



“Learning from my experience”: Acute abdomen - Perforated Meckel's diverticulitis

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ABSTRACT

This is a case report documenting the risk in imaging misinterpretation of a pediatric patient that presented with an acute abdomen. Computed Tomography (CT) demonstrated an inflamed blind ending loop of bowel in the pelvis without an obvious cecal connection. The patient was taken to the operative theater, a normal appendix and perforated Meckel's diverticulitis were resected. Meckel's diverticulum is the most common small bowel abnormality and can have complications. We will emphasize that imaging studies in a pediatric patient with Meckel's diverticulum are easily subject to errors radiologists make. This is such a cautionary and learning tale.

1. Introduction

Radiological errors were initially studied by Dr. Garland in 1949 establishing the incidence of radiological errors in the range of 15–30% [1–3]. It is important for radiologists to learn from their mistakes to help improve patient care.

Abdominal pain, fever, and elevated white blood cell count, in a pediatric patient is concerning for an acute surgical abdomen. Classically acute surgical abdomen in a pediatric patient is acute appendicitis, which is diagnosed with nausea, vomiting, anorexia, fever, peri-umbilical pain that migrates to the right lower quadrant, elevated white blood cell count, and rebound tenderness. These clinical findings with the use of a pediatric appendicitis score (Alvarado score) has a sensitivity of 72–76% and a specificity of 72–81% [4], for diagnosing uncomplicated appendicitis. When evaluating a pediatric patient for acute surgical abdomen other pathologies should be considered, which can mimic the clinical findings of acute appendicitis. Computed tomography (CT) is crucial to the evaluation of patients with abdominal pain and fever to evaluate for abscess, appendicitis, diverticulitis, and inflammatory bowel disease. Though CT is imperative for evaluation of the aforementioned diagnoses, interpretation of the provided CT images can present a challenge.

Meckel's diverticulitis and inflammatory bowel disease are potential culprits for mimicking the clinical picture of acute appendicitis [5]. Meckel's diverticulum was first described in the literature by Johann Friedrich Meckel, the younger, a German anatomist in 1809 [6]. Years later (1915), a German physician, Gramen described the clinical

presentation of acute appendicitis in perforated Meckel's diverticulitis [7]. Charles W. Mayo (1933), physician and father of the Mayo brothers who co-founded the Mayo Clinic in Rochester, MN, stated, “Meckel's diverticulum is frequently suspected, often looked for and seldom found [8].” Dr. Mayo keenly assessed that Meckel's diverticulitis, although rare, should be on the differential diagnosis in a patient with acute abdominal pain and fever.

There are two main types of error when viewing and interpreting images: perceptual and cognitive. Perceptual error includes “not seeing the abnormality,” while cognitive (or interpretive error) includes identifying an abnormality but attributing the wrong significance to the abnormality resulting in misdiagnosis. Cognitive error includes lack of knowledge, satisfaction of search, misleading clinical information propagating an error made by a colleague [2,9,10]. Additionally, radiologists fall to a phenomenon known as “satisfaction of search,” whereby discovering the abnormality and the additional abnormalities are unnoticed, because the radiologist is “satisfied with the results of the search [10].” The following case helps to describe common radiologic errors and discuss the radiologic finding with surgical correlation.

2. Case report: clinical and laboratory assessments

A 10-year-old female presented to her primary care physician with a three-day history of intermittent abdominal pain and multiple episodes of nausea and non-bloody and non-bilious vomiting. The patient denied diarrhea or constipation. The patient states that she has periumbilical

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pain, which then migrated to the right lower quadrant. The primary care physician obtained a complete blood count and significant for a white blood cell count of $20 \times 10^9/L$ (reference range, $(3.9-10.3) \times 10^9/L$) and significant tenderness on palpation of the abdomen diffusely. The patient was then sent to the emergency department. The patient was evaluated in the emergency department and also had nausea and vomiting, and decreased appetite. On physical exam the patient had a fever measuring $37.5^\circ C$ (oral) and abdominal exam demonstrated a tense, tender abdomen with palpation, no rebound tenderness, non-distended abdomen, and hypoactive bowel sounds. The obturator sign and psoas sign were absent on physical exam. Laboratory assessment was significant for a white blood cell count of $15.43 \times 10^9/L$. Clinically, acute appendicitis was suspected.

3. Case report: imaging

Due to the type and evolution of the patient's abdominal pain the emergency physician decided to forego the ultrasound and obtain a low-dose CT to evaluate for complication of acute appendicitis. The CT of the abdomen and pelvis with intravenous contrast demonstrated a dilated, fluid-filled tubular structure on the antimesenteric border in the lower abdomen, just right of midline, appearing to be in the region of the terminal ileum. This tubular structure demonstrates a thick wall with enhancement, indicating inflammation and erythema. Additionally, the wall is discontinuous and punctate foci of air, which appear to be external to this structure, indicating perforation (Fig. 2a,b). There is a punctate calcification, just outside of the distal tip of the dilated, tubular structure, which represents an enterolith. There is adjacent mesenteric stranding and fluid. Additionally, there is thickening and enhancement of the peritoneum, which is consistent with peritonitis. The complete course of the tubular structure could not be identified (Fig. 1, Fig. 3) and the appendix was not initially visualized on the CT. The surgical team was made aware of the findings and was explicitly told, "the findings are felt to represent perforated appendicitis, with peritonitis. However, a rare Meckel's diverticulitis could have a similar appearance." Retrospective evaluation of the CT scan demonstrates the appendix is present in the right lower quadrant (Fig. 4a, b).

4. Case report: continued

The patient was admitted and started on intravenous (IV) antibiotics (piperacillin/tazobactam) and taken to operating theater. An exploratory laparoscopy was performed and a Meckel's Diverticulum, which was perforated, was discovered. A Meckel's diverticulotomy and appendectomy were performed. Two pathological specimens were obtained, the appendix and Meckel's diverticulum. The appendix measured $7.2 (L) \times 0.7 (D)$ cm with no perforation (normal appendix



Fig. 1. This axial CT image with intravenous contrast shows mesenteric stranding and edema (black arrow) with an enterolith anteriorly (white arrow).

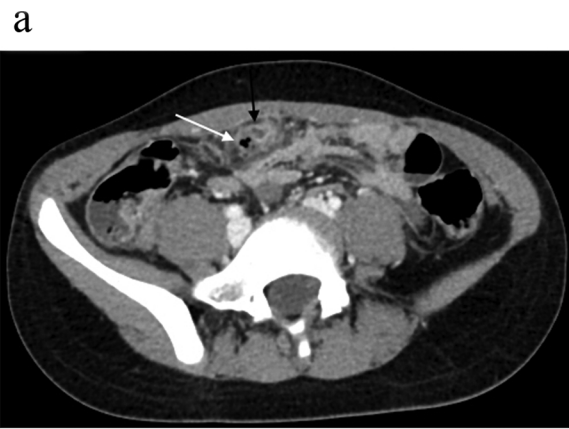


Fig. 2. These (a) axial and (b) sagittal CT images with intravenous contrast demonstrate mesenteric stranding and edema with a thick walled blind ending tubular structure with wall enhancement (black arrow). The wall is discontinuous with adjacent extraluminal air (white arrow), consistent with Meckel's diverticulitis with perforation.

without pathologic changes). The Meckel's diverticulum demonstrated a segment of bowel measuring $6.5 \times 3.5 \times 2.0$ cm, with an ulceration measuring 3.5×1.0 cm (segment of ileum with a Meckel's diverticulum with gangrenous perforation and no heterotopic tissue. The patient's postoperative course was uneventful with normalization of the WBC ($9.6 \times 10^9/L$), improvement of pain, and the patient became afebrile.

Of note, the potential misdiagnosis of appendicitis does not alter the management and treatment of the patient. The surgical team opted to proceed to the operating room without the definitive diagnosis.



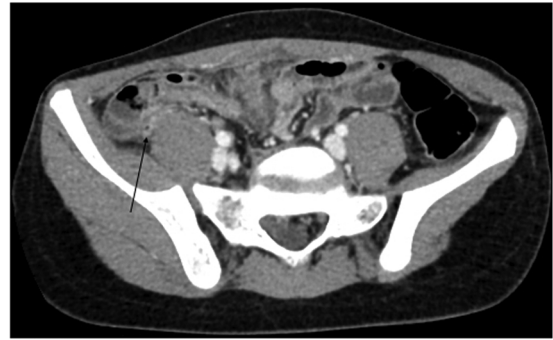
Fig. 3. This sagittal CT image with intravenous contrast reveals mesenteric stranding and edema (black arrow). The blind ending tubular structure blind with wall thickening and enhancement (white arrow).

5. Discussion

A Meckel's diverticulum is the most common congenital anomaly of the small bowel. At the embryologic 10th and 12th week of gestation the midgut recedes into the abdominal cavity, obliterating the omphalomesenteric/vitellointestinal duct (which connects the midgut to the yolk sac). When there is failure of obliteration of the proximal omphalomesenteric/vitellointestinal duct, the resulting “out pouching” is a Meckel's diverticulum [6,8,11]. A Meckel's diverticulum is a true diverticulum, which includes all layers of the small bowel including the mucosa, submucosa, muscularis externa and serosa. Meckel's diverticula are identified on the antimesenteric border of the ileum. Imaging with CT, is vital to diagnosing and evaluating complications in Meckel's diverticulitis [8].

Physicians are taught the “rule of 2's,” with respect to a Meckel's diverticulum, which is a constellation of potential data including 2 feet from ileocecal valve (60 cm), 2 types of heterotopic tissue (gastric/

a



b



Fig. 4. (a) These axial and (b) coronal CT images with intravenous contrast demonstrate air within the normal appendix (black arrow).

pancreatic), 2 times as common in men (symptomatic), present within the first 2 years of life, extends over 2 in. in length (approximately 5 cm), usually 2 types of symptoms (bleeding and obstruction), and 2% develop complications [6,11–13].

Meckel's diverticulum is present in approximately in 1–2% of the population [8,14]. Of the population that has a Meckel's diverticulum only 2% develop complications. An uncomplicated Meckel's diverticulum is difficult to visualize on CT scan (low sensitivity), since it may appear as a normal loop of bowel, but there are findings that clue the physician to its presence [12]. The CT findings for a Meckel's diverticulum may demonstrate a blind ending tubular structure on the anti-mesenteric location, with or without secondary signs of an enterolith, normal appendix, and inflammation (enteritis/colitis) [8]. Secondary signs of Meckel's diverticulum's complications increase the ability to discover a pathologic Meckel's diverticulum.

Multiple complications of Meckel's diverticulum have been described, including hemorrhage, inflammation, perforation, enterolith formation, obstruction and neoplasm. Pediatric patients' most common complication from a Meckel's diverticulum is intestinal hemorrhage [8,11], while in adults the most common complication is obstruction [12]. Most of the complications are related to the gastric mucosa excreting acid, leading to hemorrhage, inflammation, gangrene, peptic ulceration and finally perforation of the unprotected ileal mucosa with one third of the Meckel's diverticulum resulting in perforation [15]. 75% of symptomatic Meckel's diverticulum demonstrate abnormal

mucosa [16]. Enteroliths form in 3–10% of Meckel's diverticulum and are thought to be formed by stasis of bowel contents [8,12,14]. Bowel obstruction is most common in adults, which include inversion of the diverticulum, intussusception, volvulus, or neoplasm. Neoplasms are extremely rare in Meckel's diverticulum, although carcinoid tumors may have a possible association with the anomaly.

The present case demonstrated Meckel's diverticulitis with gangrenous ulceration and perforation, with an enterolith. The CT findings were consistent with discontinuous bowel wall with a small-contained extraluminal collection with air and an enterolith. Additionally present in the case was a normal appendix visualized on the CT scan in the right lower quadrant. The pathology confirmed the CT findings with gangrenous ulceration and a normal appendix.

The fact that the appendix was not visualized was a perceptual error; however, making the misdiagnosis is considered a cognitive error. Seventy percent of these errors are perceptual in nature, i.e., the radiologist does not “see” the abnormality on the imaging exam, perhaps due to poor conspicuity, satisfaction of search, or simply the “inexplicable psycho-visual phenomena of human perception” [2]. Of note, resident and fellow physicians most commonly make cognitive errors, which is what happened in the present case [1].

Management of incidental Meckel's diverticulum is controversial, although according to Zanni et al., the risks outweigh the benefits for operative management. Complicated/symptomatic Meckel's diverticulum is an urgent/emergent process that needs operative management. Additionally, while in the operative theater, the surgeon should consider an appendectomy to prevent diagnostic dilemmas [17].

This case demonstrates an opportunity to review a potential misdiagnosis, and to review and educate on the correct diagnosis of a Meckel's diverticulum. This case presents an exemplary learning opportunity for the radiological community in its effort to continually improve patient care. Errors and diagnostic mistakes should be used as learning opportunities and positive feedback, for the specific radiologist and collegially [3,18].

6. Conclusion

Meckel's diverticula are usually asymptomatic benign entities but can manifest with the clinical picture of acute appendicitis/ life threatening disease. CT imaging is important to the diagnosis with specific features including blind ending tubular structure on the anti-mesenteric location, with or without an enterolith, normal appendix, and secondary inflammatory changes of enteritis/colitis. It is important to consider this rare entity, Meckel's diverticulum, with its complications when a patient presents with abdominal pain, elevated white blood cell count, and fever. If the Meckel's diverticulum is complicated with a perforation, operative management is necessary, but if the Meckel's is incidentally found this does not necessitate surgical treatment.

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Conflict of interest

Dr. Brackett and Dr. Khullar-Gupta declare that they have no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

The authors confirm that I have submitted patient images with this manuscript and all submitted patient images are fully anonymized and informed consent was obtained.

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