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Emergency Abdominal Surgery in Infants and Children

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Abstract

The term acute abdomen refers to sudden severe abdominal pain with unclear etiology that is less than 24 h in duration. In children, acute abdominal pain presents a diagnostic dilemma. Although many cases of acute abdominal pain are benign, some of them need rapid diagnosis and treatment to minimize morbidity. The present chapter provides an overview of abdominal surgical emergencies in children and discusses the most common disorders that cause surgical acute abdomen.

Keywords: acute abdomen, infants, children, surgery, neonates

1. Introduction

1.1. Acute abdomen

The term acute abdomen refers to sudden severe abdominal pain with unclear etiology that is less than 24 h in duration. In many cases, there is a medical emergency that requires urgent and specific diagnosis. The causes of these emergencies include inflammation, abdominal organ ischemia, obstruction, hollow organ perforation, and gastrointestinal bleeding.

In children, acute abdominal pain presents a diagnostic dilemma. Although many cases of acute abdominal pain are benign, some of them require rapid diagnosis and treatment to minimize morbidity.

The most common nonsurgical condition is gastroenteritis, whereas the most common surgical condition is appendicitis. Abdominal pain in children varies with age, associated symptoms, and pain location. Meticulous history and physical examinations are essential to determine the cause of acute abdominal pain and to identify the surgical conditions, such as appendicitis.

1.2. Evaluation of the acute abdomen in children

The most appropriate therapy should then be initiated when the child's clinical status optimized. The workup should first include a thorough but efficient acquisition of the child's history and physical examination followed by the judicious use of laboratory and radiologic studies. The evaluation of children with acute abdominal pain can pose a diagnostic challenge on physicians as children may present with atypical symptoms that interfere with the usual Pattern of recognition that often guide decision making. Children are often unable to provide the desired information, which makes recognition of the cause of abdominal complaints more difficult.

Appendicitis
Meckel`s diverticulum
Intussusceptions
Intestinal malrotation
Midgut volvulus
Adhesive bowel obstruction
Testicular/ovarian torsion
Incarcerated inguinal hernia
Omental torsion
Cholecystitis
Pancreatitis
Intra-abdominal malignancies
Abdominal trauma
Surgical causes of constipation

Table 1. The most common surgical causes of acute abdomen in children.

Birth to 1 year	2 to 5 years	6 to 11 years
Intussusception	Appendicitis	Appendicitis
Hirshsprung`s disease	Incarcerated hernia	Cholecystitis
Incarcerated hernia	Intussusception	Pancreatitis
Volvulus	Volvulus	Testicular/ovarian torsion
	Trauma	Trauma
	Meckel`s diverticulum	

Table 2. Differential diagnosis of surgical acute abdomen by predominant age.

The present chapter provides an overview of abdominal surgical emergencies in children and discusses the most common disorders that cause surgical acute abdomen (**Table 1**). **Table 2** shows the differential diagnosis of surgical acute abdomen by predominant age.

2. Main body

2.1. Surgical acute abdomen in neonates

2.1.1. Gastric volvulus

Gastric volvulus is a rare, potentially life-threatening condition [1]. It may be defined as an abnormal rotation of one part of the stomach around another; the degree of the torsion varies from 180° to 360° and is associated with closed-loop obstruction and the risk of strangulation.

2.1.1.1. Clinical features

Clinical features depend on the degree of rotation and obstruction. Persistent regurgitation and vomiting (sometimes unproductive) are common. The vomiting may or may not contain bile, depending on pyloric obstruction. Hematemesis and anemia are well described in this disease.

2.1.1.2. Diagnosis

Plain abdominal pain and chest X-rays are essential. A distended stomach in an abnormal position should suggest the possibility of gastric volvulus.

Contrast studies clarify the anatomy and the site of obstruction, which is usually at the pylorus, giving a so-called “beak” deformity.

2.1.1.3. Treatment

Acute gastric volvulus requires appropriate resuscitation and urgent surgery if ischemic necrosis and gastric perforation are to be avoided.

If possible, the stomach should be decompressed preoperatively by nasogastric suction but vigorous attempts to pass a tube must be avoided because of a risk of gastric perforation.

2.1.2. Gastric perforation

Gastric perforation in neonates can be broadly categorized as spontaneous (idiopathic), ischemic, and traumatic; however, in many instances, the etiology may be multifactorial [2].

Neonatal gastric perforation can occur in full-term, premature, and small gestational age neonates.

Traumatic perforation results from pneumatic distention during mask ventilation, positive-pressure ventilation, or iatrogenic injury during gastric intubation.

2.1.2.1. *Clinical features*

The majority cases present within the first 7 days of life. The neonates are often premature or have a history of asphyxia or hypoxia. They may present with feeding intolerance or emesis (sometimes bloody). Many develop abrupt onset of rapidly progressive abdominal distention.

The abdomen may rapidly become tense and tender with signs of peritonitis. Subcutaneous emphysema in the abdominal wall or pneumoscrotum may be perceived.

2.1.2.2. *Diagnosis*

In infants with massive pneumoperitoneum, a plain abdominal X-ray will demonstrate air under the diaphragm. Other plain X-ray findings include subcutaneous emphysema, ascites, pneumoscrotum, or an oro-nasogastric tube outside the confines of the stomach.

2.1.2.3. *Treatment*

Open exploration (or laparoscopic) and repair is the essential part of treatment. However, infants with gastric perforation develop septic parameters and need to be well resuscitated preoperatively (respiratory supports, hydration, and broad spectrum antibiotics).

2.1.3. *Duodenal obstruction*

Congenital duodenal obstruction is the most common cause of intestinal obstruction in the newborn period [3].

Duodenal obstruction is the result of intrinsic lesions (atresia, stenosis, and “windsock” web), extrinsic lesions (annular pancreas, malrotation, preduodenal portal vein), or a combination of both.

2.1.3.1. *Clinical features*

About half of these patients are premature and have low birth weight. Vomiting is the most common symptom and is usually presented in the first day of life. There is minimal or no abdominal distention. The neonate may pass some meconium in the first 24 h of life.

2.1.3.2. *Diagnosis*

The diagnosis of duodenal obstruction is confirmed on X-ray examination. An abdominal X-ray will show a dilated stomach and duodenum (double-bubble sign), with no gas beyond the duodenum. In partial obstruction, there is usually some air in the distal intestine.

In some cases of partial duodenal obstruction, plain films may be normal. Upper gastrointestinal tract contrast X-ray is indicated in these patients to establish the diagnosis.

2.1.3.3. Treatment

Although duodenal atresia is a relative emergency, the patient should be hemodynamically stable preoperatively. Duodenoduodenostomy is the preferred procedure for patients with duodenal atresia.

2.1.4. Malrotation and midgut volvulus

Malrotation is the term used to denote an interference with normal process of orderly return of the fetal intestine from the physiological hernia to the abdominal cavity during which it undergoes systematic rotation and fixation [4].

2.1.4.1. Clinical features

Fifty-five percent of malrotations present within the first week of life and 80% in the first month. Recurrent episodes of subacute obstruction with intermittent bilious vomiting are the main symptoms in neonatal period.

Strangulating intestinal obstruction as a consequence of midgut volvulus can present as bile-stained vomiting, which may contain altered blood, abdominal distension and tenderness, the passage of dark blood per rectum, and shock. As the strangulation progresses to gangrene, perforation and peritonitis become evident.

2.1.4.2. Diagnosis

The plain abdominal X-ray in the infant with midgut volvulus typically shows a “gasless” appearance with air in the stomach and duodenum. Contrast studies are diagnostic (upper gastrointestinal contrast study). It shows the abnormal configuration of duodenum, (deviation of duodenojejunal junction to the right of midline). When volvulus has occurred, the duodenum and jejunum show a “corkscrew” appearance.

Ultrasonography to determine the relationship between the superior mesenteric vein (SMV) and the superior mesenteric artery (SMA) has been advocated.

2.1.4.3. Treatment

The operative correction of a malrotation should be regarded as a surgical emergency. Neonates presenting with acute strangulating obstruction as a result of midgut volvulus require a short period of intensive resuscitation preoperatively.

The volvulus occurs around the base of the narrowed midgut mesentery. The twist occurs in a clockwise direction and is untwisted by counter-clockwise rotation. In patients with extensive intestinal gangrene, frankly necrotic bowel should be resected and the bowel ends either tide off or stomas fashioned with a view to a second-look laparotomy in 24–48 h later.

In uncomplicated malrotation, Ladd's procedure (division of extensions of peritoneal folds across the bowel) is the preferred treatment.

2.1.5. *Jejuno-ileal atresia*

Jejuno-ileal atresia, defined as a congenital defect in continuity of the bowel, is a common cause of intestinal obstruction in the newborn [5].

2.1.5.1. *Clinical features*

Jejunoileal atresia presents clinically as neonatal intestinal obstruction with persistent bile-stained vomiting. Abdominal distension is frequently present. Constipation is usually not absolute and the meconium passed.

2.1.5.2. *Diagnosis*

Plain abdominal X-ray will reveal distended small bowel loops and air-fluid levels. When the abdominal X-ray suggests a complete obstruction, a contrast enema may be performed to exclude colonic atresia. The classical appearance of the colon distal to jejunoileal atresia is an unused or microcolon.

2.1.5.3. *Treatment*

The operation should not be delayed unduly as there is always a danger of further infarction of the bowel. The main surgical treatment in jejunoileal atresia is resection and anastomosis of bowel ends.

2.1.6. *Meconium ileus*

Meconium ileus is an early manifestation of cystic fibrosis (CF) due to abnormal, inspissated, and viscid mucus of intestinal origin. In children, the impacted meconium produces an intraluminal obstruction occurring in the mid-ileum, leading to a progressive abdominal distention, intestinal volvulus, atresia, gangrene, perforation, peritonitis with abdominal calcifications, and meconial pseudocyst [6].

2.1.6.1. *Clinical features*

A family history of cystic fibrosis is clearly evident in 25% of patients. Main symptoms include abdominal distension, bilious vomiting, and delayed passage of meconium. Meconium ileus can be recognized clinically as two different conditions: a simple, uncomplicated type not requiring surgery and a complicated, severe type.

In the first type, symptoms of a distal ileal obstruction are seen not later than 48 h after birth. These generalized abdominal distention, bilious vomiting, and no stool.

In the second type, the progressive abdominal distension may culminate in respiratory distress. If a perforation occurs, a pneumoperitoneum and sepsis will be the unfavorable consequences.

Sometimes, the onset is directly with meconium peritonitis, which could involute in a giant meconial pseudocyst.

2.1.6.2. *Diagnosis*

A water-soluble contrast enema is useful for both diagnosis and therapeutic purposes. Contrast enema shows microcolon appearance and pellets in terminal ileum.

2.1.6.3. *Treatment*

The first step of treatment includes medical management, such as nasogastric tube decompression, antibiotics, correction of dehydration, and contrast enema with water-soluble contrasts (Gastrografin, Golytely, N-Acetylcysteine).

When medical treatment is unsuccessful in spite of an uncomplicated meconium ileus, surgery is mandatory, and an open evacuation, resection, and ileostomy are the possible options.

The indication of operation for newborns with meconium peritonitis is a clear sign of intestinal obstruction or perforation. Infants with neonatal meconium calcifications, meconium ascites with hydrocele, or calcified meconium found in the hernia sac do not require operation.

2.1.7. *Necrotizing enterocolitis (NEC)*

NEC is the most common medical and surgical emergency affecting the gastrointestinal tract of infants in the neonatal intensive-care unit (NICU) [7]. Multiple risk factors that have been implicated in the pathogenesis of NEC include prematurity, hypoxia, initiation of enteral feeding, congenital heart disease, and bacterial infection. The majority of cases develop in infants less than 36 weeks of gestational age.

NEC is characterized by intestinal inflammation and mucosal destruction. In its most severe form, NEC is characterized by full-thickness necrosis, intestinal perforation, peritonitis, sepsis, and death.

Grade 1	Mild systemic signs (apnea, bradycardia, and temperature instability) Mild intestinal signs (abdominal distension, gastric residual, And occult blood in stool)
Grade 2	Mild-to-moderate systemic signs Additional intestinal signs (absent bowel sounds, abdominal tenderness) Radiologic signs (pneumatosis intestinal, portal venous air) Laboratory changes (metabolic acidosis, thrombocytopenia)
Grade 3	Severe systemic illness (hypotension, shock) Intestinal signs (large abdominal distension, abdominal wall discoloration, peritonitis, perforation) Severe radiologic signs (ascites, pneumoperitoneum) Progressive laboratory derangement (metabolic acidosis, DIC)

Table 3. Modified Bell's stage.

2.1.7.1. *Clinical features*

NEC may present as feeding intolerance, abdominal distension, bloody stool, hypoxia, and shock. The bell criteria (**Table 3**) allow for categorization of the severity of NEC for treatment guidelines.

Laboratory abnormalities in NEC include thrombocytopenia, leukocytosis or leukopenia, metabolic acidosis, hypercapnea, and hypoxia.

2.2. Surgical acute abdomen in children

2.2.1. *Appendicitis*

Appendicitis is a common cause of emergency abdominal surgery in children [8]. Variability in clinical findings often leads to misdiagnosis.

2.2.1.1. *Clinical features*

Interpretation of signs requires a great deal of clinical experience of examination. History and physical examination alone show a diagnostic accuracy of approximately 90%. Acute appendicitis in children is diagnosed mainly on the basis of classical symptoms of migratory right iliac fossa pain, nausea and vomiting, right-lower quadrant (RLQ) tenderness with rebound phenomenon.

In most cases, pain is initially located periumbilically and subsequently shifts to the RLQ. Fever is often present. The examiner should always consider possible atypical clinical presentation. Another important point to remember is perforation followed by a calm period (closed-cavity theory) in which pain subsides until signs of peritonitis appear.

2.2.1.2. *Diagnosis*

Laboratory tests including white blood cell (WBC) count and C-reactive protein (CRP) measurement do not provide additional information in the diagnosis of appendicitis.

Abdominal ultrasonography is an excellent screening tool for acute appendicitis. Computerized tomography (CT) scan has a slightly higher sensitivity and specificity than ultrasonography, and is associated with a lower negative appendectomy.

2.2.1.3. *Treatment*

The generally accepted treatment for appendicitis is appendectomy. Although it has been suggested that nonoperative treatment of children with uncomplicated appendicitis may be successful, there is no adequate evidence to advocate this method.

The treatment of appendicitis begins with intravenous fluid and broad-spectrum antibiotics. Management often initiating antimicrobial therapy depends on the severity of inflammation (uncomplicated or non-perforated versus complicated or perforated appendicitis).

The current standard of care for uncomplicated appendicitis is appendectomy (open or laparoscopic). The management of complicated appendicitis can be separated into nonoperative and operative treatment.

The concept of complicated appendicitis management with antibiotics alone is to decrease the significant local and regional inflammation. Once treated, most surgeons will perform interval appendectomy often 6–10 weeks later. The majority of patients who present with a well-formed abscess on initial imaging are managed nonoperatively. Primary treatment of the abscess with antibiotics alone, or antibiotics and percutaneous drainage is a widely accepted treatment strategy. Interval appendectomy is then performed after the inflammation has subsided.

2.2.2. Intussusception

Intussusception is the most frequent cause of bowel obstruction in infants and toddlers [9]. It is acquired invagination of the proximal bowel into the distal bowel, causing obstruction of the mesenteric vessels, and eventually ischemia and necrosis of bowel. There may or may not be a lead point. The vast majorities of cases do not have a lead point and are classified as primary or idiopathic. The most common lead point is a Meckel diverticulum followed by polyps and duplication.

2.2.2.1. Clinical features

The classic presentation is an infant or a young child with intermittent, crampy abdominal pain associated with “currant jelly” stool and a palpable mass on physical examination, although this triad is seen in less than a fourth of children. The abdominal pain is sudden and the child may stiffen and pull the legs up to the abdomen. Between pain attacks, the child may appear comfortable but eventually will become lethargic. Physical examination is relatively nonspecific. There may be an abdominal mass, abdominal tenderness, and distension. Prolapse of the intussusception through the anus is a grave sign.

2.2.2.2. Diagnosis

Plain flat and upright abdominal radiography have a low accuracy for the diagnosis of intussusception, and are not used as the sole diagnostic test. X-ray can be useful in identifying free air, and indicating perforation. Ultrasound imaging is the preferred method to diagnosis intussusception. The characteristic finding on ultrasound has been referred to as a “target” or a “doughnut” lesion, which consists of alternating rings of low and high echogenicity representing the bowel wall and mesenteric for within the intussusception in a transverse plan. The pseudo kidney’s sign is seen on longitudinal section. Contrast enema is also accurate, but is invasive and requires radiation.

2.2.2.3. Treatment

An air or a contrast enema is the first-line treatment as long as there are no contraindications to nonoperative management. Evidence of shock, peritonitis, sepsis, or perforation is the contraindication of enema reduction.

Surgery (open or laparoscopic) is necessary if enema reduction fails or is contraindicated.

2.2.3. Meckel diverticulum

Meckel diverticulum is a remnant of the embryologic vitelline (omphalomesenteric) duct that connects the fetal gut with the yolk sac and normally involutes between the fifth and seventh weeks of gestation [10]. Failure of duct regression results in a variety of abnormalities arising from persistence of the remnant. The most common anomaly (90%) is the classic Meckel diverticulum.

2.2.3.1. Clinical features

Gastrointestinal manifestations of Meckel diverticulum include in order of frequency, bleeding, intestinal obstruction, And inflammation of the diverticulum.

Episodic painless rectal bleeding in a young child is the classic presentation of a bleeding Meckel diverticulum. It results from ulceration of heterotopic acid-producing gastric mucosa of diverticulum.

Bowel obstruction is usually caused by a forbidden band between the umbilical and Meckel diverticulum.

Inflammation of the diverticulum (diverticulitis) is often attributed to the presence of heterotopic gastric or pancreatic tissue and is often misdiagnosed as appendicitis owing to its similar clinical course.

2.2.3.2. Diagnosis

In children presenting with obstruction or inflammation, the diagnosis of a Meckel diverticulum is not typically determined preoperatively. Meckel diverticulitis should be ruled out in any patient with a negative appendectomy. Technetium scan is commonly used to demonstrate heterotopic acid-producing mucosa of Meckel diverticulum.

2.2.3.3. Treatment

The treatment for symptomatic Meckel diverticulum consists of resection using either an open or a laparoscopic approach. Resection may be accomplished by either simple diverticulectomy or segmental ileal resection with anastomosis.

2.2.4. Inguinal hernia

Inguinal hernia is one of the most common surgical diseases [11]. Approximately 1–5% of all children will develop an inguinal hernia and a positive family history is found in about 10%. The incidence of an inguinal hernia varies directly with the degree of prematurity.

2.2.4.1. Clinical features

Most hernias are asymptomatic for inguinal bulging with straining. They are often found by the parents or pediatrician on routine physical examination. Most hernias reduce without treatment or can be reduced easily with a little manual pressure.

Incarcerated inguinal hernia is an emergency. The incidence of hernia incarceration is variable and ranges from 12 to 17%. Symptoms of incarceration are frequently manifested as a fussy or inconsolable infant with intermittent abdominal pain and vomiting. A tender and sometimes erythematous irreducible mass is noted in the groin. Abdominal distension and bloody stool are late signs. Prolonged incarceration may be associated with signs of intestinal obstruction, including poor feeding and vomiting.

2.2.4.2. Diagnosis

Inguinal hernia is a clinical diagnosis. If there are doubts about diagnosis, ultrasonography can confirm the diagnosis before the operation.

2.2.4.3. Treatment

Inguinal hernias that are easily reduced can be operated on electively (open or laparoscopic). An incarcerated hernia requires urgent reduction with firm and continuous manual pressure on the hernia mass. The presence of peritonitis or septic shock is an absolute contraindication to attempted reduction. Symptoms of bowel obstruction are a relative contraindication. Successful reduction is usually confirmed by a sudden "POP" of the contents back into the peritoneal cavity. Urgent operation is necessary if reduction fails.

2.2.5. Trauma

Trauma is the leading cause of morbidity and mortality in children from age 1 to 14 years [12]. Approximately 10% of pediatric hospitalizations and 15% of pediatric intensive care unit (PICU) admissions are dedicated to traumas. Serious intra-abdominal injuries occur in 8% of pediatric trauma victims and are caused by crushing the solid upper abdominal viscera against the vertebral column. Injuries to the liver (27%), spleen (27%), kidneys (25%), and gastrointestinal tract (21%) occur most frequently.

2.2.5.1. Clinical features

While the examination can be challenging given the development level of the child, the use of comfort strategies and distraction can calm the child. Important physical findings include vital signs, abdominal contusions or abrasions, tenderness, or distension. Particular physical findings such as the seat-belt sign are suspicious for the presence of intra-abdominal injury.

2.2.5.2. Diagnosis

Sonography has an adjunctive role in the imaging of pediatric abdominal trauma. Focused abdominal sonography for trauma (FAST) itself is most useful in detecting intra-abdominal blood, but is not sufficiently reliable to exclude blunt abdominal injuries.

CT of abdomen should be obtained in intubated patients, patients with internal bleeding (abdominal tenderness, distension, bruising, or gross hematuria), and evidence of femur fracture, elevation of serum transaminase levels, significant microscopic hematuria, and in severe injuries.

2.2.5.3. *Treatment*

Most of the abdominal injuries in children can be managed nonoperatively.

2.2.5.4. *Indication of emergent laparotomy:*

The indication of emergent laparotomy is as follows:

1. Evidence of ongoing bleeding with an abnormal abdominal examination or a positive abdominal FAST examination.
2. Signs of peritoneal irritation.
3. Pneumoperitoneum.
4. Intraperitoneal ruptures of the urinary bladder.
5. Penetrating renal injury, however, selective observation is also being applied.
6. Hemodynamic instability regardless of resuscitation.
7. Diaphragmatic injury: emergent operative exploration in these patients is indicated in the hemodynamically unstable patients with multiple organ injuries.

3. Conclusion

An expeditious workup is necessary when evaluating children presenting with acute abdominal pain to determine the most likely cause of their symptoms and determine whether or not emergent operative intervention is necessary.

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