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Gastrointestinal Tract Perforation in the Newborn and Child: Imaging Assessment

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Gastrointestinal tract perforation can arise from various underlying etiologies ranging from congenital causes to ingested foreign bodies in the pediatric patient population. Imaging assessment in patients with suspected gastrointestinal tract perforation plays a central role in making the diagnosis and follow-up evaluation. This article reviews the more common etiologies of gastrointestinal tract perforation in pediatric patients, their imaging manifestations, and strategies for imaging assessment to assist the radiologist in arriving at a timely and accurate diagnosis.
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Introduction

Gastrointestinal tract perforation in infants and children is a relatively uncommon occurrence but often has a high morbidity when encountered. Perforation of a hollow viscus in the pediatric patient frequently requires surgical intervention. A timely and accurate diagnosis is necessary to ensure prompt delivery of the appropriate treatment. Various underlying etiologies of gastrointestinal tract perforation are possible in the pediatric patient population, ranging from congenital abnormalities of the bowel to ingested foreign bodies. In nearly every case, the radiologist plays a central role in diagnosis of the perforation and providing follow-up evaluation. The purpose of this article is to review the more commonly encountered etiologies of bowel perforation in the pediatric population, their imaging manifestations, and strategies for imaging assessment.

Imaging Technique

The optimal imaging assessment technique in a pediatric patient clinically suspected of having gastrointestinal tract perforation often depends on the suspected underlying etiology. A wide range of imaging techniques is available, although the most frequently used are abdominal radiographs, fluoroscopy, and computed tomography (CT), which are discussed in the following sections.

Plain Radiographs

Abdominal and pelvic radiographs are usually the first imaging study conducted in the pediatric patient clinically suspected of gastrointestinal tract pathology. A standard 2-view abdominopelvic radiographic series composed of supine anteroposterior (AP) and upright/decubitus/cross-table lateral views is a useful initial assessment of the bowel gas pattern and allows for detection of even small volumes of free intraperitoneal gas. When necessary, the standard 2-view series can be supplemented with additional views to aid in the detection of pneumoperitoneum. Radiographic evaluation is also helpful in the assessment of the pediatric patient who is believed to have ingested a foreign body. In these circumstances, a lateral view of the neck, AP view of the chest, and AP view of the abdomen or pelvis provide a useful survey for the presence of any radiopaque foreign object and its approximate location as well as potential complications.

Fluoroscopy

Fluoroscopy can be used in diagnostic and therapeutic scenarios in the pediatric population. For the neonate presenting with clinical and radiologic findings of a bowel obstruction, a contrast enema performed with water-soluble iodinated contrast material can allow for evaluation of structural and functional abnormalities of the rectum, colon, and distal small

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bowel that may aid in diagnosis of etiologies such as meconium ileus and small bowel atresia. Contrast enemas can be useful in postoperative pediatric patients to assess for patency and dehiscence or leakage of enteric anastomoses. In infants and young children presenting with the diagnosis of ileocolic intussusception, a fluoroscopically guided air contrast enema can be therapeutic. Additionally, fluoroscopy can be used to provide additional "real-time" assessment of the nature of ingested foreign bodies— that is, when suspicion arises on ingestion of multiple magnets.

Computed Tomography

CT can be useful in the imaging assessment of patients with gastrointestinal tract perforation, especially those presenting with infectious or inflammatory, neoplastic, or traumatic causes. The addition of iodinated intravenous contrast can aid in detection of pathology specifically relating to the gastrointestinal tract wall. The addition of positive oral contrast can be helpful in circumstances where fluid-filled bowel loops may be confused with adjacent pathology, but may obscure optimal assessment of the bowel wall itself. Particular attention should be paid to CT acquisition technique in children, with careful consideration and rigorous adherence to ALARA (as low as reasonably achievable) principles. Using size-specific dosing strategies, automatic exposure control, and limiting the acquisition of multiple phases can significantly reduce the dose imparted to the child.

Spectrum of Conditions Resulting in GI Tract Perforation

Congenital Causes

Meconium Ileus

Meconium ileus is a result of mechanical obstruction of the distal ilium by thick, adhesive, inspissated, and desiccated meconium, a process that begins in utero. It is the earliest manifestation of cystic fibrosis occurring in 10%-20% of patients with cystic fibrosis.[1] Clinically, newborn infants with meconium ileus present with failure to pass meconium within the first 48 hours, abdominal distention, and frequently bilious emesis. Meconium ileus can be classified into either simple or complicated cases, each occurring with approximately 50% frequency. Simple meconium ileus often presents within the first 48 hours of birth as intestinal tract obstruction in an otherwise healthy infant. In complicated meconium ileus, thickened meconium and obstruction lead to complications such as volvulus, necrosis, perforation, and generalized meconium peritonitis with or without pseudocyst formation.[2,3]

The imaging evaluation of a patient with meconium ileus generally begins with plain abdominal radiographs obtained when an obstruction is clinically suspected (Fig. 1). In affected pediatric patients, abdominal radiographs often show a pattern of distal obstruction with multiple dilated loops of bowel throughout the abdomen, frequently without air fluid levels given the abnormally thick intraluminal meconium.[4] In the setting of complicated meconium ileus and antenatal perforation, radiographs may manifest signs of meconium peritonitis characterized by separated bowel loops, peripherally calcified pseudocysts, or irregular punctate calcifications along the peritoneal surface due to foci of calcified spilled meconium. In the male infant, calcifications can be seen within the scrotum, and similar to the intraperitoneal calcifications they are strong indicators of meconium peritonitis. It is important to note that meconium peritonitis is nonspecific for meconium ileus and can be seen in the setting of other etiologies resulting in prenatal bowel perforation.

When distal bowel obstruction is suspected clinically or radiographically, the next test performed is generally a contrast enema. Previously, the Gastrografin enema was thought to be the preferred contrast owing to its hyperosmolar nature, which resulted in osmotic movement of water into the bowel lumen. However, complications of the procedure, particularly hypertonic dehydration, raised questions about this method and subsequent research has shown that success rates in clearing the obstruction due to meconium ileus do not correlate with the osmolality of the contrast medium. An infrequent but important complication of the contrast enema is bowel perforation. A prior survey of pediatric radiologists regarding complications when performing contrast enemas for meconium ileus revealed a perforation rate of approximately 3% and showed no correlation with enema success rate, or type or osmolality of contrast medium.[5]

Jejunal-Ileal Atresia

Jejuno-ileal atresias are thought to occur owing to intrauterine vascular insults early in fetal life. Atresias occurring within the small bowel are the most common type of intestinal tract atresia, occurring with an incidence of 1:5000-1:14,000 live births.[6] Jejunal atresias are more common than ileal atresias. Associated conditions may be related to the etiology, as 10% of patients with gastroschisis, 10% of patients with cystic fibrosis or meconium ileus, and 20% of patients with malrotation have jejuno-ileal atresia.[6]

Newborn infants with jejunal atresia usually present with abdominal distention and bilious emesis. Radiographs reveal an obstructive pattern that can be characteristic, where the distended stomach, duodenum, and proximal jejunum create the so-called "triple-bubble" sign. For patients with an ileal atresia, the bowel gas pattern is often one of a more distal obstruction with numerous dilated loops of bowel. In the setting of a distal bowel obstruction, contrast enema is often performed and frequently demonstrates a microcolon. If contrast can be refluxed through the ileocecal valve and into the distal bowel, an atretic distal bowel segment may be encountered. Of note, when an isolated proximal atresia of the jejunum is present, the colon can be normal in size because the remaining small bowel distal to the atresia generates sufficient intestinal tract secretions to produce a normal caliber colon.[7] Similar to the condition in children with meconium ileus, in utero perforation may occur, resulting in meconium peritonitis, a finding that is more common in small bowel atresias than in meconium ileus (Fig. 2).[8]