Evidence-Based Management Of Neonatal Vomiting In the Emergency Department

Abstract

Vomiting accounts for up to 36% of neonatal visits to the emergency department. The causes of vomiting can range from benign to life-threatening. Evidence to guide the diagnosis and management of neonatal vomiting in the emergency department is limited. History and physical examination are extremely important in these cases, especially in identifying red flags such as bilious or projectile emesis. A thorough review is presented, discussing various imaging modalities, including plain abdominal radiography, upper gastrointestinal series, ultrasonography, and contrast enema. A systematic approach in the emergency department, as outlined in this review, is required to identify the serious causes of vomiting in the neonate.

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CME Objectives

Upon completion of this article, you should be able to:
1. Recognize the significance of bilious emesis in the neonate.
2. Differentiate the most appropriate diagnostic tests to order in the vomiting neonate based upon history and physical examination.
3. Develop a treatment plan for the vomiting neonate with suspected GERD.

Prior to beginning this activity, see “Physician CME Information” on the back page.
Case Presentations

A 3-week-old boy with emesis is brought to the ED by his parents. He has had persistent nonbilious vomiting occurring after nearly every feed for the past 2 weeks. The parents have changed his formula 3 times, but there has been no change in symptoms. Although the baby has gained weight, he has not gained as expected. No fever has been noted. The remainder of the review of systems is negative. On physical examination, the patient is well-appearing and is not dehydrated. His abdomen is soft, nontender, and nondistended. You observe a brief episode where he arches his back, grimaces, and seems to “tighten up” while lying supine. Considering all the possible diagnoses, you debate what your workup should be...

A 2-day-old girl is then brought to the ED by her parents. The infant has had 5 episodes of vomiting that day. The mother reports that the vomit has changed from the color of colostrum to a green color. The mother and baby had an uncomplicated delivery and were discharged from the hospital earlier that day. The infant passed meconium on day 1 of life and has had 5 wet diapers since birth. The mother has noted that the infant has not been as vigorous when attempting breastfeeding since that morning. The remainder of the review of systems is negative. The physical examination reveals a lethargic neonate who reacts minimally to examination. Her abdomen is distended with quiet bowel sounds, and a slight whimper is elicited with palpation. The patient appears dehydrated, and there is a light green stain on the mother’s shoulder from the emesis. You tell the patient’s mother that you have concerns and that you need to work fast to uncover the cause of her vomiting. What can be the cause of vomiting in this neonate? All bilious emesis is bad, right? Should you call the surgeon right away, or wait until you have the diagnosis? Should you get an x-ray, an ultrasound, or a UGI study?

A 4-week-old boy is sent to the ED after being seen in his pediatrician’s office for vomiting and weight loss. He is noted to have lost 8 ounces since his last office visit 1 week prior. His mother reports that, for the past 2 weeks, he has been spitting up, it has become progressively more frequent, and is now forceful. She states that the color of the emesis is the formula she has been feeding him, and the vomiting occurs after every feed. He still has 4 to 5 wet diapers per day and no diarrhea. The remainder of the review of systems is negative. On physical examination, you find a sleeping neonate who reacts to the examination by crying. You notice that he does not produce many tears and his diaper is dry. On abdominal examination, you palpate a possible small mass in the right upper quadrant, but the baby moves frequently, and the examination is difficult to reproduce. The remainder of the examination is noncontributory. As you think about the orders you want to place, you wonder if a set of electrolytes would be helpful. Should you attempt a bedside ultrasound? Which test is first-line – an ultrasound or a UGI study?

Introduction

Vomiting in the neonate is a common presenting complaint in the emergency department (ED), with etiologies ranging from benign to life-threatening. Vomiting and feeding difficulties have been reported in 11% to 36% of neonates who visit the ED.1,2 Vomiting (particularly bilious emesis) must be considered a surgical emergency until proven otherwise. The incidence of bilious emesis indicative of a surgical obstruction is reported to be between 20% and 38%.3-7 A timely and accurate diagnosis is the key to successful management.8 Determining the etiology of vomiting in the neonate can be difficult and may involve multiple imaging modalities as well as consultation with subspecialists. This review will focus on the evaluation and treatment of neonates with gastrointestinal causes of vomiting, particularly the life-threatening etiologies.

Critical Appraisal Of The Literature

A literature search was performed in PubMed and Ovid MEDLINE®, using the search terms vomiting, neonate, bilious, emesis, gastroesophageal reflux disease, GERD, malrotation, midgut volvulus, Hirschsprung disease, hypertrophic pyloric stenosis, necrotizing enterocolitis, and incarcerated inguinal hernia. Significant, well-designed, randomized controlled trials and meta-analyses were included as well as older publications that have been frequently referenced in the medical community. A search of the Cochrane Database of Systematic Reviews yielded 1 pertinent publication related to the treatment of neonatal vomiting.9 One relevant review was not included in this issue, as it had been withdrawn from the Cochrane Library because the authors were unable to update the review.10 Guidelines released through the National Guideline Clearinghouse by the American College of Radiology in 201111 and guidelines from the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) in conjunction with the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) in 200912 were reviewed. Both of these guidelines are consensus statements and not systematic, evidence-based guidelines. A search of the American Academy of Pediatrics website did not reveal any clinical practice guidelines on this topic. There is a wide range in the quality of clinical evidence available for the diagnosis and management of neonatal vomiting, with most falling into the moderately strong category. There are limited prospective studies focused on ED management.
**Etiology And Pathophysiology**

Vomiting is the forceful expulsion of gastric contents and may not be normal in the neonate. Vomiting may represent a complete or partial obstruction of the gastrointestinal tract, and, when bilious, should be regarded as a surgical emergency until proven otherwise. Differentiating between vomiting and regurgitation can often be difficult. Regurgitation is often normal in the first 3 months of life and, classically, resolves with time.

In broad terms, the causes of neonatal vomiting can be divided into obstructive and nonobstructive pathologies. Obstructive lesions in neonates can be life-threatening, and understanding the anatomy of the gastrointestinal system helps differentiate between obstructive pathologies of neonatal vomiting. Lesions that are superior to the sphincter of Oddi (such as pyloric stenosis) generally present with nonbilious vomiting. Lesions that are inferior to the sphincter of Oddi (such as malrotation with midgut volvulus) are often associated with bilious vomiting. Of the nonobstructive etiologies, gastroesophageal reflux is most common in the neonatal period. The lower esophageal sphincter is located at the junction between the esophagus and the stomach, and it is under tonic smooth muscle control. Transient lower esophageal sphincter relaxations are believed to be the major mechanism involved in regurgitation resulting in gastroesophageal reflux. Most episodes of reflux resolve by 12 to 14 months of age.

**Differential Diagnosis**

The differential diagnosis for neonatal vomiting is expansive. Due to its broad differential, emergency clinicians need to approach the vomiting neonate in a systematic fashion. Certain elements of the history and physical examination can aid the clinician in distinguishing different etiologies. Table 1 presents differential diagnoses based on obstructive or nonobstructive processes. It is important for the emergency clinician to keep in mind the similarities and differences seen among the wide variety of diagnoses in obstructive and nonobstructive pathologies. A thorough history and careful physical examination will guide the emergency clinician toward elucidating the cause of vomiting in the neonate.

**Obstructive Pathologies**

**Bilious Etiologies**

Obstructive lesions that cause vomiting in the neonate are often considered surgical emergencies and may present with bilious vomiting. Malrotation is a developmental anomaly in which the mesenteric attachment and fixation for the midgut has not developed, leaving the midgut to rotate around the mesenteric vessels. Volvulus occurs when perito-

**Nonbilious Etiologies**

Hypertrophic pyloric stenosis (HPS) is one of the nonbilious obstructive causes of vomiting. HPS causes gastric outlet obstruction, which is usually diagnosed between 2 and 12 weeks of life. It is caused by hypertrophy and hyperplasia of the layers of the pylorus, and it typically presents with projectile nonbilious emesis, although bilious emesis has been reported as well. The incidence of HPS is estimated to be 1 to 8 out of 1000 live births, with a 4:1 male predominance. A history of macrolide use in infants during the first 2 weeks of life has been noted as a risk factor for the development of HPS. A recent study of 880 infants with HPS found a risk ratio of 29.8

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**Table 1. Differential Diagnosis Of Vomiting In The Neonate**

<table>
<thead>
<tr>
<th>Obstructive Pathologies</th>
<th>Nonobstructive Pathologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malrotation with midgut volvulus</td>
<td>Gastroesophageal reflux, gastroesophageal reflux disease</td>
</tr>
<tr>
<td>Intestinal atresias</td>
<td>Overfeeding</td>
</tr>
<tr>
<td>Hypertrophic pyloric stenosis</td>
<td>Feeding intolerance (cow’s milk protein allergy, formula intolerance)</td>
</tr>
<tr>
<td>Incarcerated inguinal hernia</td>
<td>Necrotizing enterocolitis</td>
</tr>
<tr>
<td>Hirschsprung disease</td>
<td>Sepsis/infection/gastroenteritis/gastritis</td>
</tr>
<tr>
<td>Congenital anomalies (meconium ileus and meconium plug syndrome)</td>
<td>Kernicterus</td>
</tr>
<tr>
<td>Intussusception</td>
<td>Inborn errors of metabolism/congenital adrenal hyperplasia</td>
</tr>
<tr>
<td></td>
<td>Increased intracranial pressure</td>
</tr>
<tr>
<td></td>
<td>Toxin exposure</td>
</tr>
<tr>
<td></td>
<td>Nonaccidental trauma</td>
</tr>
</tbody>
</table>
meconium (> 48 h), vomiting, feeding intolerance, distended abdomen, and apathy. Barium enema, rectal suction biopsy, and anorectal manometry are all methods of diagnosis, but these do not typically occur in the ED setting. Diagnosis after the first week of life is associated with more severe presentation. Surgical consultation is required.

Other causes of delayed passage of meconium include meconium ileus and meconium plug syndrome. In the case of meconium ileus, the patient will fail to pass meconium 24 to 48 hours after birth and will develop a distended abdomen and possibly bilious emesis. This is caused by obstruction of meconium in the distal small bowel due to pancreatic insufficiency in altering the content of meconium. Contrast enema is usually both diagnostic and therapeutic, revealing a small-caliber colon. Patients should be evaluated for cystic fibrosis, as meconium ileus can be an early sign of cystic fibrosis. Infants with meconium plug syndrome have a similar presentation as infants with meconium ileus; however, the plug may be passed with digital rectal stimulation, and contrast enema usually reveals a normal colon. Most of these infants are otherwise healthy.

Intussusception is rare in pediatric patients aged < 3 months, with only 1.5% of cases described during this age. Case reports and case series have demonstrated that this condition is often misdiagnosed as necrotizing enterocolitis in neonates. Ultrasound, with or without plain film x-ray studies, is needed for diagnosis, and management is preferably pneumatic (air) over hydrostatic (contrast) enema reduction.

Nonobstructive Pathologies

Gastroesophageal Reflux And Gastroesophageal Reflux Disease
Of the nonobstructive lesions, gastroesophageal reflux is the one of the most common causes of neonatal vomiting. Gastroesophageal reflux is a normal physiologic process, occurring in up to 50% of all infants. Gastroesophageal reflux can be seen as a continuum of symptoms, ranging from mild spit-up to forceful vomiting. In contrast, gastroesophageal reflux disease (GERD) is classified by associated conditions, such as poor weight gain, refusal to feed, irritability, sleep disturbance, or esophagitis. Extrapulmonary conditions may include respiratory symptoms (such as cough, laryngitis, or wheezing). Often, a clinical diagnosis is made, but supporting studies (such as esophageal pH monitoring, upper gastrointestinal [UGI] contrast studies, scintigraphy, and ultrasound) can be of benefit when there is no clear-cut diagnosis. Controversy surrounds therapeutic modalities for GERD, which range from conservative nonpharmacologic measures to pharmacologic measures and, potentially, surgery.
Overfeeding
An important entity to distinguish from GERD is overfeeding. Overfeeding of the neonate results in vomiting simply because the stomach cannot accommodate the amount the caretaker is feeding the infant. An infant can be fed too frequently, not allowing previous feedings to be completely digested, or an infant can be fed too large a quantity at each feeding. This can be determined by questioning the caretaker about the infant’s feeding regimen. It is commonly accepted that the neonate should be fed approximately 2 to 3 ounces every 3 to 4 hours.

Feeding Intolerance
Feeding intolerances should also be considered as a cause of vomiting. Both cow’s milk protein allergy and formula intolerance can also present with diarrhea, occasionally with streaks of blood, abdominal distention, and discomfort. Often, the infant has been trialed on multiple formulas by the time of the ED visit, making pinpointing the offending agent difficult. This diagnosis may involve trial and error on the part of the infant’s pediatrician. While not uncommon, feeding intolerances should be considered a diagnosis of exclusion in the ED setting.

Necrotizing Enterocolitis
Necrotizing enterocolitis is commonly seen in premature infants in the neonatal intensive care setting, but it can also be seen in term newborns. This condition may present with bloody diarrhea, abdominal distention, and vomiting. Radiographs are the gold standard for diagnosis. Management may be medical or surgical, but should involve a surgical consultation for definitive management, based upon Bell staging.42

Sepsis And Infection
Sepsis and infection in the neonate can lead to vomiting. Evaluating the septic neonate involves a systematic approach that is well-established by the literature and for which there is an American College of Emergency Physicians policy statement.43 All infants aged < 28 days with a fever of ≥ 38°C should receive parenteral antibiotics and be admitted to the hospital. Typically, blood, urine, and cerebrospinal fluid samples are obtained and analyzed.43 Urinary tract infection should be considered in the neonate (even in the absence of fever), as vomiting is reported as a presenting symptom of urinary tract infection.44 An infant may also have a viral illness (such as gastritis or gastroenteritis) that can cause neonatal vomiting.

Kernicterus
Kernicterus is another nonobstructive cause of neonatal vomiting. It is a progressive encephalopathy caused by severely elevated levels of bilirubin, which is neurotoxic. A jaundiced neonate should be evaluated early in the course to prevent the development of kernicterus.

Inborn Errors Of Metabolism
Other metabolic conditions that may present with vomiting are inborn errors of metabolism. Most states employ newborn screening for certain metabolic conditions, but the results may not be known immediately. Congenital adrenal hyperplasia is a metabolic disease affecting the production of cortisol from cholesterol. It can be detected by laboratory results and is often brought to the pediatrician’s attention because of an abnormal newborn screen. These patients may initially present to the ED with vomiting and can appear seriously ill and dehydrated. A key to diagnosis is electrolyte abnormalities, including hyperkalemia, hyponatremia, and hypoglycemia.

Increased Intracranial Pressure
A less common cause of neonatal vomiting (but a potentially deadly one) is increased intracranial pressure. This may be due to hydrocephalus, central nervous system tumor, head trauma, meningitis, or hemorrhage. A careful history and physical examination may lead to consideration of one of these causes.

Other Nonobstructive Etiologies
Every emergency clinician should include exposure to toxins and nonaccidental trauma in the differential when evaluating neonates with vomiting. Often, a high degree of suspicion is necessary to make these diagnoses.

Prehospital Care
Vomiting in the neonate is often a frightening experience for the caregiver and may prompt a call to local emergency medical services (EMS) for evaluation. As there are life-threatening conditions that may need to be addressed, prehospital care should be aimed at efficient stabilization and safe transport. The severely dehydrated neonate may benefit from placement of an intravenous line and initiation of fluid replacement therapy. If there is altered mental status and concern for hypoglycemia, this should be assessed and remedied quickly. The most important aspect of the EMS system in this case is transporting the patient to the closest and most appropriate facility capable of caring for the neonate.

Emergency Department Evaluation
The main goals of the ED evaluation are to correctly identify patients with causes of vomiting that should be managed surgically and patients with causes of vomiting that can be appropriately managed nonsurgically. A thorough history and a focused physical examination are the key components to this assessment.
History

Quality Of Emesis

In the stable neonate, the emergency clinician should proceed with evaluation of the chief complaint with specific questions focused on the duration and details of the vomiting. Of utmost importance is the determination of the quality of the emesis. This is best done by asking the caregiver the color of the emesis and not prompting them with the term “bilious,” as one study demonstrated that most parents equated bile with the color yellow.\(^4^6\) The identification of bilious vomiting is critical, as the chance of surgical obstruction is higher. Several studies have evaluated outcomes of neonates with bilious vomiting. Godbole and Stringer prospectively evaluated 63 consecutive neonates admitted for bilious vomiting and identified a surgical cause in 24 of the patients (38\%).\(^7\) In another retrospective review by Malhotra et al, 61 infants with bilious vomiting were admitted, and 14 patients (23\%) had causes of vomiting that required surgery.\(^3\) Lilien et al studied neonates with bilious vomiting in the first 72 hours of life and found that 20% had a lesion requiring surgical intervention.\(^5\)

Determining whether the emesis is projectile or progressively worsening may guide the clinician toward an evaluation for pyloric stenosis. Of patients diagnosed with HPS, several studies have shown projectile vomiting to be present in 66% to 84% of cases.\(^2^2,2^3,4^7\)

Feeding Patterns

Details regarding the patient’s feeding patterns, both the amount per feeding and the intervals between feeds, are pertinent to the history. This can aid in determining whether a patient may have vomiting due to overfeeding.

Growth

Reviewing the patient’s birth weight as compared to the current weight on a growth curve may help to establish a pattern of insufficient growth. This may be due to lack of caloric intake related to vomiting (as in the case of patients with GERD).

Gastroesophageal Reflux Disease

Obtaining further history of feeding refusal, irritability, back arching, sleep disturbance, and respiratory symptoms could aid in the clinical diagnosis of GERD. One complication of GERD is Sandifer syndrome, in which infants can have episodes of torticollis, head-eye version, and dystonic posturing often confused with seizure disorder. This occurs in \(< 1\%\) of patients with GERD, and usually resolves when GERD is treated.\(^4^8\)

Hydration Status, Urine Output, And Stooling

Caregivers should be questioned regarding the patient’s hydration status, particularly the urine output. The presence of fever or similar symptoms in other family members may indicate an infectious etiology. The patient’s stooling habits should be discussed with the caregivers: Has meconium passed in the newborn? Is there blood in the stool? Is constipation a problem? Green, yellow, and brown stools can be considered normal in newborns, and formula-fed babies may have fewer and more-solid stools compared to breastfed infants who may have more frequent and looser stools.

Physical Examination

Vital signs (heart rate, respiratory rate, blood pressure, temperature, and oxygen saturation) should be obtained on all patients with vomiting. The patient should be weighed without clothes to obtain an accurate measurement. The neonate should be evaluated for signs of toxicity, such as overall appearance, work of breathing, and perfusion, and abnormalities should be attended to with urgency. Jaundiced skin should prompt emergency clinicians to evaluate for causes of hyperbilirubinemia. A full or bulging fontanelle may be the only subtle sign of elevated intracranial pressure, as a comprehensive neurologic examination on a neonate is often limited by the inability of the patient to cooperate and follow commands. Careful examination for signs of dehydration, such as a sunken fontanelle, absence of tears with crying, poor capillary refill, and decreased skin turgor, should be performed.

The abdominal examination is essential in all neonates with vomiting. A distended abdomen is more likely to be present in patients with a surgical cause of vomiting. Chen et al found that 61.8% of full-term newborns with abdominal distension had a congenital malformation (including congenital megacolon, anal atresia, malrotation, and intestinal atresia).\(^4^9\) Emergency clinicians should assess for hepatomegaly on abdominal examination, as this can be associated with some inborn errors of metabolism. In patients with HPS, a palpable olive-sized mass in the right upper quadrant is reported in 50% to 83% of cases.\(^2^2,2^8,2^9\)

A complete physical examination includes evaluation of the groin and genitalia. An incarcerated inguinal hernia can be seen as a hard mass overlying the inguinal canal. It may be erythematous, and it is usually tender to palpation. In female infants with congenital adrenal hyperplasia, the genitalia may be ambiguous. In the case of reported constipation or bloody stool, the emergency clinician can perform a rectal examination to assess rectal tone and the presence or absence of stool in the vault and perform a visual inspection for blood, as may be the case in necrotizing enterocolitis or intussusception. In the case of Hirschsprung disease, a classic rectal examination reveals no stool in the rectum, with explosive
discharge of foul-smelling gas upon removal of the examiner’s digit.\textsuperscript{50} Serial examinations and observation of a feeding may help identify diagnoses such as overfeeding. Emergency clinicians should also examine the patient for subtle signs of nonaccidental trauma possibly related to head or abdominal trauma.

### Diagnostic Studies

There are multiple diagnostic modalities used in the evaluation of a neonate with vomiting. Choosing the most appropriate study based upon basic historical and physical examination features will facilitate management of the patient.

#### Bedside Tests

If the vomiting neonate is difficult to arouse, a point-of-care glucose is warranted; appropriate interventions depend on the results. A urine dipstick test can aid in assessing for signs of infection and dehydration. If the emergency clinician has access to bedside point-of-care arterial blood gas and electrolyte testing, this can be helpful in assessing infants who are toxic or ill-appearing.

#### Laboratory Studies

There is no single laboratory test that will elucidate the etiology of vomiting. It is generally recognized that certain patterns of electrolytes may accompany particular diagnoses. The most well-known is the hypokalemic, hypochloremic, metabolic alkalosis of HPS.\textsuperscript{51} However, 2 studies have demonstrated that the majority of patients presenting with HPS have normal electrolytes.\textsuperscript{52,53} This may be attributed to earlier age at diagnosis, as Tutay et al confirmed that patients who were diagnosed later in life were more likely to have electrolyte abnormalities.\textsuperscript{53} In an effort to distinguish severe GERD from HPS, one study examined serum electrolytes and determined that a serum bicarbonate level > 29 mmol/L and a chloride level < 98 mmol/L had high positive predictive values (0.96 and 0.97, respectively) and specificity (0.99 for both), but low sensitivity (0.36 and 0.50, respectively).\textsuperscript{54} Patients who are significantly dehydrated may only show abnormalities of metabolic acidosis or may have an elevated blood urea nitrogen (BUN)/creatinine ratio, typically > 20. Another pattern of electrolytes to consider is hyperkalemia, hyponatremia, and hypoglycemia in patients with congenital adrenal hyperplasia. This diagnosis is typically made with newborn screening, but this should be considered in an infant presenting with vomiting and this pattern of electrolytes. For the patient who is well-appearing and well-hydrated, electrolytes are expected to be normal, and these tests are not usually necessary.

### Radiographic Imaging Studies

#### Bilious Emesis

Unlike laboratory studies, radiographic studies are the key to determining the etiology of vomiting in the neonate. Bilious vomiting in the neonate should be regarded as a surgical emergency, and it requires further radiographic evaluation for diagnosis confirmation. However, surgical consultation should not be delayed for diagnostic studies in an unstable neonate with bilious vomiting.

The American College of Radiology guidelines for evaluation of neonatal bilious emesis suggest obtaining abdominal radiographs in all patients, but, even if they are negative, pursuing a UGI contrast study is warranted.\textsuperscript{11} The sensitivity and specificity of plain abdominal radiographs for obstruction in the presence of bilious emesis have been reported to be 44\% to 50\% and 80\% to 97\%, respectively, indicating that > 50\% of cases would be missed based on radiographs alone.\textsuperscript{3,55} When an obstructive pattern is present, radiographs are most helpful, but they cannot provide a definitive diagnosis, and other studies will be needed.\textsuperscript{12} In the case of necrotizing enterocolitis, the gold standard for diagnosis is abdominal radiographs. Bell staging of the disease is based on radiographic results that will dictate therapeutic decisions.\textsuperscript{56}

The UGI contrast study is likely to be the most conclusive study in the case of bilious emesis. It is the gold standard for diagnosis of malrotation with midgut volvulus as for intestinal atresias, and it can suggest the diagnosis of meconium ileus. The findings seen on a UGI study for malrotation with midgut volvulus are: (1) obstruction seen high in the gut; (2) abnormal duodenojejunal junction; and (3) abnormal position of the proximal jejunal loops to the right of midline.\textsuperscript{55} (See Figure 2.) The UGI study

#### Figure 2. Malrotation On Upper Gastrointestinal Study

A. Graphic representation of anatomic abnormality encountered in malrotation. B. Appearance of A on upper gastrointestinal study.

is not without flaws, however, as both false-positive (15%)\textsuperscript{56,57} and false-negative (3%-6%)\textsuperscript{56,58,59} rates have been reported. The most common reason for an inaccurate reading is an abnormal jejunal position.\textsuperscript{60} In one trial, 41% of patients with a preoperative diagnosis of malrotation had discrepant findings at diagnostic laparoscopy.\textsuperscript{61}

Although the UGI has been well established as the gold standard for evaluation of bilious emesis, it does have its disadvantages, including exposure to ionizing radiation and contrast administration, which may require nasogastric tube placement.\textsuperscript{55} Despite its inadequacies, UGI studies are still superior to barium enema, which often has false-positive results in infants due to a mobile cecum (which can be a normal finding in infants).\textsuperscript{55}

Another modality for evaluation of bilious emesis is the contrast enema. For detection of malrotation, the contrast enema is inferior to UGI. In one study, 17% of patients with malrotation underwent contrast enema that was reported as inconclusive, and a confirmatory UGI was necessary.\textsuperscript{52} The contrast enema can be used as a screening tool for Hirschsprung disease, however. The presence of a “transition zone” in the rectosigmoid colon and delayed evacuation of barium are considered highly suggestive of Hirschsprung disease. The sensitivity for barium enema in Hirschsprung disease is reported to be 70% to 80% with specificity ranging from 64% to 76%.\textsuperscript{63-65} Bilious emesis and the absence of a transition zone are risk factors for false-positive results of contrast enema.\textsuperscript{66} In the case of inconclusive enema, anorectal manometry and rectal suction biopsy are regarded as the most accurate tests for Hirschsprung disease,\textsuperscript{55,67} but these are not usually undertaken in the ED setting.

**Nonbilious Emesis**

**Hypertrophic Pyloric Stenosis**

The major gastrointestinal causes of nonbilious emesis are HPS and GERD. It can be difficult to differentiate an infant with early HPS from an infant with gastroesophageal reflux. Consideration should be given to the diagnosis of HPS in infants with progressively worsening episodes of vomiting. Ultrasonography is currently regarded as the gold standard for diagnosis of HPS, and it was first described in 1977 by Teele.\textsuperscript{68} During an ultrasound for HPS, measurements are taken of the pyloric channel length and thickness. (See Figure 3.) In general, pyloric measurements of ≥ 15 mm (length) and ≥ 3 mm (wall thickness) are considered positive for HPS.\textsuperscript{69} Sensitivity of ultrasonography for HPS is reported to be 97% to 100%, with a specificity of 100%.\textsuperscript{70-72} It has been suggested that the measurement criteria should be altered for patients aged < 21 days, as, initial sonographic evaluation of these patients is often normal or borderline.\textsuperscript{73} An advantage of ultrasonography is that it is easily repeated and is cost-effective for

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**Figure 3. Ultrasound Of Hypertrophic Pyloric Stenosis**

A. Muscle wall thickness; B. Channel length.

tom scores in the clinical diagnosis of GERD. They used back arching, choking, gagging, episodes of hiccups, irritability/fussiness, refusal to feed, vomiting, and regurgitation as symptoms. They found that infants with GERD had more severe symptoms than the controls for all symptoms except refusal to feed and irritability/fussiness.

For the workup of potential GERD, a number of imaging modalities exist, but a good clinical history and physical examination are most useful. The studies are nonurgent and not expected to be performed in the ED, but rather in conjunction with the pediatrician on an outpatient basis. The emergency clinician should be aware of the diagnostic options to enable proper discussion with the caregivers. There is no consensus on the diagnostic study of choice for the diagnosis of GERD. Diagnostic options include esophageal pH monitoring, UGI study, multichannel intraluminal impedance monitoring, gastroesophageal scintigraphy, ultrasonography, and endoscopy. The most common diagnostic methods are UGI study, pH monitoring, and endoscopy. The American College of Radiology guidelines for evaluation of the vomiting neonate recommend that the gold standard for diagnosing GERD is the esophageal pH probe. Again, these diagnostic tests are not typically performed in the ED, but may be part of an inpatient or outpatient workup for GERD, depending on the patient’s needs.

**Treatment**

Initial treatment of the vomiting neonate in the ED is focused on stabilization of airway, breathing, and circulation. Placement of an intravenous line to deliver fluid for restoration of fluid balance may be indicated. If a peripheral intravenous line cannot be placed quickly, the emergency clinician should consider placement of an intravascular or umbilical line. The criteria for placing an umbilical line include a patient aged < 2 weeks and no signs of infection around the umbilical stump. Prompt diagnosis and treatment of hypoglycemia is warranted. There is controversy over what is considered hypoglycemia in the neonate, and levels have been established based on the patient’s number of hours of life. A meta-analysis by Alkalay et al demonstrated that, after 48 hours, the cutoff for the fifth percentile of neonatal blood glucose was 48 mg/dL. It is recommended that infants should be given 2 mL/kg of 10% dextrose in water (D10W) as a bolus, with glucose measurements repeated every 10 to 15 minutes until normalized. This is a smaller dose of glucose than is typically given, in an attempt to avoid hyperglycemia. Electrolyte abnormalities may be recognized from basic blood work and should also be remedied, particularly before the patient undergoes any surgical procedures.

The particular diagnosis reached after thorough investigation will mandate what therapies are necessary. This review will approach treatment in 2 broad categories: (1) obstructive management and (2) nonobstructive management.

**Management Of Obstructive Etiologies**

**Malrotation With Midgut Volvulus**

When the emergency clinician suspects the diagnosis of malrotation with midgut volvulus, the most important next step is to consult the pediatric surgeon, since bowel necrosis is correlated with increased mortality. A nasogastric tube should be placed to decompress the proximal bowel obstruction created by the malrotation. Intravenous fluid resuscitation and maintenance are critical, and the patient should be placed on NPO (nothing by mouth) status. Surgical correction of the gut anomaly is undertaken through the Ladd procedure. This procedure was first reported in 1936, and involves reduction of volvulus, division of mesenteric bands, replacement of the small bowel on the right and the large bowel on the left side of the abdomen, and appendectomy. Recent retrospective studies have looked at open versus laparoscopic Ladd procedure and concluded that the laparoscopic procedure is the therapy of choice, as it has no increase in complications or operative time, and the time to return to full feeds and length of hospital stay are shorter.

**Hypertrophic Pyloric Stenosis**

The initial treatment of HPS is correction of any electrolyte abnormality prior to surgical procedure, in order to minimize risks associated with anesthesia. Once the patient is stabilized, pyloromyotomy is performed by a surgeon, during which an incision is made through the layers of the pylorus, effectively relieving obstruction. Multiple meta-analyses have been performed comparing laparoscopic versus open techniques for pyloromyotomy. For time-related outcomes, a laparoscopic approach is preferred, but there are, otherwise, no significant differences in results. Interestingly, a study was completed looking at postoperative outcomes in patients who had a nasogastric tube placed preoperatively. Patients with nasogastric tube placement had a significantly higher number of postoperative episodes of vomiting and a longer length of stay.

**Incarcerated Inguinal Hernia**

Incarcerated inguinal hernia is a diagnosis requiring prompt recognition and the involvement of pediatric surgeons to optimize bowel salvage. Typically, history and physical examination are all the emergency clinician needs to diagnose this entity. Manual reduction should be attempted in the ED with or without the pediatric surgeon present. One study found that manual reduction is successful in 96% of patients. One technique of reduction is to apply
Clinical Pathway For Management Of Neonatal Vomiting In The Emergency Department

Neonate presents with vomiting

Stabilize airway, breathing, and circulation

Bilious emesis?

YES

NO

Projectile vomiting or suspicion of HPS?

YES

Obtain ultrasound (Class I)

NO

Obtain plain abdominal films (Class II) and/or UGI contrast study (Class I)

Stable patient?

YES

NO

Obstruction?

YES

NO

Consult pediatric surgeon, who will obtain additional diagnostic studies as needed

Consider nonsurgical causes of vomiting and admission for observation

Obstructed patient?

YES

NO

Consider nonsurgical causes of vomiting and admission for observation

Symptoms consistent with GERD?

YES

• Counsel caregivers on nonpharmacologic treatment
• Consider H2 blocker
• Ensure close follow-up with primary care physician

Discharge home
• Ensure close follow-up with primary care physician
• Counsel caregivers on symptoms warranting return to ED

Stable patient?

YES

NO

Ultrasound positive for HPS?

YES

Consult pediatric surgeon, who will obtain additional diagnostic studies as needed

Persistent vomiting?

YES

NO

Obstructed patient?

YES

NO

Consult pediatric surgeon, who will obtain additional diagnostic studies as needed

Consider nonsurgical causes of vomiting and admission for observation

NO

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient’s individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Abbreviations: ED, emergency department; GERD, gastroesophageal reflux disease; HPS, hypertrophic pyloric stenosis.

Class Of Evidence Definitions

Each action in the clinical pathways section of Emergency Medicine Practice receives a score based on the following definitions.

Class I
• Always acceptable, safe
• Definitely useful
• Proven in both efficacy and effectiveness

Level of Evidence:
• One or more large prospective studies are present (with rare exceptions)
• High-quality meta-analyses
• Study results consistently positive and compelling

Class II
• Safe, acceptable
• Probably useful

Level of Evidence:
• Generally higher levels of evidence
• Nonrandomized or retrospective studies: historic, cohort, or case control studies
• Less robust randomized controlled trials
• Results consistently positive

Class III
• May be acceptable
• Possibly useful
• Considered optional or alternative treatments

Level of Evidence:
• Generally lower or intermediate levels of evidence
• Case series, animal studies, consensus panels
• Occasionally positive results

Indeterminate
• Continuing area of research
• No recommendations until further research

Level of Evidence:
• Evidence not available
• Higher studies in progress
• Results inconsistent, contradictory
• Results not compelling

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pressure with one hand along the proximal inguinal canal and use the other hand to push the gas or contents back with gentle pressure. Pressure should be increased over the distal aspect of the hernia to reduce the bowel. Some emergency clinicians will provide analgesia and/or sedation for this procedure. No guidelines exist for medication choices. Previously, after manual reduction, there was a waiting period of 24 to 48 hours prior to open herniorrhaphy to allow time for edema to subside. Now, authors are advocating for laparoscopic herniorrhaphy sooner after manual reduction. Nonetheless, outcome measures have indicated that the laparoscopic technique requires more operating room time and patients have more postoperative pain. Open herniorrhaphy remains the mainstay of therapy if surgical correction is warranted.

**Intestinal Atresias**

Intestinal atresias, once recognized, need to be surgically corrected. The emergency clinician should refer the patient for surgical consultation. Traditionally, the lesion is repaired with transverse supraumbilical laparotomy with exteriorization of the bowel and excision of atretic ends, followed by anastomosis of the remaining bowel. As with a number of surgical lesions, trials of laparoscopic management have been undertaken. Small, early case series have demonstrated comparable postoperative courses (when compared to open surgery) and improved satisfaction with cosmetic results.

**Hirschsprung Disease**

Once the diagnosis of Hirschsprung disease is made and the patient is referred to the surgeon, the surgical management varies widely, depending upon the capabilities of the surgeon and the treating facility. The procedures all accomplish a similar goal of resecting the aganglionic segment of colon and reuniting the remaining bowel. This can occur by creating a diverting colostomy with delayed definitive repair until the child is of larger size, or by a single-stage pull-through with anastomosis. A 2009 meta-analysis found no operative technique to be superior with respect to perioperative outcomes, including mortality, morbidity, rate of enterocolitis, and functional outcome.

**Intussusception**

Intussusception, while rare in the neonatal period, is managed in the same fashion as in older children. A recent meta-analysis of 5559 patients determined that pneumatic enema reduction of intussusception is preferred to contrast enema, as there were significantly fewer failed attempts in patients without operative indications. Studies of older patients have demonstrated that there is no need to admit patients after reduction and that a short observation period in the ED for toleration of oral trials and pain control is adequate. No studies have been completed on postreduction management of neonates with intussusception. For more information on pediatric intussusception, see the January 2012 issue of *Pediatric Emergency Medicine Practice* titled "The Young Child With Lower Gastrointestinal Bleeding Or Intussusception," available at: www.ebmedicine.net/intussusception.

**Management Of Nonobstructive Etiologies**

**Gastroesophageal Reflux Disease**

The emergency clinician is likely to encounter patients with GERD, and, therefore, understanding its management is pertinent. Numerous efforts have been made to attempt to control the symptoms of GERD, but few, if any, have proven effective. Interventions for GERD can range from conservative to pharmacological to surgical. Patients with the suspected diagnosis of gastroesophageal reflux are managed with reassurance and recommendations for close follow-up of symptoms of GERD. The emergency clinician should keep in mind that this is a normal occurrence in most neonates. Neonates with GERD may need to be started on pharmacotherapy or be admitted for further evaluation.

**Nonpharmacologic Treatment**

The emergency clinician can counsel caregivers on some of the more conservative approaches to managing GERD. The most frequently studied intervention for GERD is that of thickening the infant’s feeds, if the infant is aged > 4 weeks. A meta-analysis reports that this is moderately effective at reducing symptoms. Caregivers can thicken feedings by adding dry rice cereal or changing to commercially thickened formulas. Unfortunately, this does not decrease the index measures of reflux, but it does decrease clinical regurgitation. Studies have shown that thickening feeds results in a decrease in the total number of reflux episodes, slows gastric emptying times, and decreases the amount of time infants spend crying. Other thickening agents added to formulas and proven to decrease symptoms are cornstarch and locust bean gum.

Another nonpharmacologic strategy for GERD treatment is adjusting the positioning of the patient during the postprandial period. One study by Shalaby et al found GERD symptoms to improve in 24% of infants after 2 weeks of avoiding overfeeding and avoiding seated or supine positions. Positions that may benefit the infant with GERD include sitting completely upright and prone. Flat prone positioning is better than flat supine. The amount of reflux seen in the supine position with the head elevated is equal to that of the supine and flat position. Interestingly, the infant car seat position appears to exacerbate reflux symptoms. Prone position-
ing in the postprandial period is recommended for patients with reflux, if the infant is awake and being observed.

There is a small subset of children with GERD occurring as a result of a cow’s milk protein allergy. Vomiting decreased significantly in infants with the elimination of cow’s milk protein from the diet, and reintroduction was shown to cause recurrence of symptoms. The presentations of GERD and cow’s milk protein allergy are very similar, making this diagnosis difficult. The clinician may have heightened suspicion for cow’s milk protein allergy if the patient has frequent diarrhea with mucus and/or blood streaks, or if there are other signs of atopy in the infant. Definitive diagnosis in the ED is not possible with this entity, but, if it is suspected, the patient may need referral to a gastroenterologist and/or allergist for further testing.

Pharmacologic Treatment
When nonpharmacologic treatment fails, pharmacologic management can be considered. The emergency clinician can discuss these options with the caregivers; however, generally, prescription of these medications will be from the patient’s primary care physician. The 2 major classes of pharmacologic agents are acid suppressants and prokinetic agents.

Acid Suppressants
Acid suppressants include histamine-2 (H₂) receptor antagonists and proton pump inhibitors (PPIs), both of which function as antacids.

First-line pharmacologic therapy for GERD is the use of H₂–receptor-blocker medications, such as cimetidine, ranitidine (Zantac®), and famotidine (Pepcid®). In one study, infants given once-daily dosing of ranitidine reduced time of gastric pH < 4 by 44%, and twice-daily dosing reduced time by 90%. A similar study of famotidine showed 0.5 mg/kg/day decreased the frequency of reflux, and doubling the dose also improved crying time and volume of reflux. One randomized trial of infants and children with erosive esophagitis compared cimetidine to placebo and showed significant improvement in clinical and histopathologic scores. Research demonstrates that H₂–receptor-blocker therapy results in clinically significant improvement in GERD symptoms, and a trial is recommended in the neonate with vomiting attributed to this cause when conservative measures have failed.

Another acid suppression medication is the PPI. One study in infants with symptoms suggestive of GERD who were treated empirically with a PPI showed no efficacy over placebo. A systematic review in 2011 concluded that PPIs should not be prescribed for infants with GERD, as they have not been shown to be efficacious in reducing GERD symptoms when compared to placebo, and evidence supporting their safety is lacking. This recommendation is surprising in light of the success reported with PPIs in adults, but this may be attributed to symptoms in adults being more distinct and better expressed than in infants. The studies included in the review were largely subjective, with measurements of GERD based upon questionnaires answered by the caregivers. More trials in infants are necessary in order to change this recommendation.

Acid blockers are not without side effects, which can be a reason to stop their use or to avoid initiation of this therapy. There are documented risks associated with acid suppression, and multiple authors have demonstrated statistically significant evidence of increases in the risk of community-acquired pneumonia (odds ratio [OR] 6.39; 95% CI, 1.38-29.7), gastroenteritis (OR, 3.58; 95% CI, 1.87-6.86), candidemia (OR, 1.76; 95% CI, 1.16-2.66), and even necrotizing enterocolitis (OR, 1.71; 95% CI, 1.34-2.19) in infants.

Prokinetic Agents
Prokinetic agents, such as metoclopramide (Reglan®), facilitate gastric emptying. In 2008, a systematic review of metoclopramide concluded that there is a poor level of evidence to recommend its use, and there are inconclusive safety and efficacy profiles. Twelve studies were included in the review, and, of those, only 5 were blinded randomized controlled trials. Within those 5 studies, one found no difference in scintigraphy during metoclopramide use compared to placebo, and 2 others found no improvement in pH measurements compared to placebo. The remaining 2 studies did demonstrate improvement in gastric emptying rate compared to placebo. A number of studies reported adverse events due to the medication, but incidence could not be calculated due to small study size, frequency of nonblinded study designs, and lack of systematic criteria to define an adverse event. The described side effects included lethargy, irritability, galactorrhea, extra-pyramidal reactions, and tardive dyskinesia.

Surgical Management
When medical management fails, the last option for treatment of GERD is surgical management; however, referral will likely be made by the patient’s primary care physician. The most common surgical procedure performed is Nissen fundoplication. The procedure consists of repair of the esophageal hiatus with plication of the fundus around the esophagus in a 360°-fashion. This can be performed open or laparoscopically without significant differences in complications. One of the most common complications is recurrence of reflux in up to 14% of patients undergoing fundoplication.
Necrotizing Enterocolitis
Necrotizing enterocolitis can present with distended abdomen, bilious or nonbilious emesis, and occasionally bloody stools. Initial assessment and stabilization are key to management. Diagnosis is confirmed with the abdominal radiograph. Treatment is based upon staging indicated by the Bell classification. Medical management consists of intravenous hydration, bowel rest, antibiotics, and serial abdominal radiographs. Surgical management may involve exploratory laparotomy or placement of a peritoneal drain. Typically, pneumoperitoneum is cause for surgical management, but a recent prospective trial concluded that early surgical therapy may be warranted to reduce morbidity and mortality from necrotizing enterocolitis. A Cochrane review and another randomized controlled trial have demonstrated that there is no harm or benefit to choosing peritoneal drain over exploratory laparotomy. There has been a decrease in mortality shown in patients treated with probiotics.

Management of Other Nonobstructive Causes of Neonatal Vomiting
The management of the other etiologies of nonobstructive vomiting (such as reflux), families might encounter after a patient has been discharged home, as well as in full-term infants. Premature infants can represent a very fragile portion of the population that an emergency clinician might encounter after a patient has been discharged home from the neonatal intensive care unit (NICU). While most instances of necrotizing enterocolitis are diagnosed in the NICU, it is important to recognize that it can still occur in patients who are discharged home, as well as in full-term infants.

Premature infants are also at a higher risk of having inguinal hernias that may become incarcerated. The risk in full-term newborns is 3.5% to 5%, but in preterm infants, the risk is 9% to 11%. In very low–birth-weight and preterm (<28 weeks gestation) infants, risk of incarcerated inguinal hernias can approach 30%. There is controversy surrounding when to electively repair these hernias, and, thus, a number of patients are discharged home from the NICU prior to repair and may present with an incarceration.

Special Populations
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Controversies and Cutting Edge
Cutting edge improvements in the care of neonatal vomiting are abundant, and most involve the use of ultrasound. The benefits of ultrasound include the absence of harmful effects of radiation, and the fact that it is readily available, noninvasive, and quick. One small prospective study demonstrated that ultrasound had a 100% positive predictive value in detecting surgical candidates with bilious emesis, but when ultrasound was inconclusive, follow-up radiologic contrast studies were necessary. Ultrasound is capable of diagnosing malrotation with midgut volvulus by identifying the whirlpool pattern of the superior mesenteric vein and mesentery around the superior mesenteric artery. This twisting of the mesenteric vascular structures is best seen on color Doppler imaging. The whirlpool sign has an 88% sensitivity, but it is not considered pathognomonic. A 2011 systematic review concluded that ultrasound is a good screening tool for malrotation, but its false-negative rate (between 15% and 30%) is too high to be conclusive. There are no published studies on the use of bedside ultrasound by emergency clinicians for suspected malrotation.

Ultrasound has also been shown to be diagnostic in cases of necrotizing enterocolitis. Free gas and focal fluid collections have been correlated with cases of necrotizing enterocolitis requiring surgical intervention. Ultrasound has even demonstrated abnormalities in the bowel wall prior to the appearance of these findings on plain abdominal radiography. It can be argued that monitoring the bowel with ultrasonography might help guide management of patients with necrotizing enterocolitis. However, despite these advances, it is still agreed that plain radiographs are the gold standard for evaluation of necrotizing enterocolitis.

Bedside ultrasound techniques performed in the ED are gaining popularity. Sivitz et al demonstrated that pediatric emergency clinicians could identify HPS on bedside ultrasound with 100% sensitivity and 100% specificity. There are currently no studies comparing ultrasound skills of technologists/radiologists to emergency clinicians for suspected malrotation. However, despite these advances, it is still agreed that plain radiographs are the gold standard for evaluation of necrotizing enterocolitis.

Disposition
The disposition of a neonate with vomiting depends upon the suspected diagnosis. Identifying emergent surgical causes of vomiting is extremely important. When a surgical cause is found, patients should be admitted to the hospital with pediatric surgery consultation. An infant who is well-appearing, gaining weight appropriately, and tolerating feeds in the ED is safe for outpatient referral. For nonemergent causes of neonatal vomiting (such as reflux), families...
Risk Management Pitfalls For Neonatal Vomiting

1. “The infant had bilious vomiting and did not look well, but I decided to wait until completion of the diagnostic study before calling the surgeon.”
   In a toxic-appearing neonate with bilious vomiting, the diagnosis of a malrotation with midgut volvulus must be considered. Evaluation by a pediatric surgeon as soon as this diagnosis is suspected is warranted, as bowel necrosis is correlated with increased mortality.

2. “I evaluated a well-appearing infant with a history of vomiting. When asked, the mother confirmed the emesis was “bile.” The patient appeared well and had a completely normal examination, but because of the history of bilious vomiting, I proceeded to place an NG tube, call a surgeon, and order a UGI study.”
   Most caregivers (71%) equate “bile” with the color yellow. Asking the caregiver to describe the color of the emesis and not prompting them with the term “bile” could avoid an unnecessary workup in a well-appearing infant.

3. “I admitted an infant with abdominal distension, irritability, and vomiting, but did not consider a surgical abdomen, as the vomiting was nonbilious and nonprojectile.”
   Surgical etiologies for neonates with vomiting should still be considered with nonbilious vomiting in the presence of other concerning signs and symptoms, such as abdominal distention and irritability.

4. “For this infant with bilious vomiting, the initial abdominal radiograph did not show air fluid levels, so I determined that further imaging was not necessary.”
   The sensitivity and specificity of abdominal plain radiographs for obstruction in the presence of bilious emesis have been reported to be 44% to 50% and 80% to 97%, respectively, indicating that > 50% of cases would be missed if the diagnosis is based on radiographs alone.

5. “The infant had been spitting up since birth, so I didn’t think of considering a surgical issue, although the vomiting had become more frequent and more forceful.”
   In a study of return ED visits, patients diagnosed with reflux and/or vomiting at the first visit had a high frequency of admission (55%) and diagnosis of pyloric stenosis at the second visit (26%).

6. “I made the clinical diagnosis of GERD in a well-appearing infant and started treatment with metoclopramide.”
   The recommendations for treatment of GERD in well-appearing infants include nonpharmacologic treatments and consideration of pharmacologic treatment. Considerations include avoidance of cow’s milk protein and postprandial position changes. When nonpharmacologic treatment fails, H$_2$-receptor blockers can be considered. Due to significant side effects and lack of evidence of effectiveness in the treatment of GERD, prokinetic agents (such as metoclopramide) are no longer recommended for the treatment of GERD in infants.

7. “I discharged a 3-week-old baby with vomiting with a diagnosis of GERD because the infant was too young to consider HPS and the laboratory studies did not show hypokalemia, hypochloremia, or metabolic alkalosis.”
   Several authors have demonstrated that the majority of patients with HPS have normal electrolytes. Up to 88% of patients have no electrolyte abnormalities on admission. If the diagnosis of HPS is suspected, ultrasound should be ordered.

8. “I always recommend mothers with infants with suspected GERD to thicken formula and sit the infant in a car seat after feeds.”
   Although this was traditionally thought to decrease reflux symptoms, sitting upright in car seats after feeds has been shown to increase reflux symptoms in infants.

9. “I did not feel a palpable olive-sized mass in the abdomen, so I discharged the vomiting infant home with diagnosis of reflux.”
   Since the advent of ultrasonography for diagnosing HPS, the portion of patients with a clinical finding of a palpable olive-sized mass has fallen from previous reports of 78% to 83% to only 50%. This may be due to earlier diagnosis, which renders the mass smaller and not as palpable.

10. “I suspected the diagnosis of an incarcerated hernia in an infant with a painful inguinal mass and abdominal distension and ordered an abdominal ultrasound to confirm the diagnosis.”
    Incarcerated inguinal hernia is a diagnosis requiring prompt recognition and involvement of pediatric surgeons to optimize bowel salvage. Typically, history and physical examination are all the clinician needs to diagnose this entity and manual reduction should be attempted in the ED.
should be educated about conservative antireflux therapies, including feeding smaller volumes more frequently and postprandial position recommendations. Neonates who do not look well (even those in whom the emergency clinician suspects GERD) may need admission for further workup, especially if they are failing to thrive. Choosing to start pharmacotherapy from the ED is at the discretion of the emergency clinician, and discussing this with the patient’s primary care provider is preferred, but not required. Before discharge, it is important to advise the family on reasons to return to the ED. In a study of return ED visits, patients diagnosed with reflux and/or vomiting at the first visit had high frequency of admission (55%) and diagnosis of pyloric stenosis at the second visit (26%).

**Summary**

Vomiting in the neonate has a broad differential diagnosis, and its workup can range from simple observation in the ED to multiple radiological studies.

**Time-And Cost-Effective Strategies**

- Do not perform unnecessary tests on neonates with vomiting while in the ED. In the well-appearing and well-hydrated infant without concerning signs or symptoms, history and physical examination should be sufficient to manage the patient.

  *Risk Management Caveat:* Ensure that the caregivers have close follow-up with the primary care physician. The infant may not have lost weight, but it could be early in the course of GERD (if this is the suspected diagnosis), and close follow-up can prevent the patient from presenting to the ED with failure to thrive. Secondly, if suspicion for pyloric stenosis is too low to obtain an ultrasound for this visit, educate the caregivers about the signs and symptoms and advise them to return appropriately if they develop.

- Do not perform screening electrolytes on all neonates with vomiting, as even those with surgical causes will most likely have normal electrolytes.

  *Risk Management Caveat:* It is important to recognize that there are entities in which electrolytes being abnormal may help the emergency clinician make the diagnosis (such as congenital adrenal hyperplasia). These infants tend to present as ill-appearing and/or dehydrated. Surgical cases may need electrolytes drawn to follow trends or for preoperative purposes.

In many possible causes of neonatal vomiting. The history is extremely important in differentiating the life-threatening conditions. Diagnostic imaging modalities will vary, depending on the differential diagnosis, but pediatric surgical consultation should not be delayed in ill-appearing children. A thorough history is extremely important in differentiating the many possible causes of neonatal vomiting. The well-appearing infant who is gaining weight appropriately and does not have a surgical condition on evaluation in the ED will likely be safe for discharge home. As always, it is suggested that the caregivers have close follow-up with the primary care physician for reassessment.

**Case Conclusions**

After reviewing the history of the 3-week-old boy, you determined that he presented with symptoms consistent with reflux. His poor weight gain made him a more likely candidate for GERD. The episode that you observed was most likely a component of Sandifer syndrome, which is often related to severe GERD. Intravenous hydration and stabilization were not necessary. You counseled the parents on the condition and recommended close follow-up and discussion with his pediatrician as well as a trial of H$_2$-blocker therapy.

The 2-day-old girl had a very concerning presentation. She was ill-appearing and showed signs of toxicity. Her bilious emesis was a red flag, and you promptly notified the pediatric surgeon of her presence in the ED. The patient required intravenous fluid resuscitation and placement of an NG tube for decompression of the abdomen. After appropriate resuscitation, the child was evaluated by the pediatric surgeon and taken to the operating room emergently for surgical correction with a laparoscopic Ladd procedure.

After examination, you determined that the 6-week-old boy had HPS. Because the patient was dehydrated, you ordered electrolyte studies. You obtained an ultrasound of his abdomen and palpated a very small olive-sized mass. The laboratory studies revealed that the patient was hypokalemic, hypochloremic, and in a state of metabolic alkalosis. He was referred for consultation by a pediatric surgeon and admitted for pyloromyotomy.

**References**

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.
To help the reader judge the strength of each reference, pertinent information about the study will be included in bold type following the reference, where available. The most informative references cited in this paper, as determined by the author, will be noted by an asterisk (*) next to the number of the reference.


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64. Taxman TL, Yulis BS, Rothstein FC. How useful is the barium enema in the diagnosis of infantile Hirschsprung’s disease? Am J Dis Child. 1986;140(9):881-884. (Retrospective chart review; 58 patients)


66. Diamond IR, Casadiego G, Traubici J, et al. The contrast en-


105. Shalaby TM, Orenstein SR. Efficacy of telephone teaching of conservative therapy for infants with symptomatic gastroesophageal reflux referred by pediatricians to pediatric gastroenterologists. *J Pediatr.* 2003;142(1):57-61. (Retrospective study; 394 patients)
134. Quail MA. Question 2. Is Doppler ultrasound superior to...
1. The incidence of neonatal bilious emesis indicating an obstruction requiring surgery is approximately:
   a. < 5%  
   b. 20% to 38%
   c. 60% to 74%  
   d. 100%

2. Most episodes of reflux in infants resolve by the age of:
   a. 1 month  
   b. 6 to 9 months
   c. 12 to 14 months  
   d. 18 months

3. Current literature reports that a palpable olive-sized abdominal mass in a patient with HPS is found in what percentage of cases?
   a. < 10%  
   b. 32% to 40%
   c. 50% to 83%  
   d. > 90%

4. Which of the following conditions is classically associated with nonbilious vomiting?
   a. Pyloric stenosis  
   b. Malrotation with midgut volvulus
   c. Duodenal atresia  
   d. Incarcerated hernia

5. The sensitivity of a plain abdominal radiograph in diagnosing an obstruction in the presence of bilious emesis is approximately:
   a. 5% to 10%  
   b. 23% to 30%
   c. 44% to 50%  
   d. 65% to 70%

6. The diagnostic study of choice for pyloric stenosis is:
   a. UGI study  
   b. Ultrasound
   c. Computed tomography scan  
   d. pH probe

7. The gold standard examination for evaluating for GERD is:
   a. Esophageal manometry  
   b. Ultrasound
   c. UGI  
   d. Esophageal pH probe

8. Which of the following nonpharmacologic treatment options for GERD in infants has not been shown to provide clinical improvement in reflux symptoms?
   a. Thickening formula with locust bean gum  
   b. Sitting upright in a car seat
   c. Lying prone after feeds  
   d. Thickening formula with rice cereal

9. Which of the statements in regard to treatment with a PPI for infants with GERD is TRUE?
   a. Treatment with a PPI is indicated after H2-receptor-blocker medication failure.  
   b. Treatment with a PPI has been shown to cause liver failure in infants.
   c. Treatment with a PPI is associated with an increased risk of pyloric stenosis in infants.  
   d. When compared to placebo, treatment with a PPI has not been shown to be efficacious in reducing symptoms.

10. Risk factors associated with acid suppression in the treatment of GERD include all the following EXCEPT:
    a. Increased rates of community-acquired pneumonia  
    b. Gastroenteritis
    c. Candidemia  
    d. Sudden infant death
Upper gastrointestinal (GI) bleeding (defined as bleeding that originates in the gastrointestinal tract, superior to the ligament of Treitz) is an uncommon problem that accounts for 0.2% of presenting complaints in children visiting the emergency department. Managing pediatric patients suspected of having an upper GI bleed can be anxiety-provoking, as the differential diagnosis of an upper GI bleed ranges from benign to life-threatening conditions and carries the potential for significant morbidity and mortality if management is delayed. This issue of Pediatric Emergency Medicine Practice reviews the common differential diagnosis of upper GI bleeding and focuses on the clinical evaluation and management of children with a suspected upper GI bleed.

Time-And-Cost Effective Strategies

- Prompt intravenous access is essential in managing pediatric patients with suspected GI bleeding.
- Screening laboratory studies for patients with suspected upper GI bleed include: complete blood count, comprehensive metabolic panel, prothrombin time, partial thromboplastin time, international normalized ratio.
- Blood type and screen should be ordered if there are worrisome findings on history or physical examination. Nasogastric tube lavage should be performed in the presence of worrisome symptoms and signs.

Kawasaki disease, also known as mucocutaneous lymph node syndrome, was first described in Japan in 1967. It is currently the leading cause of acquired heart disease in children in the United States. Untreated disease may lead to the formation of coronary artery aneurysms and sudden cardiac death in children. This vasculitis presents with fever for ≥ 5 days and a combination of key criteria. Because each of the symptoms is commonly seen in children, the disease can be difficult to diagnose, especially in children who present with the incomplete form of the disease. At this time, the etiology of the disease remains unknown, and there is no single diagnostic test to confirm the diagnosis. This issue reviews the presentation, diagnostic criteria, and management of Kawasaki disease. Physicians and healthcare providers need to consider Kawasaki disease as a diagnosis in pediatric patients presenting with prolonged fever, as prompt evaluation and proper management can significantly decrease the risk of serious cardiac sequelae.

Time-And-Cost Effective Strategies

- Children with fever < 5 days or symptoms that are inconsistent with Kawasaki disease can be discharged from the emergency department if they are well-appearing and if close follow-up with a primary care provider can be arranged.
- Children who have symptoms consistent with incomplete Kawasaki disease but whose laboratory testing is not definitive should be referred for echocardiography. The presence of coronary artery ectasia or perivascular echocardiogram brightness can aid in finalizing the diagnosis, ensuring that the child can be treated in a timely manner.
In addition to presenting a summary of 4 issues of *Pediatric Emergency Medicine Practice*, Vol. II of the *Pediatric Emergency Medicine Practice* Audio Series focuses on supplemental information to augment the issues. As an added bonus, you can also earn up to 1.25 AMA PRA Category 1 Credits™ at no extra charge. You only need to spend 17 to 31 minutes listening to each topic, and the entire collection contains over an hour-and-a-half of evidence-based audio content, with recommendations that you can immediately begin applying to your practice. The *Pediatric Emergency Medicine Practice* Audio Series Vol. II includes an MP3 download (available as soon as you complete your purchase).

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- **Recording date:** August 1, 2014
- **Length:** 86 minutes (individual topics run from 17-31 minutes)
- **CME:** 1.25 AMA PRA Category 1 Credits™
- **CME expiration date:** August 1, 2017
- **Price:** $59

**Topic #1: Management Of Headache In The Pediatric Emergency Department**
This issue is designed to serve as a refresher on the basics of diagnosing and treating pediatric headache for the academic and community-based emergency clinician. With so little understood about the causes of adult and pediatric headache, this audio review aims to take the practitioner one step further into the most cutting-edge theory behind the etiology and treatment options available. An accurate differential is the cornerstone to implementing the most effective treatments for primary and secondary headaches. The treatment of pediatric patients who present with acute headaches is generally the same as in adult patients, with minor exceptions. Those exceptions are presented in detail to aid the emergency clinician in successful management of pediatric headaches and effective treatment strategies unique to the pediatric population are explored.

**Topic #2: Management Of Acute Asthma In The Pediatric Patient: An Evidence-Based Review**
The emergency clinician must know how to evaluate and treat patients who present with all degrees of asthma severity. While asthma is not limited to children, the differential diagnosis may be broader in the pediatric patient population because they are sometimes unable to provide an adequate history. This audio resource serves as a reminder that “not all that wheezes is asthma,” but most patients with known asthma do wheeze. A thorough review of the most current literature on this subject is presented, and the subtle differences between diagnosing and treating pediatric patients, as opposed to adults, are also covered. In extreme asthma situations, treatment for pediatric patients is not usually the same as treatment for adult patients. When managed correctly, asthma is a disease process in which the need to intubate a crashing patient can be avoided.

**Topic #3: Evidence-Based Emergency Management Of The Pediatric Airway**
There is nothing in emergency medicine that is more stress-provoking or carries more serious consequences than intubating a pediatric patient. Whether you work 5 days a week or 5 days a month, the difficult pediatric airway is going to find you. Will you be ready? The subtle differences between effectively intubating pediatric and adult patients are minimal, but never is it more important to understand those nuances than when you have a pediatric patient in respiratory arrest. Emergency clinicians often flounder in this situation because of lack of experience and understanding of the differences between adult and pediatric airways. This audio resource explores those differences in a manner that allows the emergency clinician to command control from the most routine to the most difficult pediatric airway. This audio review not only serves as a survey of the basics, but also lays out memory tools, mnemonics, and treatment strategies that build on the adult/general emergency clinicians’ well-founded knowledge of the adult airway.

**Topic #4: Capnography In The Pediatric Emergency Department: Clinical Applications**
By the very definition of the specialty, every emergency clinician performs sedation, resuscitation, and intubation. Emergency clinicians who still rely on pulse oximetry to guide these types of interventions and procedures may quickly find themselves behind the times. The advent of waveform capnography has provided the safest possible approach to patients with potential ventilation issues. Such a device provides a potential early warning system that can alert clinicians far in advance of impending respiratory arrest and of return of spontaneous circulation before a pulse check. This audio review provides a detailed explanation of the current and future uses of capnography by exploration of the most current literature. The most validated levels of end-tidal CO₂ with waveform capnography and its physiologic interpretation are presented for immediate application into practice.

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EB Medicine is in the process of making several improvements, enhancements, and changes to its product line and services:

In Fall 2014, a redesigned website for EB Medicine will go live, with improved navigation and search, a cleaner look, and additional content features (including blog pages and discussions). We look forward to your feedback and participation — all you have to do is register on the EB Medicine site, if you have not already done so, and join the discussion!

With greater focus on online content, *EM Critical Care* will no longer be published as a separate journal, and its critical care content will be merged into *Emergency Medicine Practice*. William Knight, MD, the Editor-in-Chief of *EM Critical Care*, is joining the EMP Editorial Board as the Critical Care Section Editor. *EM Practice Guidelines Update* will be discontinued in its current form, but it will be published quarterly on the website. Sigrid Hahn, MD, continuing in her role as Guidelines Editor, will lead online discussions on important topics in practice guidelines.

Another new feature will be a twice-monthly “Editor’s Choice” newsletter to provide you with information on all EB Medicine publications, bringing to the forefront both current issues and archived topics that are trending in the medical community.

Visual Diagnosis is a featured blog on the new website that provides you with a case synopsis and a picture, allowing you to answer the question: What's the diagnosis? You will be provided with Clinical Practice Pearls and suggestions for further reading on the topic, as well as the opportunity to upload your own Visual Diagnosis and get involved in the discussion. Check back often for new cases!

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Accreditation: EB Medicine is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. This activity has been planned and implemented in accordance with the Essential Areas and Policies of the ACCME.

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ACEP Accreditation: Pediatric Emergency Medicine Practice is also approved by the American College of Emergency Physicians for 48 hours of ACEP Category 1 credit per annual subscription.

AAP Accreditation: This continuing medical education activity has been reviewed by the American Academy of Pediatrics and is acceptable for a maximum of 48 AAP credits per year. These credits can be applied toward the AAP CME/CPD Award available to Fellows and Candidate Fellows of the American Academy of Pediatrics.

AOA Accreditation: Pediatric Emergency Medicine Practice is eligible for up to 48 American Osteopathic Association Category 2A or 2B credit hours per year.

Needs Assessment: The need for this educational activity was determined by a survey of medical staff, including the editorial board of this publication; review of morbidity and mortality data from the CDC, AHA, NCHS, and ACEP; and evaluation of prior activities for emergency physicians.

Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medical/legal pitfalls for each topic covered.

Discussion of Investigational Information: As part of the newsletter, faculty may be presenting investigational information about pharmaceutical products that is outside Food and Drug Administration approved labeling. Information presented as part of this activity is intended solely as continuing medical education and is not intended to promote off-label use of any pharmaceutical product.

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Commercial Support: This issue of Pediatric Emergency Medicine Practice did not receive any commercial support.

Method of Participation:

- Print Semester Program: Paid subscribers who read all CME articles during each Pediatric Emergency Medicine Practice 6-month testing period, complete the CME Answer And Evaluation Form distributed with the June and December issues, and return it according to the published instructions are eligible for up to 4 hours of CME credit for each issue.

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