Investigation in Vomiting Children

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This article discusses how to investigate various surgical causes of vomiting. Particular emphasis is placed on plain radiographic, ultrasound, and contrast study findings. The article touches upon nineteen different diseases, and encompasses diseases found in neonates to adolescents. © 2003 Elsevier Inc. All rights reserved.

VOMITING IS A common self-limiting symptom in children, but occasionally heralds serious surgical or life-threatening disease. This review is a practical guide to the radiological findings in children who are vomiting because of surgical disease. No test should be performed before an experienced clinician assesses a child. Tests are then carried out to confirm a suspected diagnosis, eg, pyloric stenosis where a test feed is negative, or to exclude an unlikely, but potentially serious diagnosis, eg, volvulus in a well baby with an episode of bilious vomiting. Many of the pathologies discussed are best investigated by “old-fashioned” plain radiographs, ultrasound, and fluoroscopic examinations with water-soluble contrast or barium.† Computed tomography (CT), magnetic resonance imaging, and nuclear medicine examinations have a lesser role.

THE VOMITING NEONATE

Many of the causes of vomiting reflect congenital obstructions of the gastrointestinal tract. Some of these, eg, duodenal atresia, may already have been suspected at the time of antenatal fetal ultrasound scans.

Gastric Outlet Obstruction

Gastric outlet obstruction presents as a “single bubble,” which is the gas-filled stomach on an abdominal radiograph (Fig 1). There is no gas distal to the stomach and no further investigation is necessary.

Duodenal Atresia

Duodenal atresia presents as a “double bubble,” which is the air-filled stomach and dilated duodenal bulb.

Proximal Jejunal Atresia

Proximal jejunal atresia presents as a “triple bubble” because of air in the stomach, duodenal, and proximal dilated jejunum.

Distal Ileal Atresia

Radiographs show multiple air-filled loops of bowel. There is no air in the rectum. A water-soluble contrast enema may show a microcolon or normal-sized colon. There is reflux into a short segment of small bowel, which either terminates in a “cigar butt” or a small nipple. Contrast will not pass any more proximally. Filling of the appendix should not be mistaken for small-bowel filling.

Meconium Ileus

Radiographs can show peritoneal calcification if there has been a previous in utero perforation, abdominal distension with absence of gas in the right iliac fossa due to a meconium cyst, bubbly meconium in the right flank, multiple dilated air-filled loops of small bowel proximal to the ileus, and perforation (Fig 2). Water-soluble contrast enema shows a microcolon. The contrast then flows around and through the thick meconium in the cecum.

Fig 1. One-day-old child with vomiting and a “single bubble” appearance due to gastric outlet obstruction confirmed at surgery.
and proximal small bowel. The aim is to reflux watersoluble contrast proximal to the meconium obstruction and into dilated air-filled loops of gut. The osmotic load draws water into the gut lumen and may allow the baby to pass the meconium without need for laparotomy. Obviously, the baby must be well hydrated at the time of the enema, which can be repeated several times. Inability to reflux contrast into the air-filled dilated small bowel loops proximal to the obstruction should raise the possibility of an associated volvulus, which will require laparotomy.

**Hirschprung’s Disease**

Radiographs show multiple loops of air-filled dilated gut and, occasionally, a perforation. There is usually no gas in the rectum in the neonate with Hirschprung’s disease. There is often particular dilatation of the loop immediately proximal to the transition zone. A barium or water-soluble contrast enema, prior to any rectal washout, is performed looking for a transition zone. This marks the level at which the affected colon widens

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**Fig 2.** A 3 day-old baby with multiple dilated loops of gut and a supine pneumoperitoneum. Perforation of a meconium ileus was found at surgery.

**Fig 3.** High-resolution ultrasound shows a pylorus of 16-mm long and individual muscle wall thickness of over 4 mm. Pyloric stenosis was confirmed at surgery.

**Fig 4.** Six-week-old child with inconclusive pyloric ultrasound shows sign of a pyloric tumor and free esophageal reflux. Tumor was confirmed at surgery.
into normal colon. Rectosigmoid and colon affected by Hirschprung’s disease is of narrower caliber than normal colon, and often shows fine mucosal irregularities due to muscular incoordination. Total colonic Hirschprung’s poses a major problem for the radiologist. An enema can miss whole colonic involvement, as there is no transition zone. Rectal biopsy is mandatory to confirm or exclude the diagnosis.

**Meconium Plug Syndrome**

The plug is easily demonstrated as a large single filling defect within the distal colon and rectosigmoid, on a contrast enema. The plug may be aspirated back with the contrast, or may then be spontaneously voided by the baby because of the osmotic effect of contrast.

**THE VOMITING BABY**

**Gastroesophageal Reflux**

Suspected reflux is the most common indication for a barium swallow in our institution. It is an easy diagnosis if there are multiple episodes of reflux filling the esophagus with barium. However, fluoroscopic diagnosis of reflux is complicated by lack of an agreed method of performing the barium swallow test. Multiple nonphysiological methods of provoking reflux exist, and there is no agreed upon method of quantifying reflux. A barium swallow is useful in confirming or excluding an esophageal stricture, hiatus hernia, or gastric outlet obstruction. The sensitivity for demonstrating reflux is about 50% compared to the “gold standard” of a 24-hour pH probe study. The pH study is more invasive although it does not have a radiation burden. A nuclear medicine “milk reflux scan” allows physiological feeding and observation of a baby in order to document reflux over several hours after a feed containing a nuclear medicine tracer. It shows 60% to 80% sensitivity compared to 24-hour monitoring.6,7
Pyloric Stenosis

A positive test feed by an experienced clinician means that imaging is unnecessary. Radiographs show a distended stomach, often with prominent peristaltic waves, and traces of air in the remainder of the bowel. Ultrasound is both sensitive and specific at making the diagnosis of pyloric stenosis. A nasogastric tube is passed into the stomach and the stomach washed out with warm sterile water, and then filled with 30 to 60 mL of water. The pylorus is directly visualized and the length and diameter measured. Various sizes have been proposed for diagnosis of pyloric stenosis. At our institution, we diagnose pyloric stenosis when the pyloric length is over 16 mm and the transverse diameter is over 10 mm (Fig 3). The normal transverse thickness of the pyloric muscle is less than 2 mm. Over 4 mm is diagnostic of pyloric stenosis. These measurements, however, are too large for making a diagnosis of pyloric stenosis in a neonate. Pyloric stenosis can also be diagnosed by a barium meal that shows a shouldered pylorus and a "tramtrack sign" of the elongated, and partly obstructed pyloric channel (Fig 4).

Malrotation and Volvulus

Malrotation or nonrotation causes abnormal fixation of the gut within the abdominal cavity. It may be associated with a short root of the mesentery, which runs from the ligament of Treitz to the cecum. The risk of volvulus increases as the base of the small bowel mesentery decreases. Unfortunately, with fluoroscopic imaging, the bowel is visualized, not the mesentery and so the radiologist makes an informed guess about the mesenteric position from the position of the gut. The most reliable examination for confirming or excluding a malrotation is a barium meal where the column of contrast is watched during the first pass through duodenum and into jejunum. A normal duodenjejunal flexure, which is the marker for the ligament of Treitz, lies to the left of the spine at or close to the level of pylorus (usually the second

Fig 7. Fourteen-month-old with a persistent filling defect immediately above the esophagogastric junction. A plastic ballpoint pen cap was found at esophagoscopy.

Fig 8. Dilated esophagus and "rat-tail" narrowing of gastro-esophageal junction in achalasia proven with subsequent manometry.
lumbar vertebra). Most malrotations are obvious and easily diagnosed. However, a number of variants of normal duodenal anatomy overlap with subtle malrotations. These “gray” cases are best approached by direct discussion between the radiologist and surgeon about the appearances. A repeat barium meal or barium enema to show cecal position, may be useful in deciding how seriously to treat the appearances. Volvulus is due to twisting of the midgut loop on the mesentery causing venous then arterial ischemia of the gut. Radiographs may show dilated gas-filled upper small bowel, or small bowel lying in the right flank. Perforation is a grave sign. A barium or contrast meal shows the corkscrew sign of twisted bowel (Fig 5), or a complete cut-off at the level of second or third part of duodenum. Ultrasound assessment of the position of the superior mesenteric artery and vein is less reliable than a contrast meal for diagnosis of malrotation and a normal ultrasound can occur with malrotation.

Intussusception

Radiographs may appear normal, show nonspecific abnormality, or show a soft tissue mass in the right flank and absence of paucity of colonic air. Small bowel obstruction may be present but perforation is rare. A normal air- and feces-containing cecum, on an abdominal radiograph, excludes the diagnosis. Ultrasound is used to confirm the diagnosis and generally shows a complex mass in the right flank or epigastrium (Fig 6). Often individual bowel wall layers, lymph nodes, and mesenteric fat are identified within the mass. There may be trapped fluid within the intussusception or ascites.
Small bowel obstruction is shown by multiple hyperperistalsis dilated fluid-filled loops of small bowel. Ultrasound may also identify a pathological lead point. An air or contrast enema can either be used to confirm the diagnosis without ultrasound or to perform a reduction. Ultrasound-guided reduction using Hartmann’s solution or saline is as effective as barium reduction and involves no radiation exposure for patient or operator.

THE VOMITING OLDER CHILD

Esophageal Stricture and Foreign Body

Strictures are seen as a thin, constricting ring postesophageal atresia repair, a smooth mid or lower third narrowing due to reflux esophagitis, or a long irregular narrowing postcaustic ingestion. A foreign body may impact on the stricture (Fig 7).

Achalasia

Achalasia does not cause vomiting, but does cause regurgitation of undigested food and pulmonary complications due to aspiration. A chest radiograph may demonstrate areas of collapse or consolidation; a dilated air-filled esophagus, an air fluid level in the esophagus, or absence of the gastric air bubble. A barium swallow shows disordered motility in early achalasia and a dilated serpiginous esophagus containing food residue in established achalasia. The esophagus forms a smooth “rat-tail” stricture at the esophagogastric junction and one can watch barium intermittently squirting into the stomach during screening (Fig 8). Any shouldering, other stricture, or fixed polypoid intramural lesion is suspicious of a superimposed carcinoma.

Fig 11. Contrast-enhanced CT of abdomen in moribund child 10 days postappendectomy. There are multiple intraabdominal abscesses confirmed at subsequent surgery.

Fig 12. A 2-year-old boy with small bowel obstruction due to an incerated right inguinal hernia.
Duodenal Ulcer

A double-contrast barium meal using high-density barium and spot views of the duodenal cap may show spasm untreatable by intravenous antispasmodics, an ulcer niche if there is an acute ulcer, or scarring and deformity if there is a healed ulcer (Fig 9). Endoscopy is more sensitive than single-contrast barium studies for diagnosis of both gastric and duodenal ulcers.23

Appendicitis

Radiographic findings of appendicitis are generally not helpful in early disease and include normal appearances, right lower quadrant haze, blurring of the right psoas shadow, obliteration of the right properitoneal fat line, as scoliosis convex to the left, a dilated loop of small bowel—“sentinel loop” sign or the “colon cut-off” sign of a dilated ascending colon with a sharply defined lower margin (Fig 10). An appendicolith is seen in 10% to 15% of patients and clinches the diagnosis. Graded compression ultrasound demonstrates the inflamed appendix as a tender, noncompressible, tubular structure with 1 blind end and often a calcified appendicolith at its base.24,25 There is often localized ascites, hyperechoic mesenteric fat, and right iliac fossa lymphadenopathy. Perforated appendicitis may form a complex mass of fluid, fat, and gut. Ultrasound can be falsely normal if there is only a distal tip appendicitis or if there is a retrocecal appendicitis obscured by cecal gas. CT has been used for diagnosing acute appendicitis.26 CT findings in appendicitis include an enlarged appendix, appendicolith, tapered deformity of the colon—the “arrowhead” sign, stranding of adjacent fat, adjacent bowel wall thickening, and a complex mass if perforation occurs.27 CT is also useful for delineating abscesses in postappendectomy patients presenting with fever and suspected abscess (Fig 11).

Small Bowel Obstruction: Hernias or Atresias

Radiographs show multiple dilated air-filled small bowel loops or a “string of pearls” sign of small amounts of air within the gut and fluid-filling of the remainder of gut. A gas-filled loop of gut may be seen in scrotum, confirming an inguinal hernia (Fig 12). Ultrasound may be used to confirm an inguinal hernia in boys or girls.
showing the gut and mesenteric fat or ovaries and fallopian tubes. CT can be used to look for the transition zone from proximal dilated gut to collapsed gut indicating the site of obstruction.

Renal Colic
Radiographs usually show a radio opaque stone either within the renal pelvis or in the line of ureters (Fig 13). Ultrasound, which should be performed first, may also show stone as a hyperintense area within the renal pelvis with posterior shadowing. There may be hydronephrosis due to obstruction by a ureteric stone. Unenhanced CT is the most sensitive method for diagnosing a stone, showing a renal stone as a dense area within the kidney, possibly hydronephrosis, and stranding of the perirenal fat. A ureteric stone is identified as a dense focus in the line of ureter, possibly with hydronephrosis, hydrourerter, circumferential thickening of the ureteric wall and stranding of the periureteric fat.

Pancreatitis
Radiographs are generally not helpful. Calcification due to chronic pancreatitis is rare. A sentimental loop of dilated air-filled small bowel due to local ileus may be present. Cross-section imaging is used to stage the severity of pancreatitis and assess complications. Contrast-enhanced CT scan obtaining images in the arterial phase is the best method for showing the presence and assessing the percentage of pancreatic necrosis, and showing abscesses. Arterial phase CT is also best for demonstrating arterial pseudoaneurysms, although delayed CT is necessary for showing venous occlusion or stenosis. Pseudocysts can be followed either by ultrasound or CT.

Ovarian Torsion
Radiographs can mimic appendicitis or may be diagnostic if there is calcification in a torsion of an ovarian dermoid (Fig 14). Ultrasound shows a pelvic or adnexal mass that is either cystic or solid (Fig 15). A torted ovary is several times larger than normal. Doppler imaging may show the mass to be avascular. Ultrasound, CT, or magnetic resonance imaging may all show multiple peripheral cysts within the mass due to dilated follicles.

REFERENCES


