American College of Radiology
ACR Appropriateness Criteria®
Vomiting in Infants

Variant: 1   Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
Radiography abdomen	Usually Appropriate	☢☢
US abdomen (UGI tract)	Usually Not Appropriate	O
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢☢
Fluoroscopy upper GI series	Usually Not Appropriate	☢☢☢
Nuclear medicine gastroesophageal reflux scan	Usually Not Appropriate	☢☢☢

Variant: 2   Vomiting within the first 2 days after birth. Radiographs show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia). Next imaging study.

Procedure	Appropriateness Category	Peds Relative Radiation Level
Fluoroscopy upper GI series	May Be Appropriate	☢☢☢
US abdomen (UGI tract)	Usually Not Appropriate	O
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢☢
Nuclear medicine gastroesophageal reflux scan	Usually Not Appropriate	☢☢☢

Variant: 3   Vomiting within the first 2 days after birth. Radiographs show a distal bowel obstruction. Next imaging study.

Procedure	Appropriateness Category	Peds Relative Radiation Level
Fluoroscopy contrast enema	Usually Appropriate	☢☢☢☢
US abdomen (UGI tract)	Usually Not Appropriate	O
Fluoroscopy upper GI series	Usually Not Appropriate	☢☢☢
Nuclear medicine gastroesophageal reflux scan	Usually Not Appropriate	☢☢☢

Variant: 4   Bilious vomiting within the first 2 days after birth. Radiographs show a nonclassic double bubble with gas in the distal small bowel, or few distended bowel loops, or a normal bowel gas pattern. Next imaging study.

Procedure	Appropriateness Category	Peds Relative Radiation Level
Fluoroscopy upper GI series	Usually Appropriate	☢☢☢
US abdomen (UGI tract)	May Be Appropriate	O
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢☢
Nuclear medicine gastroesophageal reflux scan	Usually Not Appropriate	☢☢☢

Variant: 5   Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
Fluoroscopy upper GI series	Usually Appropriate	☢☢☢
US abdomen (UGI tract)	May Be Appropriate	O

Radiography abdomen	May Be Appropriate (Disagreement)	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢☢
Nuclear medicine gastroesophageal reflux scan	Usually Not Appropriate	☢☢☢

Variant: 6 Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
Fluoroscopy upper GI series	May Be Appropriate	☢☢☢
Nuclear medicine gastroesophageal reflux scan	May Be Appropriate	☢☢☢
US abdomen (UGI tract)	Usually Not Appropriate	O
Radiography abdomen	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢☢

Variant: 7 Infant older than 2 weeks and up to 3 months old. New onset nonbilious vomiting (suspected hypertrophic pyloric stenosis). Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US abdomen (UGI tract)	Usually Appropriate	O
Fluoroscopy upper GI series	May Be Appropriate	☢☢☢
Radiography abdomen	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢☢
Nuclear medicine gastroesophageal reflux scan	Usually Not Appropriate	☢☢☢

Panel Members

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Summary of Literature Review

Introduction/Background

Vomiting is common in infants, and in the majority of cases is benign. However, vomiting can be a sign of underlying pathology, which could be related to obstruction along the course of the gastrointestinal (GI) tract and may be secondary to infectious etiologies, neurologic diseases, mechanical, or metabolic causes [1,2]. This topic will be limited to the role of imaging in evaluation of complete or partial GI obstruction.

Clinically, vomiting is categorized as being nonbilious or bilious; the latter suggests the point of obstruction is distal to the ampulla of Vater. Most commonly, nonbilious vomiting is actually regurgitation, known as gastroesophageal reflux (GER). The clinical differentiation between vomiting and regurgitation may be challenging.

Vomiting, secondary to GER, is normal in infants, with decreased incidence with age and resolves in

time. It usually has no definitive pathologic cause and is unrelated to a functional defect. Rarely, regurgitation may be due to displacement of a portion of the stomach into the chest (ie, hiatal hernia). In other cases, lower esophageal sphincter pressures or delays in gastric emptying have been implicated as causative and typically resolve in time [1]. Parental complaints of vomiting or regurgitation in infants are common. The cause is usually GER, particularly in the first weeks of life and in part because of overfeeding. Infants with normal weight gain and no other symptoms tend not to have obstruction as the cause of their vomiting [3].

Bilious emesis or repeated forceful vomiting should be evaluated for underlying obstruction. When evaluating a neonate who presents in the first week of life with vomiting, a congenital GI tract abnormality is a primary consideration. Upper or lower tract abnormalities can cause vomiting with possible etiologies including malrotation with or without volvulus, atresia of the antropyloric region, annular pancreas, atresia/stenosis of the small bowel or colon, functional obstructions caused by Hirschsprung disease, functional immaturity of the colon, and meconium ileus. Importantly, although malrotation most commonly presents in newborns, it can present at any time during life with decreasing frequency with age.

Several GI pathologies to consider in a vomiting infant outside of the newborn period include hypertrophic pyloric stenosis (HPS), pylorospasm, formula intolerance, and gastroenteritis. In a young infant, less common GI etiologies include neonatal appendicitis, intussusception, gastric ulcer disease, gastric volvulus, trauma, and foreign body including lactobezoar. Medical causes to consider include sepsis, enteritis, pneumonia, otitis media, meningitis, raised intracranial pressure (from tumor, trauma, or hydrocephalus), kernicterus, metabolic disorders (phenylketonuria, hyperammonemia, maple syrup urine disease, galactosemia, diabetes, adrenocortical hyperplasia, and methylmalonic acidemia), diencephalic syndrome, and rarely drugs or toxic agents [3-5].

A diagnostic workup should start with a thorough clinical evaluation. History and physical examination can lead to the diagnosis in most instances. Viral gastroenteritis often appears in epidemics, with sudden onset of vomiting, mild fever, diarrhea, and a relatively short duration. Systemic infections and metabolic disorders may be diagnosed by clinical and laboratory criteria. HPS may be diagnosed by feeling the classic "olive" of hypertrophied muscle. Intussusception, which is unusual in the first 3 months of life, may be diagnosed clinically by crampy, intermittent abdominal pain sometimes progressing to bloody stools and lethargy. Patients with increased intracranial pressure may have an enlarging head circumference, bulging fontanelle, and/or neurologic signs [3,5].

When the clinical and laboratory assessment provides a definitive diagnosis and treatment plan, radiologic imaging is not required. Clinical diagnostic uncertainty may require use of imaging.

Often the initial imaging helps in determining whether the patient has bowel obstruction and may provide insight into whether it is proximal or distal obstruction. In some cases, other imaging is necessary to provide diagnosis that is more definitive, help with surgical approach, and diagnose cases that require urgent surgery.

Initial Imaging Definition
Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the

initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.

Bilious vomiting in the first days after birth is an ominous sign that suggests the possibility of bowel obstruction and in some cases the need for urgent surgery. In a study of 45 patients with bilious vomiting in the first 72 hours of life, 20% had midgut volvulus and 11% had a lower GI cause (meconium plug syndrome or left-sided microcolon) [6].

Vomiting usually begins in the first 2 days after birth in children with intestinal atresia and is usually bilious. Bilious vomiting and gastric distension suggest proximal bowel obstruction. About 15% of children with proximal bowel obstruction will have nonbilious vomiting [7]. No passage of meconium and yellow colostrum or vomitus with meconium is typical for distal bowel obstruction. Imaging has a role for definitive diagnosis of bowel obstruction as a cause of the vomiting; it can differentiate between proximal and distal obstruction and exclude midgut volvulus that requires urgent surgery.

Variant 1: Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.
A. Radiography Abdomen

When evaluating a newborn with vomiting after birth, especially when there is bilious vomiting, the initial concern is to identify diseases that require emergent surgical management, specifically, malrotation with midgut volvulus and intestinal atresias. There are some bowel gas patterns that can guide management; double bubble with no distal gas (classic double bubble) or triple bubble with no distal gas, double bubble with distal gas (nonclassic double bubble), and multiple distended bowel loops with no or decreased distal gas (see Variants 2 and 4) [8].

Variant 1: Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.
B. Fluoroscopy Contrast Enema

Although beginning the workup with a contrast enema may lead to a diagnosis, there is no relevant literature to support the use of performing a contrast enema as the initial imaging study prior to an abdominal radiograph.

Variant 1: Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.
C. Fluoroscopy Upper GI Series

Although beginning the workup with an upper GI (UGI) series may lead to a diagnosis, there is no

relevant literature to support the use of performing a UGI series as the initial imaging study prior to an abdominal radiograph.

Variant 1: Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.
D. Nuclear Medicine Gastroesophageal Reflux Scan

There is no relevant literature to support the use of reflux scintigraphy using Tc-99m sulfur colloid or Tc-99m diethylenetriamine pentaacetic acid (DTPA) or Tc-99m microaggregated albumin (MAA) in the initial imaging evaluation of the neonate with acute bilious vomiting.

Variant 1: Vomiting within the first 2 days after birth. Poor feeding or no passage of meconium. Initial imaging.
E. US Abdomen (UGI Tract)

There is no relevant literature to support the use of ultrasound (US) as the initial imaging examination prior to an abdominal radiograph for the neonate with acute bilious vomiting.

Variant 2: Vomiting within the first 2 days after birth. Radiographs show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia). Next imaging study.

Double bubble with no gas distally indicates obstruction of the duodenum. The most common etiology is duodenal atresia. All other etiologies such as duodenal web, congenital midgut volvulus, internal hernia, and obstructing duplication cyst are rare [9]. In one study of 50 neonates with duodenal obstruction, 35 had a classic "double bubble" sign, of which 32 had duodenal atresia, 2 had malrotation with volvulus, and 1 had duodenal stenosis [10]. Triple bubble with no gas distally indicates obstruction of the jejunum, usually due to atresia [8].

Variant 2: Vomiting within the first 2 days after birth. Radiographs show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia). Next imaging study.
A. Fluoroscopy Contrast Enema

In the setting of a suspected proximal atresia with absent distal bowel gas, there is no relevant literature to support the use of a contrast enema for diagnosis. Atresias can be multiple in approximately 15% of patients. Most of these can be diagnosed at the initial surgical exploration [11].

Variant 2: Vomiting within the first 2 days after birth. Radiographs show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia). Next imaging study.
B. Fluoroscopy upper GI series

In the setting of a classic double bubble or triple bubble with no gas distally, a UGI series is usually not necessary, because the positive contrast used in fluoroscopy does not typically provide more anatomic details. In some cases in which there is inadequate gastric or duodenal distention, air can be injected to the stomach through the feeding tube to better delineate the gas pattern and confirm no gas distally.

Variant 2: Vomiting within the first 2 days after birth. Radiographs show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia). Next imaging study.
C. Nuclear medicine gastroesophageal reflux scan

There is no relevant literature to support the use of reflux scintigraphy using Tc-99m sulfur colloid

or Tc-99m DTPA or Tc-99m MAA in evaluating the neonate with acute vomiting and classic double bubble or triple bubble with no gas distally.

Variant 2: Vomiting within the first 2 days after birth. Radiographs show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia). Next imaging study.
D. US abdomen (UGI tract)

There is a growing acceptance for the role of US, especially in prenatal diagnosis of duodenal atresia. In the postnatal diagnosis of duodenal atresia, there is no relevant literature to support the use of US in evaluating the neonate with acute vomiting and classic double bubble or triple bubble with no gas distally.

Variant 3: Vomiting within the first 2 days after birth. Radiographs show a distal bowel obstruction. Next imaging study.

The role of imaging in children with multiple distended bowel loops with no or decreased gas distally is to differentiate between temporary functional abnormalities that only need observation (eg, meconium plug), pathologies that require surgery (eg, ileal atresia), therapeutic enema (eg, meconium ileus), or rectal biopsy (eg, Hirschsprung disease) [12].

Variant 3: Vomiting within the first 2 days after birth. Radiographs show a distal bowel obstruction. Next imaging study.
A. Fluoroscopy contrast enema

Contrast enema is the diagnostic imaging procedure of choice when there is a suspected distal obstruction. Congenital distal obstruction can be structural or functional, in which both will give the same appearance on abdominal radiographs that show numerous dilated bowel loops with an absence or paucity of distal gas. In the setting of congenital atresia, most commonly ileal, but also distal jejunal or colonic, the lack of contents moving through the bowel results in a microcolon [12].

Variant 3: Vomiting within the first 2 days after birth. Radiographs show a distal bowel obstruction. Next imaging study.
B. Fluoroscopy upper GI series

There is no relevant literature to support the use of a UGI series in the evaluation of the neonate with suspected distal obstruction.

Variant 3: Vomiting within the first 2 days after birth. Radiographs show a distal bowel obstruction. Next imaging study.
C. Nuclear medicine gastroesophageal reflux scan

There is no relevant literature to support the use of reflux scintigraphy using Tc-99m sulfur colloid or Tc-99m DTPA or Tc-99m MAA in the evaluation of the neonate with suspected distal obstruction.

Variant 3: Vomiting within the first 2 days after birth. Radiographs show a distal bowel obstruction. Next imaging study.
D. US abdomen (UGI tract)

There is no relevant literature to support the use of US in the evaluation of the neonate with suspected distal obstruction.

Variant 4: Bilious vomiting within the first 2 days after birth. Radiographs show a nonclassic double bubble with gas in the distal small bowel, or few distended bowel loops, or a normal

bowel gas pattern. Next imaging study.

The role of imaging in a child with bilious vomiting in the first 2 days of life with nonclassic double bubble or few distended bowel loops is to differentiate between congenital intestinal atresia and stenosis and midgut volvulus, which requires urgent surgery. Malrotation or midgut volvulus with incomplete obstruction may have a normal bowel gas pattern [5,6,11].

Variant 4: Bilious vomiting within the first 2 days after birth. Radiographs show a nonclassic double bubble with gas in the distal small bowel, or few distended bowel loops, or a normal bowel gas pattern. Next imaging study.
A. Fluoroscopy contrast enema

Abnormalities of the lower GI tract that cause bilious vomiting may be demonstrated by contrast enema [4,13]. The use of a barium enema for analyzing malrotation is less direct than analysis of a UGI series. Approximately 20% of barium enemas may be falsely negative, whereas up to 15% of infants have a high mobile cecum that may cause false-positive interpretations of the study [14].

Variant 4: Bilious vomiting within the first 2 days after birth. Radiographs show a nonclassic double bubble with gas in the distal small bowel, or few distended bowel loops, or a normal bowel gas pattern. Next imaging study.
B. Fluoroscopy upper GI series

To answer the key imaging question in such patients—that is, whether the child has malrotation or midgut volvulus—requires direct imaging of the stomach and small bowel. The most important finding that indicates malrotation is abnormal position of the duodenal jejunal junction (location of the ligament of Treitz) [5,6,15]. Although the UGI series is considered the reference standard for evaluating malrotation, false-positive and false-negative interpretations may occur. In a retrospective review of 229 cases by Sizemore et al [16], UGI had a sensitivity of 96% with two false-positives (abnormal jejunal position with no malrotation) and seven false-negatives (normal jejunal position with malrotation). Retrospective reviews by Hsiao et al [17] and another study by Long et al [18] noted false-positive rates of 10% and 15%, respectively. Redundant duodenum, bowel distension, and jejunal position can lead to inaccurate UGI interpretation; thus a meticulous technique is warranted [16-18]. The UGI study may also indicate if there is midgut volvulus that requires urgent surgery [5,6,11].

Variant 4: Bilious vomiting within the first 2 days after birth. Radiographs show a nonclassic double bubble with gas in the distal small bowel, or few distended bowel loops, or a normal bowel gas pattern. Next imaging study.
C. Nuclear medicine gastroesophageal reflux scan

There is no relevant literature to support the use of reflux scintigraphy using Tc-99m sulfur colloid or Tc-99m DTPA or Tc-99m MAA in the evaluation of the neonate with acute bilious vomiting.

Variant 4: Bilious vomiting within the first 2 days after birth. Radiographs show a nonclassic double bubble with gas in the distal small bowel, or few distended bowel loops, or a normal bowel gas pattern. Next imaging study.
D. US abdomen (UGI tract)

There are limited data on the accuracy of US as the primary imaging modality in evaluating malrotation and midgut volvulus. There are two anatomical landmarks that can be evaluated by US that may indicate malrotation; position of the superior mesenteric vein (SMV) in relation to the superior mesenteric artery (SMA) and the position of the third portion of the duodenum behind the SMA [19-21]. A normal SMV/SMA relationship does not preclude malrotation, with both false-

positive (21%) and false-negative (2%–3%) results reported [22]. Obscuration of the SMA and SMV by bowel gas has been reported to occur in up to 17% of cases [23]. In a small prospective series, US demonstrated abnormal position of the duodenum in 50% of children who had surgery for malrotation [24]. In addition, malrotation represents a spectrum of abnormal bowel fixation that may include a situation in which the duodenum courses behind the SMA [25].

Although US has limitation for the diagnosis of malrotation, there are a few studies showing high sensitivity and specificity for midgut volvulus. The US finding of the whirlpool sign (a clockwise wrapping of the SMV and mesentery around the SMA as the fixed axis) is specific for volvulus [15,26-28]. It is important to recognize sonographic features of midgut volvulus because they can help to substantiate the diagnosis in an equivocal UGI study or when US is performed for other indications (eg, evaluation for HPS).

Variant 5: Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.

Most congenital intestinal atresia and stenosis will present in the first 2 days of life. Midgut volvulus is the most important diagnosis in older infants presenting with bilious vomiting because this is a medical emergency [15].

Variant 5: Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.
A. Fluoroscopy contrast enema

There is no relevant literature to support the use of a contrast enema as the initial imaging study for suspected malrotation. In suspected malrotation with midgut volvulus, if the UGI fails to show the etiology or is equivocal, a contrast enema may be performed as a follow-up study in the workup of bilious vomiting. However, up to 15% of individuals may have a normal mobile cecum [29]. More commonly, if the UGI is equivocal, small bowel follow through to the cecum may be pursued.

Variant 5: Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.
B. Fluoroscopy upper GI series

The barium UGI series evaluates the esophagus, stomach, pylorus, and the duodenum to the duodenal jejunal junction, indicating the location of the ligament of Treitz [5,6,15]. Although the UGI series is considered the reference standard for evaluating malrotation, false-positive and false-negative interpretations may occur. In a retrospective review of 229 cases by Sizemore et al [16], UGI had a sensitivity of 96% with two false-positives (abnormal jejunal position with no malrotation) and seven false-negatives (normal jejunal position with malrotation). Retrospective reviews by Hsiao et al [17] and another such study by Long et al [18] noted false-positive rates of 10% and 15%, respectively. The studies concluded that redundant duodenum, bowel distension, and jejunal position can lead to inaccurate UGI interpretation; thus meticulous technique is warranted [16-18].

Variant 5: Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.
C. Nuclear medicine gastroesophageal reflux scan

Reflux scintigraphy can be highly effective in analyzing gastric emptying and GER, but there is no relevant literature to support the use of reflux scintigraphy using Tc-99m sulfur colloid or Tc-99m

DTPA or Tc-99m MAA in the evaluation of the neonate with acute bilious vomiting.

Variant 5: Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.
D. Radiography abdomen

Abdominal radiographs have a limited role in determining subsequent imaging workup, keeping in mind that normal abdominal radiographs do not exclude the diagnosis of malrotation. In a group studied by Lilien et al [6], only 44% of patients who required surgery for bilious vomiting had definitively positive radiograph readings. If the radiographs do show signs of obstruction, the pattern of bowel distension can help direct further evaluation with an UGI series or contrast enema, respectively. Thus, although the plain radiograph may not be able to make the diagnosis of malrotation without supportive imaging, it may serve a complementary role to guide further imaging.

Variant 5: Bilious vomiting in an infant older than 2 days (suspected malrotation). Initial imaging.
E. US abdomen (UGI tract)

There are limited data on the accuracy of US as the primary imaging modality in evaluating malrotation and midgut volvulus. There are two anatomical landmarks that can be evaluated by US that may indicate malrotation—position of the SMV in relation to the SMA and the position of the third part of the duodenum behind the SMA [19-21]. A normal SMV/SMA relationship does not preclude malrotation, with both false-positive (21%) and false-negative (2%–3%) results reported [22]. Obscuration of the SMA and SMV by bowel gas has been reported to occur in up to 17% of cases [23]. In a small prospective series, US demonstrated abnormal position of the duodenum in 50% of children who had surgery for malrotation [24]. In addition, malrotation represents a spectrum of abnormal bowel fixation that may include a situation in which the duodenum courses behind the SMA [25].

Although US has limitation for the diagnosis of malrotation, there are few studies showing high sensitivity and specificity for midgut volvulus. The US finding of the whirlpool sign is specific for volvulus [15,26-28]. It is important to recognize sonographic features of midgut volvulus because they can help to substantiate the diagnosis in an equivocal UGI study or when US is performed for other indications (eg, evaluation for HPS).

Variant 6: Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.

There are several common causes of intermittent vomiting from birth. In a review of 145 such cases by O'Keeffe et al [30], 43 were due to idiopathic GER, 40 to HPS, 27 to overfeeding, 15 to pylorospasm, 14 to milk allergy, and 1 to gastroenteritis. Other diagnostic possibilities include gastric volvulus and, rarely, gastric ulcers [19,31-33].

The most common cause for intermittent vomiting or regurgitation since birth is GER. The brief passage of gastric contents into the esophagus (GER) is a normal physiologic process that occurs in healthy infants and children. GER disease (GERD) occurs when GER causes complications such as poor weight gain or esophagitis. Competence of the lower esophageal sphincter is based on anatomic and physiologic factors that are not completely understood. The sphincter mechanism is not fully mature for at least the first 6 weeks of life. This explains the decrease incidence of GER after infancy. There is no consensus on the optimal workup of GER and the significance of a

"positive" test [20]. In children with GER that are otherwise healthy, imaging is usually not necessary.

Variant 6: Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.
A. Fluoroscopy contrast enema

There is no relevant literature to support the use of contrast enema in the evaluation for GER.

Variant 6: Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.
B. Fluoroscopy upper GI series

Clinical practice guidelines on GER from 2001 [2] state that the sensitivity, specificity, and positive predictive values of a UGI series range from 31% to 86%, 21% to 83%, and 80% to 82%, respectively, when compared to esophageal pH monitoring. The recent clinical practice guidelines from the North American and European Societies for Pediatric Gastroenterology, Hepatology, and Nutrition state that UGI is not useful for diagnosing GER but can help exclude or confirm anatomic abnormalities that cause symptoms similar to GER [34]. The brief duration of the UGI series results in false-negative results for GER, whereas the frequent occurrence of nonpathological reflux results in false-positive results. Thus, the UGI series is not a useful test to reliably determine the presence or absence of GER. In patients with severe or complicated GERD who will be managed with gastrostomy tube placement and Nissen fundoplication or with gastrojejunostomy tube, the UGI is useful to exclude anatomic abnormalities, such as esophageal stricture or malrotation, that would need to be addressed at the time of surgery.

Variant 6: Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.
C. Nuclear medicine gastroesophageal reflux scan

Reflux scintigraphy can be performed using Tc-99m sulfur colloid or Tc-99m DTPA or Tc-99m MAA mixed in a feeding. Seibert et al [35] noted reflux scintigraphy to be 79% sensitive when compared to a 24-hour pH esophageal probe as a standard. Methodology and interpretation criteria for reflux scintigraphy are not uniform from center to center [36,37]. Several studies have tried to standardize the methodology of the examination. A 1-hour scintigraphic study formatted in 60-second frames provides a quantitative representation of postprandial GER for children, particularly in the absence of rapid gastric emptying [38]. False-negative examinations can be associated with delayed gastric emptying, and in this patient group, prolongation of the study beyond 60 minutes or confirmatory pH probe evaluation may be advisable. Othman [39] proposes that placing the patient in multiple positions during the scan results in a percentage yield of a positive study that is 3-fold that of the conventional supine position technique.

In a series of symptomatic and asymptomatic preterm infants who had reached 32 to 34 weeks postconceptual age, reflux scintigraphy demonstrated a high incidence of reflux in both groups that did not correlate with symptoms [40]. Use of this examination thus may be limited to patients older than 3 months of age in which other modalities have excluded an anatomic cause for feeding disorders [35,41,42].

Variant 6: Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.
D. Radiography abdomen

There is no relevant literature to support the use of radiographs in the evaluation for GER.

Variant 6: Infant with nonbilious vomiting, and otherwise healthy (suspected uncomplicated esophageal reflux). Initial imaging.
E. US abdomen (UGI tract)

There is no relevant literature to support the use of US in the diagnosis of reflux, and inconsistent results are reported with sensitivity ranging from 38% to 100% [43-47]. US diagnosis of reflux is made by visualizing water placed into the stomach refluxing into the distal esophagus. However, there is no standardization of the study, and the amount of water and duration of observation varies.

Variant 7: Infant older than 2 weeks and up to 3 months old. New onset nonbilious vomiting (suspected hypertrophic pyloric stenosis). Initial imaging.

A. Fluoroscopy contrast enema

There is no relevant literature to support the use of contrast enema for evaluation of HPS.

Variant 7: Infant older than 2 weeks and up to 3 months old. New onset nonbilious vomiting (suspected hypertrophic pyloric stenosis). Initial imaging.
B. Fluoroscopy upper GI series

Though the UGI series is excellent for diagnosing obstructive causes of vomiting in this age group, it is less ideal than US as an initial imaging test if HPS is a strong consideration [48,49].

When doing a UGI for evaluation of HPS, one can note the mass impression of the hypertrophied pyloric muscle on the barium-filled antrum ("shoulder sign") or the filling of the proximal pylorus ("beak sign") or the entire elongated pylorus ("string sign") with barium [4]. Because of the delayed gastric emptying present in cases of HPS, the beak and string signs can be difficult to document, often requiring considerable fluoroscopic time [3,4].

Variant 7: Infant older than 2 weeks and up to 3 months old. New onset nonbilious vomiting (suspected hypertrophic pyloric stenosis). Initial imaging.
C. Nuclear medicine gastroesophageal reflux scan

If all other causes of vomiting have been excluded, reflux scintigraphy using Tc-99m sulfur colloid may be useful for functional evaluation of gastric emptying, although such patients are typically older than 3 months of age when scintigraphy is requested.

Variant 7: Infant older than 2 weeks and up to 3 months old. New onset nonbilious vomiting (suspected hypertrophic pyloric stenosis). Initial imaging.
D. Radiography abdomen

Abdominal radiographs may show gastric distension with HPS. On occasion, the stomach appears shaped like a "caterpillar" because of peristalsis against the obstructed pylorus and, less commonly, mass impression of the thickened pyloric muscle on an air-filled gastric antrum may be noted [50]. However, radiographs are most often not helpful in HPS diagnosis and are usually nonspecific in cases of GER or gastroenteritis.

Variant 7: Infant older than 2 weeks and up to 3 months old. New onset nonbilious vomiting (suspected hypertrophic pyloric stenosis). Initial imaging.
E. US abdomen (UGI tract)

US is highly accurate method for diagnosing HPS with sensitivity, specificity, and accuracy of 100% [46]. US allows real-time imaging of the pyloric muscle and channel. The diagnosis of HPS is based on imaging of a constant elongated, thick-walled pylorus with no passage of gastric content. The diagnosis is supported by measurements of pyloric channel length and muscle thickness [30,31,41,45,51]. Muscle thickness of ≥4 mm with a length of >18 mm are considered positive for HPS, but measurements between 3 and 4 mm may also be positive, particularly in the premature or younger neonate [52]. Muscle thickness measurement may be obtained on transverse or longitudinal views of the pylorus [45]. In a few patients, there is overlap of these measurements, most notably between patients with pylorospasm and patients with evolving HPS. Diagnostic caution with careful clinical follow-up has been suggested for the diagnosis of pylorospasm to avoid the possibility of underdiagnosing cases evolving into HPS [53]. Pylorospasm is said to be the most common cause of gastric outlet obstruction in this age group, and it is treated conservatively [31]. Imaging is recommended to be performed over a period of time so that the diagnosis of HPS is not made erroneously.

Summary of Highlights

- **Variant 1:** Radiography abdomen is usually appropriate for the initial imaging of an infant vomiting within the first 2 days after birth and with poor feeding or no passage of meconium.
- **Variant 2:** Fluoroscopy UGI series may be appropriate for the next imaging study of an infant vomiting within the first 2 days after birth and with radiographs that show classic double bubble or triple bubble with little or no gas distally (suspected proximal bowel obstruction or atresia).
- **Variant 3:** Fluoroscopy contrast enema is usually appropriate for the next imaging study of an infant vomiting within the first 2 days after birth with radiographs that show a distal bowel obstruction.
- **Variant 4:** Fluoroscopy UGI series is usually appropriate for the next imaging study of an infant who has bilious vomiting within the first 2 days after birth and with radiographs showing a nonclassic double bubble with gas in the distal small bowel or few distended bowel loops or a normal bowel gas pattern.
- **Variant 5:** Fluoroscopy UGI series is usually appropriate for the initial imaging of an infant older than 2 days (suspected malrotation) with bilious vomiting. The panel did not agree on recommending radiography abdomen for this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from radiography abdomen for this clinical scenario. This procedure in this patient population is controversial but may be appropriate.
- **Variant 6:** Fluoroscopy UGI series may be appropriate for the initial imaging of an infant with nonbilious vomiting and otherwise healthy (suspected uncomplicated esophageal reflux). The panel did not agree on recommending nuclear medicine GER scan for this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from nuclear medicine GER scan for this clinical scenario. This procedure in this patient population is controversial but may be appropriate.
- **Variant 7:** US abdomen (UGI tract) is usually appropriate for the initial imaging of an infant older than 2 weeks and up to 3 months old with a new onset nonbilious vomiting (suspected HPS).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv

☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

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