Acute Surgical Conditions of the Abdomen

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The expanding influence of managed care and complicated referral patterns places greater emphasis on the diagnostic skills of the pediatrician. Differentiating acute surgical conditions of the abdomen from a number of nonsurgical illnesses is challenging. This article reviews common surgical illnesses of the abdomen that confront the physician caring for children. To present this information in the most clinically relevant manner, these conditions have been arranged according to their initial presenting signs and symptoms: pain, vomiting, and bleeding.

PAIN

The pediatrician frequently is required to evaluate the child with abdominal pain or tenderness. The most important diagnostic goal is to identify those patients who have an acute surgical condition causing pain.

Appendicitis and the Differential Diagnosis

Acute appendicitis is the most frequent reason for emergency abdominal surgery in childhood. Approximately four per 1000 children undergo appendectomy each year. In prepubertal children, males and females are equally affected. The frequent occurrence of surgical and nonsurgical conditions that mimic appendicitis (Table 1) can make the diagnosis difficult. A presumptive diagnosis of appendicitis frequently can be made on the basis of the time course and pattern of pain development. Too often, laboratory and radiographic findings are either not helpful or misleading.

Most children with appendicitis will describe a fairly typical history of the progression of abdominal pain. The onset of pain is usually slow and periumbilical in location. Early pain from appendicitis results
from appendiceal distension. This causes stretch signals to be sent via visceral afferent nerves to the tenth thoracic level of the spinal cord, which provides efferent innervation to the umbilical area. As transmural inflammation progresses, pain becomes located where the appendix contacts the peritoneum. This is characteristically in the right lower quadrant but may occur in the pelvis. In the latter circumstance, a particularly helpful symptom that should be sought is suprapubic pain on urination.

Examination of the child begins with observation. A child with appendicitis will lie quietly, often with the legs drawn up for comfort. Abdominal palpation is the most reliable diagnostic maneuver and should begin in the area away from that which is most painful. Examination of the right lower quadrant is facilitated by raising the legs slightly to relax the abdominal rectus muscles. Gentle palpation yields the best results. The patient with simple appendicitis will demonstrate pointed tenderness and guarding in the right lower quadrant while patients with advanced appendicitis will have generalized tenderness, indicative of peritonitis. Those patients with pelvic appendicitis will have pain and often a palpable mass on rectal examination. Rectal examination should always be performed when appendicitis is suspected, and a bimanual examination is the best way to evaluate the pelvic contents. The child should be lying supine with the knees drawn up for such an examination.

Additional diagnostic tests may be helpful. Leukocytosis with a left shift in the WBC differential count often accompanies simple appendicitis. If needed, abdominal radiographic findings may support the diagnosis of appendicitis. This includes the presence of a fecalith, curvature of the spine toward the right, or localized ileus in the right lower quadrant. Recently, ultrasonography has been used to evaluate children for appendicitis when the history and clinical findings are unclear. Abdominal ultrasound examination is useful in evaluating the adolescent female with right lower quadrant pain. Ultrasonography readily identifies symptomatic ovarian conditions such as ovarian torsion, cysts, or tumors that may mimic appendicitis. While the sensitivity of ultrasound for appendicitis is 75%, its specificity approaches 100%.

Patients with suspected appendicitis, after adequate preoperative hydration, are taken to the operating room and undergo appendectomy. Children with simple appendicitis receive prophylactic antibiotics such as cefazolin or cefoxitin. Discharge is 1 or 2 days following surgery.

Children with perforated appendicitis receive antibiotics to cover both aerobic and anaerobic bacteria. Cultures taken at the time of surgery with request for antibiotic sensitivities determine the best postoperative antibiotic coverage. Antibiotics are discontinued only when the white blood cell count and differential are normal and the child has been afebrile for a minimum of 48 hours. Treatment duration may be as brief as 5 days.

The role of peritoneal drainage in perforated appendicitis remains controversial but is usually reserved for children with a localized appendiceal abscess with a well-defined inflammatory wall.

Despite new diagnostic techniques, early diagnosis of appendicitis is difficult in many patients. Primary care pediatricians should have a high index of suspicion for appendicitis in children with vomiting and right lower quadrant abdominal pain.

### Ovarian Pathology

Ovarian disease should be considered in the differential diagnosis of the girl with lower abdominal pain. Torsion of the ovary may result from a cystic or solid mass within the ovary, although torsion of a normal ovary also may occur. Benign tumors include cystic teratomas, granulosa cell tumors, and cystic adenomas. Rarely, malignant solid tumors such as malignant teratomas present as ovarian torsion.

Differentiating ovarian torsion from appendicitis can be difficult. A careful history of the onset of pain can be helpful. Girls with torsion will often describe a sudden onset of pain and will locate its origin to the right or left lower quadrants. This is in distinction to the periumbilical location of pain in early appendicitis. Bimanual rectal and abdominal palpation frequently reveals a movable pelvic mass. The enlarged ovary will locate itself centrally within the pelvis, making designation of the side of origin difficult.

Pelvic ultrasonography is the best diagnostic test to evaluate for an ovarian mass or torsion. In addition to identifying the presence of an ovarian mass, ultrasound will differentiate between cystic and solid masses. Girls with diagnosed ovarian torsion should undergo exploratory laparotomy. In confusing cases,
**TABLE 2**

**Causes of Intestinal Obstruction**

<table>
<thead>
<tr>
<th>Infant/Young Child</th>
<th>Older Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyloric stenosis</td>
<td>Appendicitis (perforated)</td>
</tr>
<tr>
<td>Inguinal hernia</td>
<td>Adhesions</td>
</tr>
<tr>
<td>Malrotation</td>
<td>Inguinal hernia</td>
</tr>
<tr>
<td>Intestinal atresia or stenosis</td>
<td>Inflammatory bowel disease</td>
</tr>
<tr>
<td>Intraluminal web</td>
<td>Intussusception (lead-point)</td>
</tr>
<tr>
<td>Adhesions</td>
<td>Malrotation</td>
</tr>
<tr>
<td>Intussusception</td>
<td>Omphalomesenteric remnants</td>
</tr>
<tr>
<td>Appendicitis</td>
<td></td>
</tr>
<tr>
<td>Intestinal duplication</td>
<td></td>
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<tr>
<td>Omphalomesenteric remnants</td>
<td></td>
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<tr>
<td>Hirschsprung's disease</td>
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</table>

Diagnostic laparoscopy can be performed to inspect the adnexa. Infarcted ovaries and ovarian masses are removed. The fallopian tube is preserved if it is not involved in the torsion and if there is no suspicion of malignancy. Most conditions causing ovarian torsion are benign. If a malignant tumor is suspected, ascitic fluid is sampled and the remainder of the abdomen is explored for tumor deposits. If a frozen section confirms malignancy, iliac and periaortic lymph nodes are sampled.

**Cholelithiasis/Cholecystitis**

Symptomatic cholelithiasis should be considered as a diagnostic possibility in children with both right upper quadrant pain and vague abdominal complaints. Although not as common as in adults, cholelithiasis should be included in the differential diagnosis of abdominal pain in children. This is especially so in teenage females with a family history of gallstones. Gallstones form as a result of an imbalance in the relative concentrations of bile, lecithin, and cholesterol.

As in adults, gallstones of children are usually cholesterol stones. Obesity and high estrogen states such as pregnancy and the use of birth control pills are predisposing factors in older children. Stones in younger children are usually associated with risk factors such as total parenteral nutrition or distal ileal resection. Frequently, gallstones in children develop from excess circulating bilirubin pigment secondary to hemolytic diseases.

Symptoms from gallstones may develop in children at any age. There may be either right upper quadrant pain and tenderness or vague epigastric and abdominal pain.

Cholelithiasis is diagnosed by plain abdominal radiography, ultrasound, and cholecistography. Abdominal radiographs occasionally demonstrate the presence of a calcified right upper quadrant mass. Children have a greater chance of having radiopaque gallstones than adults.² Real-time ultrasonography is the usual method for visualizing gallstones. In addition, ultrasound will demonstrate the thickness of the gallbladder wall and the diameter of the common and hepatic ducts. Cholecistography involves the intravenous injection of a technetium radioisotope (PIPIDA or HIDA). These isotopes are taken up by the liver, excreted into the biliary ducts, and collected in the gallbladder. The isotope is then passed into the common duct and duodenum by contraction of the gallbladder. Cholecystitis causes inflammation of the cystic duct, preventing the isotope from entering the gallbladder. The test is of greatest diagnostic use when an acute inflammatory process involves the gallbladder.

Children with symptomatic gallstones should undergo cholecystectomy. In increasing numbers of institutions, laparoscopic cholecystectomy is performed. Patients are usually discharged within 24 to 48 hours. Given the rapid recovery children have from open cholecystectomy, it is unclear at present if laparoscopic removal has significant cost advantages. However, the benefits of limited incisions and reduced pain with laparoscopy do, however, represent real advantages for the patient.

**INTESTINAL OBSTRUCTION AND VOMITING**

The pediatrician is often asked to evaluate the vomiting child. Distinction must be made between the child with a mechanical intestinal obstruction and vomiting from an infectious etiology or other causes. A carefully obtained history and physical examination often will provide clues to the correct diagnosis. In children who have had previous abdominal surgery, intestinal adhesions remain a common cause of intestinal obstruction. Radiologic examinations are also extremely important in making the diagnosis of obstruction. For example, in ileocolic intussusception, contrast enemas administered under fluoroscopic control can be both diagnostic and therapeutic. Common causes of intestinal obstruction vary among age groups. Selected problems seen frequently by pediatricians are noted in Table 2.

**Pyloric Stenosis**

Pyloric stenosis is the most common surgical cause of vomiting in the infant. The typical child is a healthy 3- to 5-week-old infant who presents with

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projectile vomiting. Vigorous vomiting occurs immediately after feeding, and the infant is characteristically hungry after the emesis. It is extremely unusual for the child to have bilious vomiting. Appearance of bile should raise the suspicion of duodenal obstruction and malrotation. Often, a family history of pyloric stenosis can be elicited.

Diagnosis begins with an attempt to palpate an "olive" in the epigastrium. This is best done with the child resting comfortably in the mother's lap. The infant's abdominal wall must be completely relaxed. The stomach may need to be decompressed using a nasogastric tube. Slow, gentle palpation of the epigastrium will reveal the mobile, smooth, firm mass, which is the hypertrophied pyloric musculature. If the tumor is not felt, feeding the child glucose water often makes the mass palpable.

When the diagnosis is in doubt, an abdominal ultrasound can establish the diagnosis. Several studies of normal infants and babies with confirmed pyloric stenosis have provided information on the normal dimensions of the pylorus. The length of the pyloric channel is abnormal if >16 mm, and the diameter of the pyloric musculature is abnormal if >11 mm. If ultrasound is not available, an upper gastrointestinal series is the time-tested method of diagnosing pyloric stenosis. A long and extremely narrowed pyloric canal is considered a positive study. If an upper GI is necessary, vigorous lavage of the residual gastric barium is necessary to minimize the risk of vomiting and aspiration of barium in the perioperative period.

Infants with pyloric stenosis have varying degrees of dehydration. Due to a chloride deficit, they present with a characteristic hypochloremic, hypokalemic metabolic alkalosis. These electrolyte imbalances are corrected prior to surgery with intravenous solutions. When the infant is properly hydrated and in electrolyte balance, a pyloromyotomy is performed. Through a small right upper quadrant incision, the hypertrophied pylorus is elevated into the wound, and the anterior musculature is split through its entire depth and length. Four to 5 hours following surgery, feedings are begun; the feeding volume is increased to full volume over the next 24 to 48 hours, at which time the infant is discharged. Pyloromyotomy reliably corrects pyloric stenosis with no long-term sequela. Interestingly, the hypertrophy of the pyloric musculature gradually disappears over the ensuing months.

Malrotation

Malrotation with midgut volvulus should always be suspected in the infant or child with bilious vomiting. Although other problems result in bilious emesis, the potential catastrophic consequences of untreated midgut volvulus make its recognition and treatment imperative.

Acute appendicitis is the most frequent reason for emergency abdominal surgery in childhood.

Malrotation of the intestine results from failure of the midgut to properly affix itself to the posterior wall of the abdomen. This results in a spectrum of fixation anomalies of the intestine and colon. Because mesenteric fixation is incomplete, volvulus can occur about a narrowed mesenteric pedicle. This results in a compromised mesenteric circulation with potential for a midgut infarction.

Infants with malrotation and midgut volvulus usually have bilious vomiting. Abdominal distension may not be present. As infarction progresses, the infant develops painful abdominal distension and shock. Plain abdominal radiographs may show gastric distension and a paucity of intestinal air distally, but in some cases the radiographs appear normal. The diagnostic study of choice is an upper gastrointestinal series, which documents malposition of the duodenum and demonstrates obstruction due to the volvulus. Although a contrast enema can be used to diagnose malrotation, it is not always reliable, especially if a midgut volvulus has occurred. Rapid fluid resuscitation should be achieved, and the child taken to the operating room with haste. During abdominal exploration, the intestinal volvulus is untwisted, nonviable intestine is resected, and a Ladd's procedure is performed. Ladd's procedure includes division of mesenteric bands, appendectomy, and placement of the small intestine on the right side of the abdomen and the colon in the left side.

Prompt recognition and treatment of the child with malrotation and midgut volvulus avoids the problems attendant with massive small bowel resection. An aggressive diagnostic approach to the child with bilious emesis is warranted given the dire consequences of delayed recognition and treatment.

Intussusception

Intussusception results when a portion of proximal bowel becomes invaginated into distal bowel. It then is propelled distally by peristalsis. The clinical signs and symptoms of this condition are early vomiting and severe, recurrent abdominal cramping.

Intussusception occurs most commonly in the first year of life and involves the distal ileum and proximal colon. It is uncommon for infants to have pathologic lead points; lead points usually occur in older children and those with ileal-ileal intussusception.

The typical infant is healthy and presents with sudden screaming and drawing up of the knees to the abdomen. With the passage of time, a bloody (current
TABLE 3
Causes of Bleeding in Infants and Children

**Upper GI**
- Esophagitis
- Esophageal varices
- Gastritis
- Peptic ulcer disease

**Lower GI**
- Intestinal polyps
  - Juvenile polyps
  - Adenomatous polyps
- Familial multiple polyposis
- Meckel's diverticulum
- Angiodysplasia
- Intestinal duplication
- Inflammatory bowel disease
- Hemorrhoids
- Fissure-in-ano

Jelly stool may be passed. The child's abdomen is soft between painful episodes, and careful palpation will often reveal a soft sausage-shaped mass in the right upper quadrant. Rectal examination will reveal guaiac-positive mucus or gross blood. In prolonged cases, the intussusception may be felt at the fingertip on rectal examination. Plain abdominal radiographs may show a paucity of gas in the right lower quadrant or findings consistent with small bowel obstruction such as air fluid levels and proximal intestinal dilation. If the child has no evidence of peritonitis, a nasogastric tube is placed and a radiographic enema is performed. A surgeon should be notified at this time, in case immediate operative reduction is required.

Barium or air contrast enema is diagnostic and can be therapeutic as well. Both air and barium have comparable success rates of 50% to 80% in reducing intussusceptions. Should reduction be unsuccessful, a laparotomy is necessary. A right lower quadrant incision exposes the intussusception; it is gently reduced by squeezing the intussuscepted bowel back toward the cecum until complete reduction is achieved. If manual reduction is not possible, the involved segment of bowel is resected and an end-to-end anastomosis performed. If manual reduction is successful, an appendectomy frequently is performed. Recurrence may follow either hydrostatic or operative reduction in 5% to 10% of cases. Parents should be advised of this; they soon become expert at recognizing the symptom complex if intussusception is recurrent.

**Incarcerated Inguinal Hernia**

An incarcerated hernia is one in which the intestine contained in the inguinal sac cannot be reduced. In this event, bowel obstruction can develop and progress to strangulation and infarction. The majority of children with an incarcerated hernia are under 1 year of age. There may or may not have been a history of prior hernia. The infant with an incarcerated hernia presents with irritability, vomiting, and abdominal pain. Physical examination reveals a swollen, firm, tender mass in the groin or scrotum. An abdominal radiograph may show a small bowel obstruction and gas in the affected groin. Unless peritonitis is evident, attempts should be made to reduce the hernia. Irreducible hernias should be treated with surgery. After opening the hernia sac, the bowel is inspected for viability. Nonviable bowel is resected. Viable bowel is reduced into the peritoneal cavity, and the hernia sac is resected. After repair, nasogastric intestinal decompression is applied until bowel activity returns. After full feedings are resumed, the child is discharged.

Infants with irritability and vomiting always should be evaluated for incarceration of an inguinal hernia. Early manual reduction avoids emergency operation and hospitalization.

**Other Surgical Causes of Intestinal Obstruction**

Less common causes of intestinal obstruction include appendicitis, inflammatory bowel disease, and adhesive bowel obstruction. The child with advanced appendicitis may present with a bowel obstruction. After perforation, the resultant fibrinous peritoneal exudate may result in fixation of the bowel and obstruction. These children frequently have a prolonged history of abdominal pain, vomiting, and fever. At operation, the adhesions are divided and the appendix removed.

Children with obstruction due to inflammatory bowel disease usually present with a prodrome of recurrent abdominal pain, frequent stools, and weight loss. The obstruction is usually partial and often can be managed by medical measures. Resection is reserved for those patients with complete obstruction or intractability of symptoms despite medical management.

Children with previous intra-abdominal surgery, vomiting, and abdominal cramping should be suspected of having an adhesive bowel obstruction. Plain abdominal radiographs will demonstrate air fluid levels and a paucity of gas in the colon. Children without peritonitis can be managed with intravenous hydration and nasogastric suctioning. If the obstruction fails to improve in 6 to 8 hours, surgery is performed to divide the adhesions. Unfortunately, to date, no techniques have been developed to prevent adhesion formation.

**GASTROINTESTINAL BLEEDING**

Gastrointestinal bleeding is an alarming sign to both parent and practitioner. Initial diagnostic efforts...
should identify the location and estimate the severity of the bleeding. Upper gastrointestinal bleeding results from sources proximal to Treitz's ligament. All other bleeding is considered to be lower gastrointestinal bleeding.

The infant or child with upper gastrointestinal hemorrhage usually presents with hematemesis. Treatment begins with placement of a nasogastric tube to clear the stomach of blood and allow assessment of the rate of ongoing bleeding. If bleeding is active, two large bore intravenous catheters should be placed for volume resuscitation. Most upper gastrointestinal hemorrhage in children is self limited and can be managed nonoperatively. Upper gastrointestinal endoscopy is used for diagnosis. The differential diagnosis for upper gastrointestinal hemorrhage is presented in Table 3.

It is unusual for a child to require acute surgical therapy for bleeding due to esophagitis, gastritis, or peptic ulcer disease. Variceal hemorrhage is first treated with injection sclerotherapy and then a portosystemic venous shunt if sclerotherapy is unsuccessful.

Lower gastrointestinal hemorrhage manifests itself in several ways depending on the rate and source of bleeding. Slow bleeding from a proximal source results in melena or black stools. Distal bleeding produces bright red blood per rectum or bloodstreaked stool. Inspection of the anus and rectal examination yield important diagnostic clues. Anal inspection may demonstrate a fissure in ano or rarely, hemorrhoidal bleeding. Palpation of a rectal polyp should prompt further workup for polyposis. Proctosigmoidoscopy or colonoscopy with polyp removal is required. The vast majority of polyps are juvenile polyps or benign hamartomas of the intestinal mucosa that may slough spontaneously.

Table 3 lists causes of lower gastrointestinal bleeding. It is unusual for lower gastrointestinal bleeding to require acute surgical intervention. One cause of severe lower gastrointestinal bleeding that may require urgent surgery is Meckel's diverticulum.

**Meckel's Diverticulum**

A Meckel's diverticulum is a true diverticulum of the small intestine located on the antimesenteric border of the distal ileum. It may contain heterotopic tissue, including gastric mucosa or pancreatic tissue. Acid-secreting gastric mucosa may lead to ulceration of either the adjacent ileum or the diverticulum itself. There is little if any abdominal pain, and bleeding can be either chronic and minimal or acute and massive. The latter type of bleeding often ceases spontaneously. A nasogastric tube is passed to rule out an upper gastrointestinal source of bleeding, and blood volume resuscitation commences.

An abdominal scan using technetium 99 pertechnetate is a fairly reliable method for diagnosing Meckel's diverticulum. There is selective uptake of technetium by the heterotopic gastric mucosa in the diverticulum. If the scan is positive, the child is scheduled for surgery after hemodynamic stability is achieved. If bleeding persists, urgent surgery is required. At laparotomy, the diverticulum is excised, including the ulcer. This may require a segmental bowel resection that includes the diverticulum. A Meckel's diverticulum should always be considered in the infant or child with serious lower gastrointestinal hemorrhage.

**REFERENCES**