GASTROINTESTINAL BLEEDING IN INFANCY AND CHILDHOOD

Victor L. Fox, MD

Gastrointestinal bleeding is an alarming problem in children. The total blood volume of a child is relatively small and can deplete rapidly, whereas resuscitation efforts are hindered by difficult venous access. Yet, mortality in children is quite low because of their robust physiology and general paucity of comorbid conditions and because of the attentive care usually afforded them. This experience contrasts sharply with significant mortality in elderly patients despite aggressive management.

Although many causes of gastrointestinal bleeding are common to children and adults, the frequency of specific causes differs greatly, and some lesions, such as necrotizing enterocolitis or allergic colitis, are unique to children. This article reviews the spectrum of gastrointestinal bleeding in infants and children. The causes, diagnostic evaluation, and management are discussed, and differences with adult medicine are highlighted.

UPPER GASTROINTESTINAL BLEEDING

Epidemiology

There are few quantitative data regarding the epidemiology of gastrointestinal bleeding in children. It is relatively uncommon but not rare. The incidence of upper gastrointestinal bleeding in ambulatory pediatric patients has not been reported. Published data are limited to the pediatric intensive care unit (ICU) population. One prospective ICU
study\textsuperscript{112} reported an incidence of 6.4% (63 episodes in 984 patients). Only four (0.4\%) episodes were considered life-threatening. Other studies reported an incidence of 25\% among ICU patients not receiving prophylactic therapy for bleeding.

**Causes**

The common causes of upper gastrointestinal bleeding in children are listed in Table 1. A few disorders are unique to neonates and young infants. The newborn may swallow maternal blood during birthing\textsuperscript{25} or later ingest blood while nursing from a bleeding nipple and present with clinical features that mimic gastrointestinal bleeding. True hemorrhage may arise from esophagitis, gastritis, or gastroduodenal ulceration in the full-term or premature newborn.\textsuperscript{22, 142, 208} The mechanism for this entity is poorly understood. Some cases represent stressed preterm infants in an ICU setting, whereas other cases are healthy full-term newborns\textsuperscript{74, 119} without identifiable risk factors. Gastric acid production normally begins shortly after birth and probably contributes to the pathogenesis. In one case, prenatal exposure to maternal cocaine may have been a contributing factor.\textsuperscript{194} Administered drugs, such as tolazone,\textsuperscript{51} an $\alpha$-adrenergic antagonist, and sulindac,\textsuperscript{136} a nonsteroidal anti-inflammatory drug (NSAID), have also been implicated. Upper gastrointestinal bleeding has been identified in utero by prenatal ultrasound and confirmed postnatally.\textsuperscript{13, 150} Pathogenesis in these cases is obscure, although esophageal duplication was present in one case.\textsuperscript{150}

Coagulopathy resulting from vitamin K deficiency, known as hemorrhagic disease of the newborn, has nearly disappeared since the introduction of routine vitamin K administration shortly after birth. Risk factors for this disease include failure to treat with vitamin K, altered bowel flora as a result of antibiotics, fat malabsorption (e.g., cystic fibrosis), and breast-feeding. Liver failure in the newborn resulting from metabolic (e.g., neonatal iron storage disease) or ischemic injury is usually accompanied by deficiency in blood clotting factors and may result in gastroin-

<table>
<thead>
<tr>
<th>Neonate (Birth–1 mo)</th>
<th>Infant–Adolescent (1 mo–18 y)</th>
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<tr>
<td>Swallowed maternal blood</td>
<td>Gastritis</td>
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<tr>
<td>Gastritis</td>
<td>Esophagitis</td>
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<tr>
<td>Esophagitis</td>
<td>Gastroduodenal ulcer</td>
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<td>Gastroduodenal ulcer</td>
<td>Mallory-Weiss tear</td>
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<tr>
<td>Coagulopathy associated with infection</td>
<td>Varices</td>
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<tr>
<td>Vascular anomaly</td>
<td>Gastrointestinal duplication</td>
</tr>
<tr>
<td>Hemorrhagic disease (vitamin K deficiency)</td>
<td>Vascular anomaly</td>
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<tr>
<td></td>
<td>Coagulopathy</td>
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<td>Hemobilia</td>
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testinal bleeding. Coagulopathy and bleeding may also result from over-
whelming viral or bacterial newborn sepsis.

Hematemesis may be the presenting sign of cow’s milk allergy in
the formula-fed or, rarely, breast-fed newborn or young infant. Hematemesis has also been reported in association with partially
obstructing lesions in the upper gastrointestinal tract, such as hyperto-
phic pyloric stenosis, duodenal web, or antral web. In these
cases, bleeding may arise from secondary peptic ulceration or mechani-
cal injury to the mucosa (e.g., Mallory-Weiss tear) or gastric cardia
prolapse. Other rare reports of upper gastrointestinal bleeding in the
newborn have included pyloroduodenal intestinal duplication and
heterotopic pancreatic tissue in the stomach.

Ulcer and Gastritis

Children may develop ulcers because of stress from surgery, burns,
increased intracranial pressure, birthing, acute self-limited viral illness,
and multiorgan system disease; medications; infection; ischemia; me-
chanical trauma from foreign bodies or gastrostomy tubes; and tumor.
Large acute or chronic ulcers, particularly duodenal ulcers, are relatively
uncommon in children compared with adults. They most often occur in
children recovering from surgery or receiving ICU support. Ross et
al. reported massive hemorrhage from posterior duodenal ulcers in 3
of 29 children who underwent surgery for a posterior fossa brain tumor.
Similar bleeding was not encountered in 35 children with other types of
brain tumors. Gastric ulceration and erosions may be seen in children
receiving NSAIDs, such as aspirin, ibuprofen, naproxen, and ketoro-

cal.

Although Helicobacter pylori infection can cause gastroduodenal ulcer
disease in children as in adults, diffuse nodular gastritis is the
commoner pediatric lesion. The nodules represent polyclonal mucosal
lymphoid aggregates. Rarely, this infection gives rise in children to a
low-grade lymphoma known as mucosal-associated lymphoid tissue lymphoma (MALToma), which can have an irregular and ulcerated surface
pattern. Other ulcerating gastric tumors in children are rare and include
leiomyosarcoma, teratoma, and hemangiopericytoma.

Esophagitis

Children with severe gastroesophageal reflux disease, often associ-
ated with neuromuscular disease (e.g., cerebral palsy) or hiatal hernia,
may present with bleeding as a result of ulcerating or erosive esophagi-
tis. Other causes of esophagitis in children that may lead to bleeding
include mechanical injury from a foreign body, chemical injury from a
caustic ingestion or medication (pill esophagitis) and infection (Candida
albicans, Aspergillus, herpes simplex virus, and cytomegalovirus).
Varices

Gastroesophageal varices form in children with intrahepatic or extrahepatic causes of portal hypertension and rarely in association with congenital heart disease or vascular malformations. Cirrhosis is implicated in most pediatric cases of portal hypertension. Cirrhosis should be considered in patients with chronic biliary diseases, such as biliary atresia, cystic fibrosis, sclerosing cholangitis, and parenteral nutrition–induced or other cholestatic syndromes, and chronic hepatocellular diseases, such as autoimmune hepatitis, viral hepatitis, α1-antitrypsin deficiency, glycogen storage disease, and steatohepatitis. Noncirrhotic causes of intrahepatic portal hypertension in children are far less common and include congenital hepatic fibrosis, veno-occlusive disease, and schistosomiasis.

Biliary atresia is the leading cause of pediatric liver failure. Survival requires early surgical intervention with portoenterostomy. Varices may form during infancy and early childhood despite appropriate therapy, however, as a result of ineffective biliary drainage, chronic cholangitis, and progressive cirrhosis. The onset of bleeding relates to the rate of disease progression and can occur within the first year of life. Late-onset variceal bleeding, resulting from gradual insidious disease progression, can occur.

Extrahepatic portal vein obstruction is an equally important cause of portal hypertension in children, representing most cases in some published series. Although most patients ultimately experience an episode of variceal bleeding, the age of presentation is highly variable. Other extrahepatic venous obstructions causing varices, such as splenic vein thrombosis and hepatic vein obstruction (Budd-Chiari syndrome), rarely occur in children.

Other Causes

Vascular anomalies are a rare cause of upper gastrointestinal bleeding in children. They may be focal lesions, such as an isolated gastric hemangioma, Dieulafoy's lesion, or aortoesophageal fistula, or diffuse lesions, such as hereditary hemorrhagic telangiectasia, neonatal hemangiomatosis, and Kasabach-Merritt syndrome.

Although more typically located in the small bowel, gastrointestinal duplications can occur in the upper gastrointestinal tract and cause hemorrhage. Long-segment esophageal atresia or severe caustic injury sometimes leads to esophageal replacement with colonic interposition. This condition may be complicated by bleeding from ulceration at the cologastric anastomosis. Children living in tropical climates are susceptible to bleeding caused by gastrointestinal parasites, including pharyngeal leeches and hookworm (Ancylostoma duodenale) infestation.

Other miscellaneous reports in children have included vasculitis (Henoch-Schönlein purpura), varioloform gastritis, ruptured pancreatic pseudocyst, gastric polyp in two children with
Menkes’ disease,98 mastocytosis,177 foreign body injury,75 and Munchausen’s syndrome by proxy.128

Diagnosis

A detailed history and careful physical examination accompanied by limited laboratory studies may identify the underlying cause and predict the severity of gastrointestinal hemorrhage. Infants and young children with upper gastrointestinal bleeding may present with hematochezia because of their relatively accelerated intestinal transit times compared with adults. A nasogastric tube aspirate should be obtained early in the evaluation to confirm the presence of fresh blood and to assess the extent of active bleeding. In a child, age-adjusted tachycardia is the most sensitive indicator of acute, severe blood loss. Hypotension and delayed capillary refill are ominous signs of severe hypovolemia and shock. The nasopharynx should be carefully examined to exclude a nongastrointestinal source of bleeding. Skin findings may reveal evidence of a generalized vascular disorder. The abdominal examination is of great importance; the physician should look for signs of liver disease or portal hypertension. Only a few laboratory studies are essential in the initial evaluation, including baseline blood and platelet counts, coagulation times, and liver function chemistries. The Apt test,42 or a comparable substitute, may be useful when the source of bleeding—newborn versus mother—is unclear.

Radiologic and Nuclear Medicine Imaging

Diagnostic radiology serves a limited role in the initial investigation of upper gastrointestinal bleeding in children. Plain x-ray film is useful if a foreign body, bowel perforation, or bowel obstruction is suspected. Barium contrast is too insensitive to detect reliably superficial mucosal lesions and too often delays establishing a precise diagnosis and initiating treatment. Ultrasonography is the modality of choice when liver disease, portal hypertension, or large vascular anomalies are suspected. Structural information and blood flow dynamics can be assessed noninvasively and without the need for sedation by Doppler ultrasound. Computed tomography (CT) and magnetic resonance (MR) imaging are valuable noninvasive modalities when mass lesions or vascular malformations are suspected, but sedation is frequently required for these tests in children.

Scintigraphy is rarely used to evaluate upper gastrointestinal bleeding. Exceptional cases may include the technetium 99m-pertechnetate scan for suspected enteric duplications (similar to a Meckel’s scan) and the technetium 99m-labeled red blood cell scan to detect an obscure bleeding site. Angiography is used selectively in children when bleeding is so massive that endoscopic evaluation and therapy are difficult and when vascular anomalies or hemobilia is suspected. Angiography, simi-
lar to endoscopy, offers the benefit of both diagnosis and treatment of selected lesions.124

**Endoscopy**

Upper gastrointestinal endoscopy is the preferred diagnostic procedure to evaluate upper gastrointestinal bleeding in children because it is sensitive and specific and, for some lesions, provides the means for immediate therapy. Endoscopic techniques and equipment are similar for children and adults. Smaller-diameter endoscopes are required for young children and infants to prevent mechanical injury and avoid airway compression. A deep level of conscious sedation is often necessary to render a child cooperative for successful endoscopy. Conscious sedation is achieved safely in most children using conventional combinations of opioid (e.g., fentanyl) and benzodiazepine (e.g., midazolam) medications in weight-adjusted doses.12, 34 If bleeding is active or severe or if endoscopic therapy is likely, general anesthesia with a protected airway (endotracheal tube) is warranted to facilitate an optimal examination and minimize the risk of aspiration of blood.

The indications for early endoscopy in children are not standardized because there are no published pediatric studies comparing outcomes of early endoscopy with conservative management that is limited to supportive medical care. Also the prognosis of bleeding or the risk of rebleeding in children, based on endoscopic stigmata (e.g., visible vessel), has not been investigated. Endoscopy is generally recommended for children with acute severe hemorrhage requiring blood transfusion or with unexplained low-grade persistent or recurrent bleeding. Endoscopy appears to be as safe in children as in adults, although few studies have specifically addressed safety in a large pediatric series. Balsells et al12 reported a retrospective review of 2711 endoscopic procedures in 2026 children in which the combined major and minor complication rate was only 0.3% with no deaths. A prospective multicenter survey5 of 2046 pediatric esophagogastroduodenoscopies reported one bowel perforation and one incident of postprocedure bleeding.

Several authors have retrospectively analyzed the endoscopic findings in a series of children. Cox and Ament44 reported the findings in 68 children and adolescents with upper gastrointestinal bleeding. The five commonest causes were duodenal ulcer (20%), gastric ulcer (18%), esophagitis (15%), gastritis (13%), and varices (10%). Chang et al32 reported the causes in 27 infants. Duodenal ulcer, hemorrhagic gastritis, and gastric erosions were the commonest causes. Four of 27 (15%) infants had no identifiable lesion. Bleeding was often preceded by acute viral infection with fever, aspirin ingestion, and diarrhea. Among 29 children reviewed by Quak et al,156 upper gastrointestinal bleeding was caused by gastric erosion (27.6%), esophagitis (17.2%), esophageal varices (13.8%), duodenal ulcer (10.3%), and Mallory-Weiss tear (3.5%). Eight children (27.6%) had no identified lesion. Factors that alter the relative frequency of reported lesions include patient age, medication exposure,
and subspecialty referral. Centers that specialize in liver disease and offer organ transplantation report proportionately more variceal bleeding. Endoscopic ultrasonography has been used to assess gastroesophageal varices and visible vessels associated with upper gastrointestinal bleeding in adults. Similar application in children may prove useful but has not yet been reported.

**Treatment**

When choosing a specific therapy, factors such as the severity of active bleeding; the medical condition of the patient; the quality of endoscopic, radiologic, and surgical resources; and the predicted behavior of an identified lesion must be considered. Treatment guidelines have not been formulated because of a lack of published data comparing outcomes of various therapeutic interventions for children with upper gastrointestinal bleeding.

**Medical Therapy**

Medical therapy is similar for adults and children, differing mostly in the dosage of medications. Basic stabilization is initiated with provisions for adequate oxygen delivery, blood volume resuscitation, and correction of coagulopathy and any life-threatening electrolyte or metabolic disturbance. Achieving venous access can be difficult in a small infant, particularly if hypovolemic shock has occurred. Intraosseous fluid infusion can be life-saving in this situation.164

Table 2 lists pediatric doses for medications commonly used in upper gastrointestinal bleeding. Early empiric use of acid-suppressive medications in children104, 110, 111, 145 is justified based on the predominance of peptic causes. Medications that induce visceral vasoconstriction, such as octreotide175 or vasopressin,197 may be useful for suspected active variceal bleeding. Both are tolerated well by children, but octreotide may be the drug of choice because of equal efficacy and lack of significant side effects. Children with hemorrhagic gastritis or gastroduodenal ulceration associated with *H. pylori* may benefit from antibiotic eradication of the infection to prevent relapsing ulceration.

**Endoscopic Therapy**

Children with an actively bleeding focal lesion or with a lesion at high risk of rebleeding are candidates for endoscopic therapy. Treatment of high-risk lesions, such as a duodenal ulcer with a visible vessel, may provoke torrential arterial bleeding, and surgical backup should be urgently available to intervene if uncontrolled bleeding ensues. Many of the hemostatic endoscopic techniques used successfully in adult patients—including electrocoagulation, laser photocoagulation, injection of epinephrine and sclerosants, elastic band ligation, and mechanical
Table 2. PHARMACOTHERAPY IN PEDIATRIC PATIENTS WITH GASTROINTESTINAL BLEEDING

<table>
<thead>
<tr>
<th>Acid reduction*</th>
<th>Dose</th>
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<tbody>
<tr>
<td>Magnesium hydroxide and aluminum hydroxide suspension</td>
<td>0.5-1.0 mL/kg/dose every 1-4 h (oral)</td>
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<td></td>
<td>Titrate to gastric pH &gt;4</td>
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<tr>
<td>Ranitidine (H₂-receptor antagonist)</td>
<td>4 mg/kg/d continuous or divided doses (IV)</td>
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<tr>
<td>Omeprazole (proton-pump inhibitor)</td>
<td>6-10 mg/kg/d divided in 2-3 doses (oral)</td>
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<td></td>
<td>1 mg/kg/dose (maximum 40 mg) every 12-24 h (oral)</td>
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<tr>
<td>Cytoprotection</td>
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<tr>
<td>Sucralfate</td>
<td>1-4 g/d in 4 divided doses (oral)</td>
</tr>
<tr>
<td>Misoprostol (prostaglandin agonist)</td>
<td>100-200 µg every 6-8 h (oral)</td>
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<tr>
<td>Vasoconstriction</td>
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<tr>
<td>Octreotide (somatostatin analog)</td>
<td>1 µg/kg (maximum 100 µg) bolus followed by 1 µg/kg/h continuously (IV)</td>
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<tr>
<td></td>
<td>1 µg/kg/dose (maximum 100 µg) every 8-12 h (subcutaneously)</td>
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<tr>
<td>Vasoconstrictin</td>
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<tr>
<td>Vasopressin</td>
<td>0.01 units/kg/min or 0.1-0.4 units/1.73 m²/min continuously (IV)</td>
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<tr>
<td>Antibiotic†</td>
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<tr>
<td>Amoxicillin</td>
<td>20 mg/kg/dose (maximum 1000 mg) every 12 h (oral)</td>
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<tr>
<td>Clarithromycin</td>
<td>7.5 mg/kg/dose (maximum 500 mg) every 12 h (oral)</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>10 mg/kg/dose (maximum 500 mg) every 12 h (oral)</td>
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*Treatment is optimal when maintaining gastric pH >4.
†For 80% to 90% eradication of Helicobacter pylori use clarithromycin plus metronidazole or clarithromycin plus amoxicillin together with omeprazole twice a day for 1 to 2 weeks.
IV = intravenous.
clips—have been applied in children. With the exception of variceal eradication, however, published pediatric experience is limited to case reports. Consequently, no conclusions can be made about optimal techniques for treating nonvariceal bleeding in children. The choice of endoscopic techniques is sometimes limited because some therapeutic catheters cannot be advanced through the narrow operating channel (2.0 mm diameter) of the smallest pediatric endoscopes. Argon plasma coagulation, a noncontact electrocoagulation technique, can be performed using a 1.5-mm diameter catheter that fits through any pediatric endoscope. Injection techniques are appealing because of simplicity; low cost; portability; and, in the case of epinephrine, lack of tissue destruction. Injection catheters small enough to fit through a pediatric endoscope are readily available.

Injection sclerotherapy for esophageal varices is a well-established hemostatic technique in children. Injection technique and sclerosants are similar for adults and children, with the exception of using smaller volumes of sclerosant per injection in children. The amount injected is determined empirically by the endoscopist. The use of titrated 0.5-mL aliquots per injection and the least total amount necessary to induce hemostasis is advisable because serious complications, such as stricture and perforation, are probably dose related. Many pediatric series representing experience in more than 10 countries have been published over the past 2 decades. Four studies involved only children with extrahepatic portal vein obstruction, and only one study dealt exclusively with intrahepatic disease. Most reports combined patients with both intrahepatic and extrahepatic disease, making conclusions about outcome difficult to interpret. Reported efficacy for controlling active bleeding in children exceeds 90%. Active bleeding from varices is uncommon and not clearly described in most pediatric reports. The cessation of active bleeding may simply be spontaneous and coincidental with endoscopic intervention. Eradication of esophageal varices is successfully accomplished by sclerotherapy in more than 90% of children. Bleeding may recur, however, either before complete eradication or despite eradication (as a result of another source, such as gastric varices, congestive gastritis, duodenal varices) or subsequently after esophageal varices reoccur. Short-term recurrence of varices and bleeding is commoner for children with intrahepatic disease than for children with extrahepatic portal vein obstruction. Most of the serious complications associated with sclerotherapy in adults have also been reported in children. Esophageal stricture is commonest, occurring in about 5% to 20% in most pediatric series. Superficial ulceration is common, but deep ulceration and perforation are rare. Ischemic spinal cord injury has been reported.

Elastic band ligation of varices has been performed in children with comparable safety and efficacy as reported in adults. The published experience, however, is limited to only 55 patients in five pediatric centers in the United States, Spain, and Japan. Compared with sclerotherapy, greater endoscopic skill may be needed to manipulate the
ligation device within the narrow esophagus of a young child. The original technique should be modified by eliminating the use of an overtube, and subsequent sclerotherapy may still be necessary to eradicate small residual varices that cannot be ligated. Apart from overtube injury, no major complications of elastic band ligation have been reported in children. Ohnuma et al reported the use of mucosal clips for eradicating esophageal varices in a small series of children.

Bleeding from and endoscopic management of gastric varices (excluding varices at the gastroesophageal junction) has been infrequently described in children. Conventional sclerosing agents may not adequately control bleeding. Fuster et al reported using cyanoacrylate (Histoacryl) for gastric varices in children after reports of successful application in adults.

**Interventional Radiology**

Arteriographic embolization is potentially useful to control bleeding from ulcers or vascular anomalies in children. Transjugular intrahepatic portosystemic shunt (TIPS) may be performed for patients with intrahepatic causes of portal hypertension. Experience with TIPS is limited in children, but the results are promising. The procedure may not be feasible in some children because of small size or unfavorable vascular anatomy. Adverse outcomes include encephalopathy and restenosis of the shunt.

**Surgery**

Surgery is reserved for bleeding uncontrollable by less invasive interventions. Prior diagnostic localization of the bleeding site should be performed whenever possible to guide the surgery. The commonest pediatric indications for surgery are duodenal ulcer with arterial bleeding, perforation, or obstruction and gastroesophageal varices. The incidence of surgery for peptic ulcer disease has decreased dramatically since the introduction of histamine \(_2\) (H\(_2\))-receptor antagonists, proton-pump inhibitors, and H. pylori therapy. Azarow et al reviewed a 45-year pediatric surgical experience with 43 children who required surgery for peptic ulcer disease. Thirty-eight of the 43 patients were in the pre-H\(_2\)-receptor antagonist era. Only two patients in the proton-pump inhibitor era required surgery—one for obstruction and one for bleeding. Nine patients required surgery for perforation, and eight of nine occurred in the pre-H\(_2\)-receptor antagonist era. Current surgical therapy for ulcer bleeding is usually limited to oversewing the ulcer bed for hemostasis. More aggressive approaches, such as resection and vagotomy, are rarely necessary.

Surgical treatment of bleeding gastroesophageal varices includes creation of one of several types of portosystemic shunts (central portocaval, mesocaval, or distal splenorenal) or esophageal transection and devascularization (Sugiara procedure). These interventions are most
often undertaken in children with extrahepatic portal vein obstruction and normal hepatic function.\textsuperscript{4, 118} De Ville de Goyet et al\textsuperscript{49} reported successful portal revascularization in seven children with extrahepatic portal vein obstruction. The obstruction was bypassed by a venous jugular autograft between the superior mesenteric vein and the left portal vein. Patients with intrahepatic disease and intractable variceal bleeding may also require shunt surgery,\textsuperscript{62, 159} although the TIPS procedure is an attractive alternative in suitable candidates awaiting liver transplantation.

\textbf{Mortality}

Upper gastrointestinal bleeding in children is rarely fatal. There have been case reports of massive hemorrhage and death in children with serious underlying disease, however. Fatalities have been reported with \textit{Candida} esophagitis in a child with acquired immunodeficiency syndrome (AIDS),\textsuperscript{30} perforated ulcer in critically ill neonates,\textsuperscript{142} gastric polyps in a child with Menkes' disease,\textsuperscript{98} sulindac-induced gastritis in a neonate,\textsuperscript{136} vascular anomaly,\textsuperscript{139} and varices associated with anomalous pulmonary venous drainage.\textsuperscript{60, 107}

\textbf{LOWER GASTROINTESTINAL BLEEDING}

\textbf{Epidemiology}

Even though rectal bleeding is commonly encountered in clinical pediatric practice, the epidemiology of this problem is not well established in an ambulatory care setting. Teach and Fleisher\textsuperscript{192} reported the course of 104 children with rectal bleeding presenting to a tertiary care emergency department during a 10-month period. Rectal bleeding represented the chief complaint in 0.3\% of all visits during this time period. Almost half of the children were younger than 1 year old. Allergic colitis was the commonest diagnosis, followed closely by anorectal fissure, in children younger than 1 year old. Infectious gastroenteritis and anorectal fissure were the commonest diagnoses in the 12 to 60 months and the greater than 60 months age groups. Four children had a life-threatening diagnosis (three with ileocolic intussusception, one with Meckel's diverticulum). Of these four children, three required surgery, and one required a blood transfusion. There were no fatalities. Juvenile polyp, a common cause of rectal bleeding in children, may have been underrepresented in this sample because of the young age of the patients.

\textbf{Causes}

Table 3 lists common causes of rectal bleeding in children. Age is an important consideration. A few disorders (e.g., allergic colitis and
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<thead>
<tr>
<th>Newborn (Birth–1 mo)</th>
<th>Infant (1 mo–2 y)</th>
<th>Child (2–12 y)</th>
<th>Adolescent (12–18 y)</th>
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<tbody>
<tr>
<td>Milk protein allergy</td>
<td>Milk protein allergy</td>
<td>Anal fissure</td>
<td>Anal fissure</td>
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<tr>
<td>Swallowed maternal blood</td>
<td>Anal fissure</td>
<td>Juvenile polyp</td>
<td>Infectious enterocolitis</td>
</tr>
<tr>
<td>Upper gastrointestinal hemorrhage</td>
<td>Intussusception</td>
<td>Infectious enterocolitis</td>
<td>Idiopathic inflammatory bowel disease</td>
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<tr>
<td>Necrotizing enterocolitis</td>
<td>Upper gastrointestinal hemorrhage</td>
<td>Idiopathic inflammatory bowel disease</td>
<td>Juvenile polyp</td>
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<tr>
<td>Hirschsprung’s enterocolitis</td>
<td>Infectious enterocolitis</td>
<td>Solitary rectal ulcer</td>
<td>Solitary rectal ulcer</td>
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<td>Midgut volvulus</td>
<td>Meckel’s diverticulum</td>
<td>Intussusception</td>
<td>Vascularitis</td>
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<td>Coagulopathy</td>
<td>Vascular anomaly</td>
<td>Intestinal duplication</td>
<td>Vascular anomaly</td>
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<td>Henoch-Schönlein purpura</td>
<td>Hemorrhoids</td>
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<td>Hemolytic-uremic syndrome</td>
<td>Intestinal duplication</td>
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<td>Vascular anomaly</td>
<td>Upper gastrointestinal hemorrhage</td>
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necrotizing enterocolitis) are uniquely found in neonates and young infants, whereas others more typically occur during early childhood (e.g., juvenile polyp) or adolescence (e.g., inflammatory bowel disease). As with adults, the character of the bleeding in a child may help narrow the differential diagnoses. Fresh red blood or hematochezia usually indicates bleeding from the colon rather than small bowel or upper gastrointestinal tract. This finding is less reliable in young infants, however, given their relatively faster intestinal transit. *Currant jelly stool*, representing a mixture of blood, mucoid exudate, and stool, suggests an ischemic or inflammatory lesion, such as acute colitis or intussusception. Maroon-colored stool occurs with bleeding from a distal small bowel lesion, such as a Meckel’s diverticulum. Streaks of red blood on the surface of formed stool suggest a distal rectosigmoid lesion, such as a juvenile polyp or anal fissure.

**Neonate and Early Infancy**

The most important diagnosis to exclude in the neonate with rectal bleeding is necrotizing enterocolitis. The typical clinical presentation is a hospitalized preterm infant with small amounts of gross blood in the stool, feeding intolerance, and emerging signs of systemic instability. Healthy full-term neonates may rarely develop necrotizing enterocolitis. Antenatal exposure to maternal cocaine use may be a risk factor for necrotizing enterocolitis. Enterocolitis in a neonate or infant with abdominal distention and impaired defecation may be due to Hirschsprung’s disease. Colitis in otherwise well-appearing infants is most often due to cow’s milk protein allergy (Fig. 1). Although most of these infants have been exposed to cow’s milk-containing formula, others are breast-fed and must have been sensitized through cow’s milk protein antigens entering into the mother’s milk. Soy intolerance is uncommon (14%) in infants and children with cow’s milk allergy. Taylor et al described a series of infants with short bowel syndrome and noninfectious hemorrhagic colitis. Despite feeding with hydrolyzed protein-containing or amino acid-containing formula, the histology of colonic biopsy specimens resembled that found in allergic colitis.

Bowel obstruction with ischemic injury should be suspected in an infant or young child with vomiting, pain, and small amounts of blood in the stool. Intestinal volvulus and ileocolic intussusception are the most important diagnoses. Intussusception in infants is usually idiopathic or associated with lymphoid hyperplasia of the terminal ileum. Older children with intussusception should be investigated to exclude a mass lesion, such as a polyp,intestinal duplication, or Meckel’s diverticulum. Meckel’s diverticulum and intestinal duplications are important sources of gastrointestinal bleeding in a child. Bleeding from gastric heterotopia in the rectum and colon has been reported in several young children. Kestemberg et al identified *H. pylori*-like organisms associated with bleeding heterotopic gastric mucosa in the rectum of a child.
Infection

Infectious enterocolitis can present with bloody stool at any age. Important bacterial pathogens include *Salmonella*, *Shigella*, *Campylobacter*, *Yersinia enterocolitica*, *Clostridium difficile*, and *Escherichia coli* (0157:H7). *Entamoeba histolytica* is the most important parasitic pathogen. It is rarely reported in children without an appropriate travel history and may require tissue biopsy to establish the correct diagnosis. Cytomegalovirus can cause enterocolitis in children with primary or secondary immunodeficiency and can present with massive life-threatening hemorrhage. Rectal bleeding occurs less commonly with other opportunistic infections, such as *Mycobacterium avium* complex and disseminated aspergillosis in immunocompromised children. Children with AIDS can suffer life-threatening gastrointestinal bleeding from aphthous ulceration in the absence of a detectable infectious cause. Typhlitis, a polymicrobial inflammatory disease in the cecum of severely immunosuppressed patients, can present with massive gastrointestinal bleeding.

Ischemia

Other ischemic and idiopathic inflammatory diseases are major causes of mucosal ulceration and active bleeding. Hemolytic-uremic syndrome and Henoch-Schönlein purpura are the commonest vasculitic diseases of childhood that cause intestinal ulceration. Hemolytic-uremic syndrome is characterized by microangiopathic hemolytic anemia, thrombocytopenia, and acute renal failure. Acute colitis occurs in approximately 50% of cases, often associated with Shiga toxin–producing *E. coli* (0157:H7). Intestinal perforation resulting from ischemia has been reported. Henoch-Schönlein purpura characteristically produces an urticarial rash on the buttocks and lower extremities that progresses to

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**Figure 1.** A, Rectosigmoid lymphoid nodularity in an infant with cow’s milk protein allergy and grossly bloody, mucoid stool. (Courtesy of A. Flores, MD, Waltham, MA.) B, Eosinophilic colitis with intraepithelial eosinophils (arrowheads) and an eosinophilic crypt abscess with focal epithelial damage (arrows). (Courtesy of K. Badizadegan, MD, Boston, MA.)

**Figure 2.** Focal ulcer at the site of ileocolonic anastomosis in a 9-year-old girl with chronic anemia. (Courtesy of G. Furuta, MD, Boston, MA.) The patient underwent surgery as a newborn for gastrochisis and multiple ileal atresias.

**Figure 3.** Prominent irregular mucosal veins in the rectosigmoid colon of a 2-year-old boy with intermittent rectal bleeding caused by a capillary lymphaticovenous malformation (Klippel-Trenaunay syndrome).

**Figure 4.** A, Large pedunculated juvenile polyp with ulcerated surface found in the transverse colon of a 6-year-old boy with crampy abdominal pain and hematochezia. B, Characteristic histology of a juvenile polyp with cystically dilated glands, increased vascularity, and inflammatory cell infiltrate. (Courtesy of D. Antonioli, MD, Boston, MA.)
papular purpuric lesions. Skin edema and large joint arthralgia frequently occur. More serious complications involve renal disease (40%) and gastrointestinal symptoms (50% to 70%). Massive intestinal bleeding has been reported, but minor blood loss or guaiac-positive stool is commoner. Pseudomembranous colitis associated with *C. difficile* infection is a toxin-mediated ischemic injury. Postoperative ischemia from transient hypoperfusion or thromboembolic disease can cause ulceration and bleeding in vulnerable *watershed* regions of the colon in children as in adults. Acute drug (cocaine)-induced ischemia with hemorrhage has rarely been reported in children.¹⁶⁰

Unusual entities include postoperative ileocolonic anastomotic ulcer¹⁹, ⁴⁰, ⁷⁸, ¹⁴⁹, ¹⁷⁹ and solitary rectal ulcer and mucosal prolapse syndrome. The former is uniquely a pediatric disorder that follows ileocolonic resection (Fig. 2). The mechanism of injury remains obscure, but ischemia may be a contributing factor. The solitary rectal ulcer syndrome is found in children⁴⁷, ⁵⁶ and adults. The bleeding cloacogenic polyp¹⁵⁴ probably represents another clinical manifestation of the same disease process.

**Idiopathic Colitis**

Idiopathic inflammatory bowel disease, either ulcerative colitis or Crohn’s disease, must be considered in the older child or adolescent who presents with rectal bleeding. Mild limited colitis in a child can present with minor amounts of rectal bleeding without a history of diarrhea, urgency, pain, or other clinical signs of colitis. Severe hemorrhage may ensue with progression to severe diffuse disease and transmural extension into deeper vascularized layers of the bowel wall or focal deep ulceration. Lymphoid nodular hyperplasia has been reported as a cause of rectal bleeding, primarily in infants.¹⁶, ³⁹, ⁹⁹ This condition may represent a mild form of colitis triggered by protein allergy or unidentified infection. It is also a feature of colitis associated with immunoregulatory disorders.

**Vascular Lesions**

Vascular anomalies⁶⁵ are a rare cause of rectal bleeding in a child of any age. Lesions that present with bleeding during infancy are most often hemangiomas—benign endothelial neoplasms that typically proliferate during the first year of life, then involute during early childhood. Bleeding also may arise from vascular malformations—congenital lesions that result from abnormal vascular morphogenesis. Although present at birth, these lesions can grow larger with the patient and produce intermittent or intractable bleeding at any age.⁶⁴ Venous malformations are among the most common anomalies in children. They are often mislabeled as hemangiomas. A complex malformation known as the *Klippel-Trenaunay syndrome*⁶, ¹⁰, ¹⁷⁰, ¹⁹³ is a capillary-lymphaticovenous malformation that results in limb hypertrophy and can extend into the pelvis and colon, resulting in rectal bleeding (Fig. 3). Another venous malformation
commonly associated with gastrointestinal bleeding is the blue rubber bleb nevus syndrome. Patients are often recognized immediately by the characteristic cutaneous lesions.143

Hereditary hemorrhagic telangiectasia usually presents in childhood with epistaxis, and visceral involvement emerges later in life. Cynamon et al.46 however, described four children, 1.5 to 5.5 years old, with multiple telangiectases of the colon, of whom three had a family history of telangiectasis. Odell et al.39 described a unique case of a neonate with gastrointestinal bleeding and disseminated cutaneous and gastrointestinal vascular anomalies resembling hereditary hemorrhagic telangiectasia but with distinct features that they termed infantile hemorrhagic angiodysplasia. De la Torre Mondragon et al.48 reported nine children with rectal bleeding from colonic angiodysplasia. The mean age of onset of bleeding was 2.3 years. An 8-year-old boy with colonic angiodysplasia was reported by Sasaki et al.168 There are reports of other rare lesions in children, such as arteriovenous malformation or Dieulafoy’s lesion of the Hemorrhoids are occasionally found but rarely cause bleeding in healthy young children. Hemorrhoids and colorectal varices may, however, become symptomatic in children with portal hypertension.17,80

Polyps and Tumors

Beyond infancy, juvenile polyps are the commonest source of significant rectal bleeding in childhood. Painless, intermittent bleeding is typical. Juvenile polyps (Fig. 4) are nonneoplastic polyps that contain dilated cystic spaces, infiltrating inflammatory cells, marked vascularity, and areas of eroded epithelium.91 They predominantly occur in the rectosigmoid but may occur throughout the colon. Children with multiple or recurrent juvenile polyps may have juvenile polyposis coli or juvenile polyposis syndrome, a genetic disorder that has an increased risk of adenomatous degeneration and malignancy.36,82 Bleeding from hamartomatous polyps (e.g., Peutz-Jeghers syndrome) is unusual unless accompanied by intussusception and bowel ischemia.

Other tumors presenting with rectal bleeding in childhood are rare. In particular, colon cancer is rare in infants and children. Cummings et al.44 reported a case of colonic leiomyoma presenting with gastrointestinal bleeding in a child. Hyams et al.94 reported an unusual presentation of histiocytosis X in a 5-month-old infant with diffuse histiocytic infiltration and ulceration of the colon.

Other Causes

Foreign body injury must be considered, including ingested glass, a broken glass rectal thermometer, or other sharp objects. Unexplained bleeding despite extensive evaluation should also raise suspicion of Munchausen’s syndrome by proxy.128


**Diagnosis**

As with upper gastrointestinal bleeding, the history and physical examination help narrow the differential diagnosis. Crampy abdominal pain and stool mixed with mucus and blood suggest an infectious, inflammatory, or ischemic process. Painless bleeding is more typical for a juvenile polyp, ulcerated duplication, or vascular anomaly. The skin should be carefully examined for vascular lesions. Meticulous examination of the anus and perineum may reveal a fissure or markers of inflammatory bowel disease, such as a skin tag or a fistula. Several laboratory studies are helpful. A Wright stain of the stool demonstrating numerous eosinophils is highly suggestive of allergic colitis. Stool should be submitted promptly for bacterial culture and for *C. difficile* toxin assay in the evaluation of suspected colitis to avoid unnecessary endoscopy in patients with bacterial colitis. Complete blood count, blood smear, platelet count, urinalysis, blood urea nitrogen, and serum creatinine should be determined in the evaluation of suspected hemolytic-uremic syndrome.

**Endoscopy**

Colonoscopy\(^1\) is the preferred diagnostic modality for rectal bleeding. Sensitivity and specificity exceed that of contrast radiology, and simultaneous therapy may be an option. Limited inspection of the rectosigmoid is usually sufficient for infants with allergic colitis and may be adequate to establish an initial diagnosis of infectious, ischemic, or idiopathic colitis in older children. A normal saline enema just before the procedure may be sufficient preparation for such a limited examination. In other cases, complete colonoscopy is preferred to identify focal or multifocal lesions or assess the extent of colonic involvement. Unless ischemia or obstruction is suspected, a suitable bowel preparation should be administered to facilitate optimal visualization and potential intervention. Bowel preparation is safely achieved in children using a continuous nasogastric infusion (25 mL/kg/h) of a standard polyethylene-glycol electrolyte solution until fecal contents have been adequately evacuated. Colonoscopy can be performed safely in children using intravenous sedation.\(^1\) Deep sedation or general anesthesia is often preferred, however, when a lengthy or painful procedure or therapeutic intervention is anticipated. A small-diameter colonoscope (11 mm) can be used in most children beyond 2 years of age. A smaller-diameter gastroscope is required in infants.

Multiple studies demonstrate the predominance of juvenile polyps as the source of rectal bleeding in children. Perisic\(^2\) examined by complete colonoscopy 71 children with rectal bleeding and found polyps in 45 (63%). Eighty-three percent of resected polyps were the juvenile type. Quak and Prabhakaran\(^3\) reported a series of 26 children (age range, 2 weeks to 180 months) examined by colonoscopy for rectal bleeding. Diagnoses included colitis (*n* = 10), juvenile polyps (*n* = 5), lymphoid hyperplasia (*n* = 1), and solitary sigmoid ulcer (*n* = 1). Khurana et al\(^4\)
reported the colonoscopic findings in a series of 85 children living in a tropical setting and presenting with recurrent rectal bleeding. Juvenile polyp \( n = 40 \) was still the predominant finding, followed by amebic ulcer \( n = 20 \), polyposis syndrome \( n = 5 \), and solitary rectal ulcer \( n = 4 \).

The number of colonic polyps is important because multiple or recurrent polyps may indicate a polyposis disorder. Perisic\(^{151} \) found multiple polyps in 40% of children with a detectable polyp. Cynamon et al\(^{45} \) reported their experience with complete colonoscopy in 41 children with polyps. Of the 36 patients with juvenile polyps, 58% had more than one polyp. Although none of these patients had a family history of polyps, at least five of the patients (14%) have a high risk for juvenile polyposis coli because of a large number (>10) of polyps or the presence of focal adenomatous epithelium. In a series reported by Hoffenberg et al,\(^{88, 99} 9 \) (12%) of 78 children with colonic polyps fit the criteria (>10 polyps) for juvenile polyposis coli despite a negative family history.

Examination of the terminal ileum should be routinely attempted to detect active bleeding from the small bowel or Crohn’s ileitis. Examination of the ileocolonic junction is also required to detect the postoperative anastomotic ulceration.

Superficial mucosal vascular lesions, such as telangiectasis, hemangioma, or venous malformation, are best visualized by colonoscopy. Endosonography is comparatively more sensitive than endoscopy for detecting submucosal lesions and may be particularly useful in cases of vascular anomalies.\(^{68, 162} \) Yachha et al\(^{99} \) looked for rectal varices in 25 children (ages 3 to 16 years) with extrahepatic portal hypertension. Varices were detected in 36% by endoscopy and in 76% by endoscopic ultrasound.

**Radiology and Nuclear Medicine**

Plain abdominal radiographs may provide useful information in children with rectal bleeding when pain or vomiting is present. Supine and upright (or lateral decubitus) views should be obtained to look for a distorted bowel gas pattern indicating mass effect or obstruction, air-fluid levels, or pneumoperitoneum. Focal or generalized bowel wall thickening (thumbprinting) suggests severe colitis, particularly ischemic colitis.

Ultrasonography can detect bowel wall thickening or identify characteristic features of intussusception. Air contrast\(^{146} \) or barium contrast enema is necessary to confirm and may also treat colonic intussusception. Cross-sectional imaging with CT or MR imaging is generally reserved for evaluation of mass lesions or complex vascular anomalies.

As with upper gastrointestinal bleeding, angiography and scintigraphy may be useful to localize an obscure site of lower gastrointestinal bleeding. Angiography can sometimes further differentiate types of lesions. Burrows et al\(^{26} \) found that hemangiomas and vascular malformations in the face and extremities can be reliably distinguished on the basis
of their angiographic appearance. Presumably the same distinctions apply to visceral lesions.

Treatment

Medical Therapy

Bleeding from allergic colitis of infancy responds promptly to dietary restriction and introduction of hydrolyzed protein formula. Ischemic colitis (necrotizing enterocolitis) is treated supportively. Appropriate antibiotics and immunosuppressive and anti-inflammatory agents are used to treat infectious colitis and idiopathic inflammatory disease. Rapidly proliferating hemangiomas have been successfully treated with corticosteroids and with interferon-α.

Endoscopic Therapy

Endoscopic therapy in children is primarily polypectomy, although other hemostatic techniques, such as sclerotherapy, electrocautery, laser, and elastic band ligation have been used in children for vascular colonic anomalies. The polypectomy technique is the same as in adult patients. Standard polypectomy snares and electrocautery units are used. Juvenile polyps in children tend to be small to medium diameter (5 to 15 mm) and are often pedunculated, making resection with minisnares straightforward. Advanced techniques, such as submucosal injection for elevation of sessile polyps and injection of the stalk with epinephrine, are rarely necessary. Although malignancy is rare, an effort should be made to resect and retrieve all polyps for histopathologic examination to exclude the presence of adenomatous or cancerous epithelium.

Surgery

Surgery is most often indicated for bleeding resulting from nonreducible intussusception or a vascular anomaly. Ein et al compared their experience with intussusception during the 1960s and late 1980s and found that surgical intervention had been reduced from a rate of 55% to 19% because of the high level of success with pneumatic reduction. Among the recent group, 30% of those needing surgery required bowel resection. Patients with vascular anomalies may require excision of focal lesions (e.g., blue rubber bleb nevus) or surgical resection or exclusion of a larger segment of involved bowel (e.g., rectosigmoid venous malformation).

Mortality

Children rarely die from lower gastrointestinal bleeding. Urushihara et al reported three fatalities among 14 infants with enterocolitis associ-
ated with Hirschsprung's disease. The most severe cases had either pseudomembranous or hemorrhagic necrotizing enterocolitis.

**SMALL BOWEL HEMORRHAGE**

Meckel's diverticulum, a congenital remnant of the vitellointestinal duct described by Meckel in 1809, is the most important source of small bowel hemorrhage in children.\(^{201}\) It obeys the rule of 2s: present in 2% of the population, located 2 feet from the ileocecal valve, and bleeding in children younger than 2 years of age. The diverticulum arises on the antimesenteric border of the ileum and is lined by ileal mucosa that frequently contains ectopic gastric or pancreatic tissue. Bleeding occurs because of peptic ulceration of ectopic gastric tissue within the diverticulum or adjacent ileum or because of ischemic injury accompanying intussusception. Diagnosis is by radionuclide scan (technetium 99m-pertechnetate) or surgical exploration. Treatment is surgical resection.

Duplications are the second most important source of small bowel hemorrhage in children. Although they may arise anywhere along the length of the gastrointestinal tract, they are most often found in the small intestine.\(^{87}\) In contrast with Meckel's diverticula, duplications arise from the mesenteric border of the bowel.\(^{204}\) Similar to Meckel's diverticula, duplications frequently contain ectopic gastric mucosa and cause bleeding from peptic ulcer or ischemic injury from intussusception. Diagnosis is by radionuclide scan, ultrasonography, or CT scan or surgical exploration, and treatment is by surgical resection.

Idiopathic necrotizing enteritis\(^{189,205}\) is an unusual entity that appears to be distinct from Crohn's enteritis or other inflammatory or ischemic diseases. Children may present with massive bleeding, unexplained blood loss, perforation, or obstruction. Surgery is required for diagnosis and treatment. Several fatal cases of cytomegalovirus ileitis have been reported in human immunodeficiency virus–infected infants presenting with massive hemorrhage.\(^{52,102}\) Other disorders that rarely cause significant bleeding from the small bowel are Crohn's disease, Henoch-Schönlein purpura, systemic vasculitis (e.g., systemic lupus erythematosus), lymphoma, and vascular anomalies (e.g., blue rubber bleb nevus syndrome).

Peroral enteroscopy is rarely performed in children to investigate suspected small bowel bleeding. Most lesions require surgical intervention, and suitable equipment for enteroscopy in small children is not available. Intraoperative enteroscopy may be helpful to localize a lesion not readily visible from the serosal surface.

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