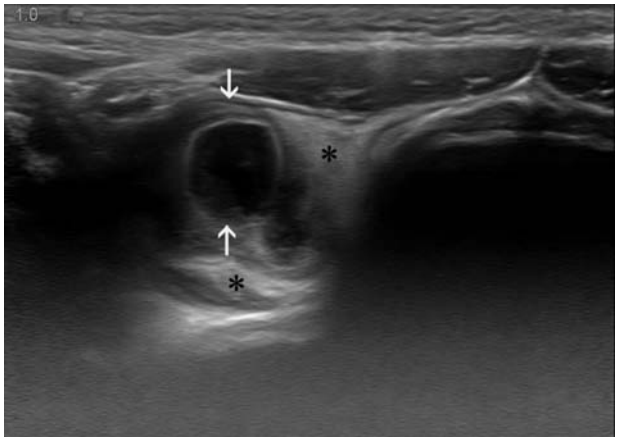

FIGURE 2. Patient 1. Ultrasound image shows a transverse view of a cyst-like structure (arrows) with bowel wall thickening and hyperechoic surrounding tissue, representing fat stranding (*). This structure is referred to the "bowel signature" as seen with a Meckel diverticulum.

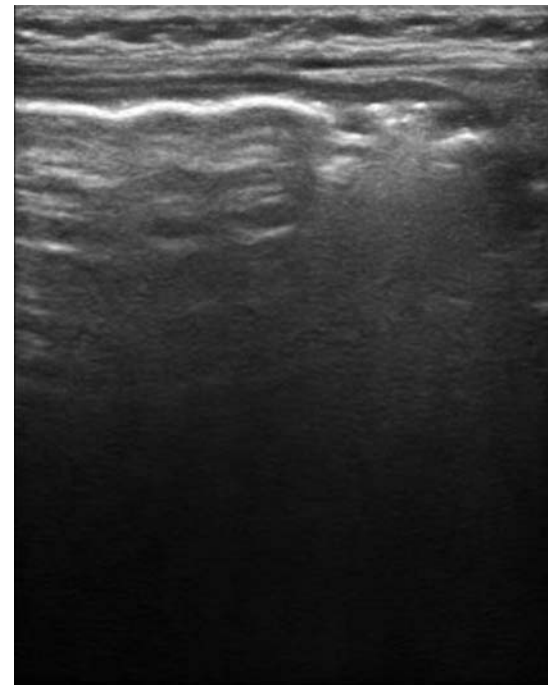

FIGURE 3. This ultrasound image is an example of a normal bowel. A normal bowel usually has a 5-layer sonographic appearance with an echogenic layer that reflects the superficial mucosal layer, a hyperechoic layer representing deep mucosa, and a third hyperechoic layer of submucosa and muscularis propria interface, whereas the actual muscularis propria is a hypoechoic fourth layer, and, finally, serosa, which is seen as a small hyperechoic fifth layer. It is often difficult to fully visualize normal bowel because of bowel gas scattering and shadowing.

FIGURE 4. Patient 1. Computed tomography of the abdomen demonstrated a rounded structure (arrows) located immediately underneath the cecum, attached to the adjacent small bowel loop by a very narrow neck. There are marked wall thickening and surrounding fat stranding and fluid, with marked wall enhancement. This represents an inflamed Meckel diverticulum.

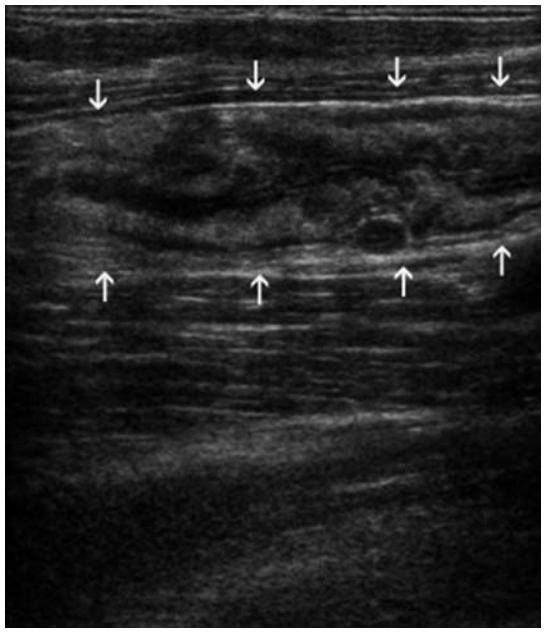

FIGURE 5. Patient 2. Ultrasound image shows the hallmark of infectious ileocecitis. The bowel (arrows) exhibits symmetrical bowel wall thickening of the cecum. The cecum is identified as a blind-ending loop of large bowel located adjacent to the right iliac crest. The lack of definable haustra is characteristic of large bowel.

extended to search for the normal appendix, which should originate from the cecum instead of the small bowel.

Ileocecitis is sonographically demonstrated by symmetric bowel wall thickening of the terminal ileum and cecum. Wall thickening is usually limited to the mucosal and submucosal layers and has been referred to as the "Elizabethan ruff" (Fig. 6).[8]

DISCUSSION AND LITERATURE REVIEW

Appendicitis is the most frequently diagnosed surgical condition in children presenting to the ED.[9] Clinical judgment alone is often suboptimal, because history, physical examination, and laboratory testing are imprecise and inaccurate.[10–12] Computed tomography has been utilized with great accuracy, but unfortunately exposes children to ionizing radiation, which over a lifetime can contribute to cancers.[13,14] Radiologist-performed graded compression ultrasonography has been shown to improve diagnostic accuracy while minimizing adverse outcomes associated with the use of ionizing radiation.[14–16] Recently, emergency physicians have shown accuracy in utilizing point-of-care ultrasonography for diagnosing appendicitis in children.[17] The use of point-of-care ultrasound has been shown to decrease ED lengths of stay, a decreased use of computed tomography scans, and decreased cost.[18] Limited studies have shown a high specificity (90%–94%), but only a moderate sensitivity (60%–85%).[17–19] Therefore, caution should be used in "ruling out" appendicitis by point-of-care ultrasonography. With the growing use of point-of-care ultrasound, providers must also be aware of mimickers of appendicitis that may be misinterpreted by ultrasound. Becoming familiar with these pathological entities has the potential to improve the accuracy of this evaluation. The majority of the literature for these entities has been described in the evaluation by radiologists. To our knowledge, these are novel entities to be evaluated by point-of-care ultrasonography.

A Meckel diverticulum is the most common congenital anomaly of the gastrointestinal tract, with an incidence of 1% to 3%, although only 4% to 6% of those affected become symptomatic.[20–22] If the vitelline duct fails to obliterate during fetal development, a Meckel diverticulum can form. The most common presentation for a complicated Meckel diverticulum is diverticulitis, which often mimics appendicitis and is easily misdiagnosed.[7,23] Other complications include inflammation, obstruction, intussusception, perforation, and acute bleeding.[24] The traditional method of detecting a Meckel diverticulum has been technetium Tc 99 m pertechnetate scintigraphy; however, it cannot detect specific complications, such as Meckel diverticulitis.[6] Ultrasound can also readily identify the possible complications of a Meckel diverticulum, including diverticulitis, hemorrhage, perforation, and intussusception.[25]

An additional mimicker of appendicitis is ileocecitis, or inflammation of a portion of the small intestine. This may be present in Crohn disease or have infectious etiologies; *Yersinia enterocolitica*, *Campylobacter* species, and *Salmonella* species are among the more common organisms to produce acute ileocecitis.[8,26,27] These organisms are important causes of diarrhea in humans. However, it is less known that the same organisms can also cause right-lower-quadrant pain mimicking appendicitis.[26] Interestingly, in patients with ileocecitis, pain is the predominant symptom, whereas diarrhea is often mild or absent.[28] Studies suggest that the sonographic finding of bowel wall thickening may be useful in differentiating bacterial ileocecitis from acute appendicitis.[27,29,30] However, acute appendicitis may also produce a secondary reactive ileocecitis. Therefore, it is necessary to document a normal appendix in patients when there is a finding of mucosal thickening of the ileum and cecum. Otherwise, an inaccurate diagnosis of infectious ileocecitis may be made.[8] Fortunately, Rioux[31] found that the visualization rate of an appendix in acute ileocecitis

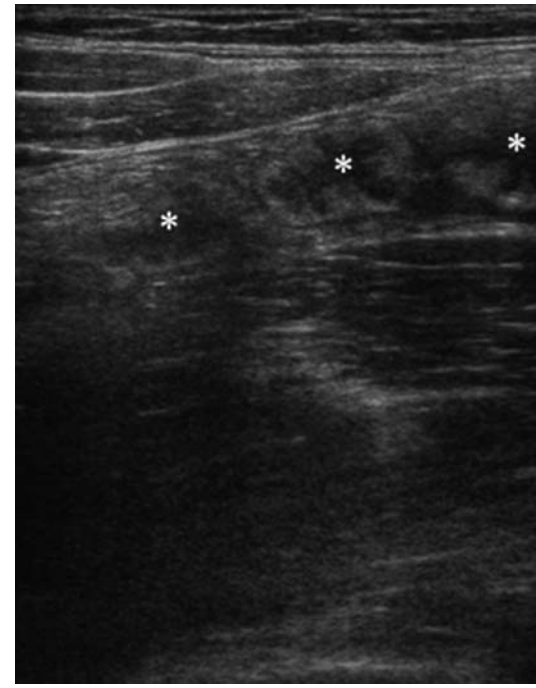

FIGURE 6. Patient 2. Ultrasound image shows the combination of wall thickening and contraction of the haustra (*), a typical image in the transverse view of the small bowel as is seen in ileocecitis. This is referred to as a "ruff," or ruffled collar worn in Elizabethan era clothing.

is significantly higher than that of controls (70.3% and 49.2%, respectively). Some of the reasons for this high visualization rate may be that in acute ileocecitis there is a decrease in intestinal gas and increased fluid within the intestine. Bowel wall edema may also improve visualization of the bowel.[32]

CONCLUSIONS

Two common mimickers for clinical acute appendicitis, Meckel diverticulitis and acute ileocecitis, may be further defined using point-of-care ultrasound. Sonographers must be aware of these entities and visualize a normal appendix prior to making such an alternate diagnosis. Future investigation may help delineate the role of point-of-care ultrasound in evaluating these clinical entities.

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