Surgical care of neonates, infants, and children differs in many respects from that of adults. Accordingly, it is essential that surgeons caring for preadult patients be capable of recognizing and managing certain clinical problems that occur frequently in this population. To this end, we begin this chapter by discussing several basic considerations related to pediatric physiology, which is markedly different from adult physiology. With this general discussion as a background, we then provide an overview of specific surgical problems commonly encountered in pediatric patients.

**Physiologic Considerations**

**HOMEOSTASIS**

*Fluids and Electrolytes*

Management of fluids and electrolytes in neonates and infants requires a thorough understanding of the changes in body fluid compartments that occur during development [see Figure 1]. At birth, total body water accounts for roughly 75% of total body weight (TBW), but this percentage decreases rapidly in the first few days, falling slowly toward 60% over the first year. Similarly, extracellular fluid volume accounts for 45% of TBW at birth but only 20% by the end of the first year. Newborns have lower glomerular filtration rates and reduced renal concentrating ability; consequently, they tolerate dehydration poorly and cannot excrete a water load as effectively as older persons with mature kidneys can. For this reason, adequate fluid management is especially challenging in these patients.

Measurement of urine output is a useful guide to fluid management, provided that accurate urine collections can be obtained. In critically ill infants and children, a urinary catheter should be inserted to ensure accurate urine collections. Catheterization of male neonates and infants carries a significant risk of trauma to the small urethra; in these patients, the use of properly secured collection bags may allow accurate measurement of urine output without the need for catheter insertion. An appropriate urine output is 1 to 2 ml/kg/hr.

Insensible water loss results from continuous evaporative loss of water through the respiratory tract and the skin. In premature infants, a large proportion of insensible water loss occurs transcutaneously. Insensible water loss from the skin can be minimized by using incubators in the neonatal intensive care unit (NICU) and extremity coverings in the operating room. Insensible water loss from the lungs can be decreased by humidifying the inspired gases.

In general, the maintenance fluid requirement of a neonate is considered to be 70 ml/kg/24 hr initially; this figure rises to 100 ml/kg/24 hr after a few days of life. Neonates with surgical problems may require dramatically increased amounts of fluid.

The sodium requirement of a full-term infant is, on average, 2 mEq/kg/24 hr. Conditions such as intestinal obstruction and peritonitis increase sodium loss and therefore increase sodium requirements. Although full-term infants can retain sodium as well as adults do in the face of a sodium deficit, they are unable to excrete excess sodium as effectively. As a result, excessive infusion of sodium can rapidly result in hypernatremia.

The generally accepted potassium requirement is 2 mEq/kg/24 hr after the first 2 to 3 days of life. However, the need for potassium replacement can be significant in the first few days of life as well, especially after a major surgical intervention. Thus, potassium should be administered in the first 1 or 2 days of life after an operation once urine output has been established.

In view of the various fluid and electrolyte requirements of neonates and infants, the initial fluid used in surgical management of these patients, both preoperatively and postoperatively, should be 5% or 10% dextrose in 0.2% saline [see Table 1].

**Acid-Base Status**

Metabolic alkalosis caused by loss of electrolytes (specifically, chloride) may occur with prolonged gastric suction or vomiting; usually, it is easily corrected by replacing the lost electrolytes (e.g., by administering potassium chloride). Metabolic acidosis, on the other hand, is usually the result of poor tissue perfusion and lactic acidosis; it is best corrected by treating the underlying cause of the
**Table 1** Daily Fluid Requirements for Neonates and Infants

<table>
<thead>
<tr>
<th>Weight</th>
<th>Fluid Requirements*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature &lt; 1.5 kg</td>
<td>150 ml/kg</td>
</tr>
<tr>
<td>Neonates and infants 1.5–10 kg</td>
<td>100 ml/kg</td>
</tr>
<tr>
<td>Infants and children 10–20 kg</td>
<td>1,000 ml + 50 ml/kg over 10 kg</td>
</tr>
<tr>
<td>Children &gt; 20 kg</td>
<td>1,500 ml + 20 ml/kg over 20 kg</td>
</tr>
</tbody>
</table>

*Maintenance Na+ and K+ requirements range from 2 to 4 mEq/kg; solution can generally be given as 0.2% saline, with 5% or 10% dextrose and K+ added.

poor perfusion and by temporarily administering buffers (e.g., sodium bicarbonate). It should be noted that standard sodium bicarbonate solutions are extremely hypertonic and should be diluted before administration, especially when they are being given to neonates.

**Temperature**

In neonates, strict regulation of the environmental temperature is critical for preventing hypothermia. Compared with older children and adults, infants have a higher ratio of body surface area to weight, less subcutaneous fat (and therefore poorer thermal insulation), and less lean body mass (which is required for generating and retaining heat).

Maintaining the body temperature of neonates and young infants is critical both in the NICU and in the OR. In the NICU, the infant may be placed in an incubator (which is designed to reduce airflow across the skin and provide a tightly regulated, thermally neutral environment) or on a bed with an overhead radiant heater. In the OR, the ambient room temperature may be raised, overhead radiant Warmers may be used, circulatory warm air blankets may be applied, and the head and extremities may be wrapped in plastic. Ventilatory gases are warmed and humidified, and warm intravenous and irrigation fluids are used.

**NUTRITION**

Whereas the nutritional requirements of children and teenagers do not differ significantly from those of adults [see **Nutritional Support**], the requirements of infants do. Not only must the metabolic demands that a major illness or operation imposes on all patients be taken into account, but special consideration must also be given to the smaller body size of infants, their rapid growth, their highly variable fluid requirements, and the immaturity of certain of their organ systems. These characteristics, coupled with the low caloric reserves present if the infant is premature or sick, make adequate nutritional intake particularly important. Consequently, infants whose nutritional needs are not met as the result of a functional or organic disorder of the gastrointestinal tract can rapidly acquire protein-calorie malnutrition. Even a relatively short period of inadequate nutrition can lead to impaired host resistance, an increased risk of infection, and poor wound healing, all of which contribute appreciably to morbidity and mortality in infants and children with surgical disease.

**Nutritional Requirements**

Infants have higher weight-adjusted caloric requirements than older children and adults do [see **Table 2**], and these requirements are further increased by periods of active growth and extreme physical activity.11,12 Major illness or surgical trauma may raise caloric requirements even further. However, measured energy expenditures do not appear to be elevated in neonatal surgical patients and critically ill premature infants.13-15 In general, calories should be provided in the proportions found in a well-balanced diet: 50% carbohydrate, 35% fat, and 15% protein.

The protein needs of infants are based on the combined requirements for maintenance and growth. Most of the increase in body protein occurs during the first year of life, which explains why protein requirements are highest in infancy and decrease with age. Of the 20 amino acids from which proteins are synthesized, eight are essential in adults, but it is believed that in addition, histidine is essential in infants and cysteine and tyrosine in premature infants.

In general, infants require more vitamins and minerals than adults do. Increased amounts of calcium and phosphorus are particularly important because of the rapid growth rate of the infant’s skeleton.

**Nutritional Assessment**

In many cases, a sick infant’s history and overall appearance provide sufficient grounds for initiating nutritional support. For example, a preterm infant with respiratory distress who is small for his or her gestational age clearly requires parenteral nutrition, as does a newborn with gastroschisis. Physical variables that should be considered in nutritional assessment include weight, length, head circumference, chest circumference, and triceps skinfold thickness. No blood test reflects changes in the patient’s nutritional status with ideal accuracy, but serum albumin, prealbumin, and transferrin levels are frequently used as markers.

**Enteral Nutrition**

The type of nutritional support to be employed depends on the disease affecting the patient and on the patient’s overall health status. From a physiologic standpoint, enteral nutrition is preferable and is the first choice for patients whose GI tract is functioning adequately.16 For infants younger than 1 year, breast milk or a standard infant formula is delivered orally or via a tube.17 For older children who are unable or unwilling to eat, a liquid diet consisting of either blenderized food or liquid formula may be employed. A number of nutritionally complete liquid formulas are commercially available. Specialized formulas are available for use in patients who have lactose intolerance or protein sensitivity or who are experiencing renal or hepatic failure.

The use of predigested or elemental diets may allow patients with injured intestine or inadequate intestinal length to absorb enteral feedings. In children who cannot manage oral feedings, nasogastric and nasojejunal tubes are used. If the child’s condition necessitates long-term tube feeding, a gastrostomy may be necessary.

**Table 2** Daily Kilocalorie and Protein Requirements for Infants and Children

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Kilocalorie Requirements* (kcal/kg)</th>
<th>Protein Requirements (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1</td>
<td>90–120</td>
<td>2.0–3.5</td>
</tr>
<tr>
<td>1–7</td>
<td>75–90</td>
<td>2.0–2.5</td>
</tr>
<tr>
<td>7–12</td>
<td>60–75</td>
<td>2.0</td>
</tr>
<tr>
<td>12–18</td>
<td>50–60</td>
<td>1.5</td>
</tr>
<tr>
<td>&gt;18</td>
<td>25–30</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*These numbers represent volume administered when 1 kcal/ml solutions are used. Growth can be maintained with 10% to 20% fewer calories if parenteral nutrition is employed.
Postoperative Feeding

Infants have more difficulty in feeding during the early months of life. This is especially true of premature infants, in whom the complex physiology of sucking and swallowing is not yet fully developed. In addition, the work of feeding accounts for most of an infant’s caloric expenditure in the early months, and a stressed infant tires easily. For this reason, gavage or gastrostomy tube feedings are generally employed for the early stages of postoperative feeding in infants. Feeding is begun after the resolution of postoperative ileus has been demonstrated by the passage of meconium or stool. Further evidence that the bowel is beginning to function is the disappearance of the bilious green color of the gastric aspirate and the decrease in the volume of the aspirate from the nasogastric or gastrostomy tube. Initially, small volumes of rehydration fluid are given orally or via a gastrostomy tube. If these are tolerated, the feedings are increased incrementally until the nutritional goals for the patient have been reached.

Infants tolerate increases in volume more readily than increases in osmolality. Accordingly, it is often best to start with diluted formulas (three-quarter-strength, half-strength, or quarter-strength), then, as nutritional requirements grow, increase the volume first and subsequently increase the concentration as necessary to supply the required amount of calories.

Elemental or chemically defined diets require a minimum of digestive work and are free of residual bulk. They may be accepted by infants if given orally; however, they are unpalatable and thus are usually given by tube. Because of the high osmolality of these diets, constant infusion with a pump may be necessary to prevent the development of dumping syndrome. The ease of GI absorption and the minimal residue make elemental diets useful as an intermediate step between parenteral nutrition and regular feedings. In infants, whenever possible, oral feedings or oral stimulation should accompany tube feedings.

Parenteral Nutrition

The concept of total parenteral nutrition (TPN) had been entertained for decades for its initial development, but it was not until the 1960s that the major breakthrough occurred, when Dudrick and associates successfully administered a hypertonic glucose solution into a central vein. In the early years after the group’s initial success, this approach to TPN began to be widely used in newborns with GI anomalies. Since then, the technique has been applied to the care of patients of all age groups, with dramatic results [see 8:22 Nutritional Support]. Less concentrated solutions are available for administration into peripheral veins.

Generally, TPN is reserved for infants and children who are threatened by catabolic or nutritional deficits because feeding via the GI tract is hazardous, inadequate, or impossible. Conditions that may necessitate TPN include intestinal obstruction from congenital disorders, prolonged postoperative ileus, peritonitis, intestinal fistulas, chronic nonspecific diarrhea, necrotizing enterocolitis, short-bowel syndrome, extensive burns, and abdominal neoplasms treated with surgery, chemotherapy, and radiation. Besides being used for nutritional repletion of malnourished children, TPN may also be employed prophylactically when prolonged starvation is expected, as in cases of gastrochisis. In infants, TPN is indicated if nutrition is inadequate for longer than 3 days; however, in older children and adults, a longer period of inadequate nutrition may be tolerated, depending on patients’ nutritional status before operation or at the onset of illness. The benefits of improved nutrition in terms of reducing mortality and morbidity must be weighed against the risks of serious complications, especially sepsis. TPN should not be employed when enteral nutrition is feasible. Every effort should be made to use the enteral route for feeding, including the use of transpyloric feeding tubes.

Infants receiving TPN must be carefully monitored. Essential clinical measurements include weight, length, and intake and output volumes. Blood tests must be employed judiciously and sparingly in infants and children because of their small total blood volume. At the start of therapy and once a week thereafter, a complete blood count should be done, blood urea nitrogen should be measured, and serum levels of electrolytes, glucose, calcium, phosphorus, magnesium, and albumin should be assessed. Serum levels of liver enzymes, bilirubin, and creatinine should be measured at the start of therapy and every 2 weeks thereafter.

On average, neonates gain 15 to 25 g/day with TPN, and older children gain 0.5% of TBW/day. Greater weight gains may signal excessive administration of fluids or intake of calories.

The main complications of parenteral nutrition include catheter-based problems (e.g., sepsis, malfunction, and venous thrombosis), electrolyte abnormalities, and (especially in infants receiving long-term TPN) hepatic cholestasis, which ultimately can result in cirrhosis and hepatic failure. Strategies to minimize liver damage include early and aggressive treatment of infection, avoidance of excessive caloric intake, limitation of protein intake, and supplemental trophic enteral nutrition.

HEMODYNAMIC IMBALANCE AND SHOCK

For proper assessment of shock in infants and children, it is necessary to be familiar with the normal vital signs in these age groups [see Table 3]. The two types of shock most frequently seen are hypovolemic shock and septic shock; in infants and children, septic shock is the most common form. The response of newborns and infants to hypovolemic or septic shock is significantly different from the response of older children and adults. For example, neonates affected by profound shock tend to become bradycardic, whereas adults are more likely to become tachycardic. Moreover, neonates, especially premature neonates, normally have a low blood pressure; consequently, shock often does not evoke any further significant reduction of blood pressure. The hypovolemia caused by the shock...
results in decreased venous return, which lowers cardiac output; the reduced cardiac output leads to poor tissue perfusion and the development of lactic acidosis.

Gram-negative bacteria are the organisms most often responsible for septic shock. Peritonitis resulting from intestinal perforation is a common cause of septic shock in neonates and infants; other causes are urinary tract infections, respiratory tract infections, and contaminated intravascular catheters. The pathophysiology of septic shock differs substantially from that of hypovolemic shock; however, in both states, stasis and pooling of blood in the capillary bed lead to reduction of the circulating blood volume.23

Treatment

The mainstay of therapy for hypovolemic shock is administration of fluid and blood. In neonates, the hematocrit should be maintained at 45% to ensure adequate oxygen delivery. In many infants, hypovolemic shock is caused not by hemorrhage but by dehydration (e.g., from severe gastroenteritis). This dehydration is usually hypertonic because of the significant loss of hypotonic fluid. As a rule, neonates and infants in hypovolemic shock lose much more water than electrolytes, and as a result, serum sodium levels may exceed 150 mEq/L. Emergency treatment involves infusion of isotonic solutions of sodium chloride with careful monitoring of serum electrolyte concentrations.

Because septic shock, like hypovolemic shock, is characterized by reduced circulating blood volume, initial therapy involves infusion of large volumes of colloid solutions. Most of the experimental and clinical data suggest that colloid solutions are preferable to crystalloid solutions in this setting, both for children and for adults. In addition, broad-spectrum antibiotics should always be administered.

If fluid infusion has been maximally effective (as evidenced by a normal to elevated central venous pressure) but hypotension persists, pharmacologic agents must be given to improve myocardial contractility. The most commonly used agents are the alpha and beta agonists dopamine and dobutamine, which primarily have inotropic and mild vasodilatory effects at lower doses. Infants and children in shock require continuous monitoring and close clinical observation and should therefore be managed in the ICU.

Common Surgical Problems of Newborns

Neonatal surgical problems often present as emergencies and necessitate rapid stabilization and transfer of the patient to a pediatric surgical center. Proper initial management is crucial and may have a pronounced effect on overall outcome. The organ systems most commonly affected are the respiratory tract and the GI tract.

EMERGENCY SURGICAL PROBLEMS

In many communities, the general surgeon is frequently called on to assist in the diagnosis and initial care of a neonate with an apparent surgical problem. After stabilization measures have been carried out and preliminary tests have been performed to establish a diagnosis, the baby may be transported to a pediatric center that is specially equipped and staffed to manage the specific surgical problem present.

The steps in the stabilization of a critically ill neonate before transport are similar to the ABCs of initial care in an adult (Airway, Breathing, Circulation). By the time the surgeon is consulted, the neonatologist or pediatrician may have accomplished initial stabilization and begun to prepare the baby for transfer. The surgeon’s immediate responsibility may be to establish vascular access. In some cases, a peripheral venous cannula may be appropriate; more often, a central catheter is inserted via an umbilical vein or artery. In babies with omphalocele or gastrochisis, the I.V. line ideally should be placed in the upper extremities or the neck. Appropriate fluids should be infused to prevent dehydration and to correct any fluid or electrolyte deficits. When required, a nasogastric or esophageal suction tube should be placed and decompression initiated. This maneuver is extremely important if transport by air is considered: trapped gases change in volume with alterations in barometric pressure, and such changes may have particularly deleterious effects on infants who have intestinal gas, pneumothorax, or pneumomediastinum.

Vitamin K should be given in the form of phytonadione, 1 mg (0.5 mg for babies who weigh less than 1,500 g). Appropriate antibiotics should also be administered. Finally, the infant should be wrapped and placed in an incubator or a radiant warmer to stabilize body temperature and maintain it at normal levels.

The use of sophisticated transport teams with appropriate equipment and supplies is the safest method of moving these babies between hospitals. Early stabilization and close communication between the referring physician, the accepting physician, and the transport team are essential for minimizing the potential risks and morbidity associated with patient transfer.

The following seven emergency surgical problems are commonly encountered in neonates. Each involves special considerations in the preparation of the patient for interhospital transfer.

1. Congenital diaphragmatic hernia (CDH): insert a nasogastric or orogastric tube. Ventilation by face mask is contraindicated; if ventilation is required, intubate.
2. Esophageal atresia: insert a tube to aspirate secretions from pouch (use a Replogle tube, if available). If possible, avoid mechanical ventilation; if intubation is required, use high-frequency, low-pressure ventilation to prevent distention and possible perforation of the stomach.
4. Intestinal obstruction: use nasogastric or orogastric suction. Confirm placement and function of I.V. lines.
5. Omphalocele or gastrochisis: use nasogastric or orogastric suction. Cover the sac with nonadherent gauze, and take care not to rupture the membrane (if present); cover the intestine with saline-soaked gauze and a see-through bowel bag. Place the I.V. line in the upper extremity or the neck, if possible. Maintain hydration by increasing fluid administration to replace fluid lost from the exposed bowel. Support the bowel with dressings. Maintain body temperature.
6. Exstrophy of the bladder: cover the exposed bladder with a nonadherent dressing.
7. Meningomyelocele: cover the sac with a nonadherent dressing.

RESPIRATORY PROBLEMS

Cystic Disease of the Lung

Cystic lung disease, especially congenital cystic adenomatoid malformation (CCAM) of the left lower lobe, can mimic diaphragmatic hernia both clinically and radiographically [see Figure 2a].24,25 Unlike a newborn with diaphragmatic hernia, however, a newborn with CCAM will have an abdomen with the normal degree of protuberance. If an infant with CCAM experiences marked respiratory distress that necessitates intubation and mechanical ventilation, it is better to perform an emergency lobectomy than to subject the baby to a period of mechanical ventilation, with its
attendant risks (i.e., barotrauma and oxygen toxicity). If the lesion is asymptomatic, it can be resected later in infancy to prevent infectious complications and possible (albeit rare) transformation into a malignancy.

**Diaphragmatic Hernia**

Infants with CDH may be quite ill at birth, often suffering from acute respiratory distress and hemodynamic instability. Because the intestines are located in the chest, an infant with CDH appears to have a scaphoid abdomen [see Figure 2b]. The entire stomach may be in the chest, and as a result, it may be difficult to pass a nasogastric tube into the stomach. A plain x-ray usually establishes the diagnosis.

CDH is an embryopathy that results from abnormal development of the diaphragm and the lungs. The defect in the diaphragm allows herniation of abdominal contents. On the affected side, as well as on the contralateral side, the lung shows hypoplasia, which varies in severity. The small vessels (arterioles) are excessively muscularized and can easily constrict. The main pathophysiologic consequence of CDH is not the presence of the hernia but, rather, severe pulmonary hypertension. Accordingly, initial treatment is aimed at preventing or, if prevention is not possible, mitigating pulmonary hypertension and its sequelae.

Babies with CDH require immediate resuscitation, correction of acidosis, and, in most cases, endotracheal intubation. Placement of an orogastric tube can help decompress the GI tract. Once the baby is relatively stable, surgical intervention should be delayed to allow time for the pulmonary hypertension to decrease or disappear. There is evidence to suggest that gentle ventilation with permissive hypercapnia may decrease secondary barotrauma and long-term morbidity. If the baby cannot be stabilized with conventional, jet, high-frequency, or oscillation ventilation and inhaled

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**Figure 2** Shown are common neonatal chest abnormalities: (a) congenital cystic adenomatoid malformation (CCAM) with a large cyst in the left lung (arrow) and mediastinal shift; (b) congenital diaphragmatic hernia (CDH) on the right side, with the liver and intestines within the chest cavity; (c) hyperinflated left lung with mediastinal shift caused by lobar emphysema; and (d) pulmonary sequestration with consolidation caused by pneumonia.
Nitrous oxide,
extracorporeal membrane oxygenation (ECMO) may be indicated; the hernia should be addressed after the ECMO run is completed. If the procedure, the intestines are reduced into the abdominal cavity, and the diaphragmatic defect is repaired, either in the OR or in the NICU. However, the operative procedure usually does not significantly alter the underlying pathophysiologic condition. In many cases, the newborn’s condition improves at first after the operation but then begins to deteriorate. This response is seen less frequently with delayed surgical repair. If conventional treatment fails to control the pulmonary hypertension, ECMO may be instituted postoperatively. The precise impact of ECMO on overall outcome for CDH is still a matter of debate, though most pediatric surgeons agree that this technique has a role as a lifesaving measure if all other interventions fail.

Lobar Emphysema

The term lobar emphysema refers to overexpansion of a segment of lung, which can compromise ventilation in a newborn if significant compression of a healthy lung or a mediastinal shift occurs. If the patient is exhibiting symptoms, urgent resection is usually required, though emergency bronchoscopic decompression has also been employed in this setting. If the patient shows no significant symptoms, follow-up directed toward the affected areas of the lung is appropriate; occasionally, the condition resolves spontaneously.

Pulmonary Sequestration

The term pulmonary sequestration denotes a condition in which lung tissue is supplied with blood by the systemic circulation. Often, this condition is diagnosed prenatally by means of fetal ultrasonography. Patients with pulmonary sequestration are often asymptomatic at birth, but if respiratory distress develops, urgent surgical intervention is required. If the lesions remain asymptomatic, removal later in life is recommended so that they do not become a nidus for infection.

Intestinal Obstruction

Not uncommonly, surgeons are asked to evaluate newborns for possible obstruction of the GI tract. These patients usually present with choking or vomiting. The list of possible causative conditions is fairly extensive, and most of these conditions must ultimately be managed by a pediatric surgeon. Nevertheless, it may be helpful in the initial stages to employ an algorithmic approach, which often serves to narrow the range of possible causes.

The color of the emesis helps to establish the level of the obstruction. If the emesis is nonbilious, the obstruction is proximal to the ampulla of Vater. If an orogastric tube cannot be placed, the diagnosis is esophageal atresia, which can be confirmed by a chest x-ray that demonstrates a curled-up tube in the upper esophageal pouch. If the x-ray shows air below the diaphragm, the diagnosis is a distal tracheoesophageal fistula. If there is no mechanical obstruction of the esophagus, the diagnosis may simply be gastroesophageal reflux (GER). Other surgical causes of nonbilious emesis are preampullary duodenal atresia or web, neonatal pyloric stenosis (uncommon), and pyloric atresia (extremely rare).

Bilious emesis in a newborn is a potentially more serious problem. Except for medical ileus, the main causes are all related to underlying surgical problems. If the baby’s abdomen is not distended, he or she may have a proximal obstruction. If an abdominal x-ray series shows a double-bubble sign without distal air, duodenal atresia is likely. If distal air is seen, the diagnosis is either a duodenal web or malrotation with possible volvulus. The latter represents a much more worrisome situation and constitutes a true surgical emergency, which must be diagnosed quickly by means of an upper GI study. In a newborn with volvulus, prompt exploration is required to prevent extensive necrosis of the midgut.

If the abdomen is distended, the obstruction is more distal. Physical examination is warranted to rule out an incarcerated inguinal hernia. Inspection of the perineum is necessary to look for possible anorectal malformation. Stippled calcifications on an abdominal film are pathognomonic of meconium peritonitis, which usually necessitates surgical exploration. If the anus is patent, a contrast enema study helps establish a diagnosis. A microcolon represents an unused lower GI tract, which may be seen with jejunoileal atresia or meconium ileus. The latter condition is usually characterized by the presence of large amounts of meconium in the terminal ileum and can often be treated successfully by administering water-soluble contrast enemas. There are other meconium-related functional obstructions that occur without microcolon, such as meconium plug syndrome and small left colon syndrome, both of which usually respond to treatment with enemas. If the lower GI study shows a normal or slightly dilated colon with a narrowed or spastic-appearing rectosigmoid, the likely diagnosis is Hirschsprung disease, which can be confirmed by suction biopsy of the rectum.

Abdominal Wall Defects

The overall incidence of neonatal abdominal wall defects is approximately one in every 2,000 births; however, the incidence of gastroschisis appears to be rising slowly. Omphalocele represents an arrest in development, which may explain the increased frequency of chromosomal abnormalities and other structural birth defects in children with this condition. The exact cause of gastroschisis is unclear, but it does not represent a normal stage of development; it appears to be more common with younger mothers, and environmental factors seem to play a role.

The extra-abdominal intestine is prone to vascular compromise, which explains the higher incidence of bowel atresia in these patients. Although debate continues, most authors believe that babies with gastroschisis can safely be delivered vaginally.

Although omphalocele is associated with a higher overall mortality than gastroschisis, the latter is more challenging to manage in the immediate postnatal period. The exposure of bowel results in greater insensible loss of fluid and heat. Kinking of the intestinal blood supply may lead to venous congestion and ischemia. It is crucial to place children with gastroschisis in a warm environment and to protect the bowel (which is easily accomplished with the help of a plastic bowel bag). Intravenous access should be established immediately, and resuscitation should be initiated, guided by the infant’s heart rate. Transfer to a pediatric surgical center is mandatory. The surgical options are (1) primary repair of the defect, if the abdominal cavity accommodates the exposed organs easily, and (2) gradual reduction of the intestines by means of a silo technique.

Emergency surgical intervention is rarely required for management of omphalocele. Such defects may be either closed primarily or repaired with any of several staged approaches, depending on their size. Giant omphaloceles are best treated observantly, with the overlying membrane used as a temporary silo and definitive repair delayed until a reasonable intra-abdominal domain has developed.

Circumcision

Circumcision remains one of the most commonly performed procedures in male newborns. Approximately 1.2 million circumcisions are performed annually in the United States. Although the precise etiology of penile cancer is unknown, it is clear that circumcision is associated with a reduced risk of penile cancer. In addition, circumcision has been shown to reduce the incidence of urinary tract infections, homosexual infections, and heterosexual infections. It is estimated that circumcision reduces the risk of acquiring HIV by about 60%.
Neonate presents with symptoms of GI obstruction (typically choking or emesis)

**Emesis is nonbilious**

Attemp to place oro gastric tube.

**Emesis is bilious**

Look for underlying medical or surgical condition.

OG tube can be placed

Patient has gastroesophageal reflex, preampullary duodenal atresia or web, pyloric stenosis, or (rarely) pyloric atresia. Treat with semielective surgery.

OG tube cannot be placed

Patient has esophageal atresia. Obtain x-rays of chest to confirm diagnosis. VACTERL workup is indicated. Air seen below diaphragm signals presence of distal tracheoesophageal fistula. If patient is sick, treat with gastrostomy and delayed repair. If not, treat with primary repair.

Abdomen is distended

Perform physical examination; inspect perineum.

Abdomen is not distended

Obtain x-rays of upper GI tract to assess completeness of obstruction.

Malrotation/volvulus is ruled out

Patient has duodenal atresia/web or annular pancreas. Treat with semielective duodenoduodenostomy.

Findings are suggestive of malrotation/volvulus

Treat surgically on emergency basis.

Patient has incarcerated inguinal hernia

Reduce and repair hernia.

Anus is patent

Obtain abdominal x-rays.

Anus is not patent or perineal fistula is noted

Patient has anorectal malformation. *High lesion*: treat with colostomy or pullthrough. *Low lesion*: treat with perineal anoplasty.

Abdominal x-ray shows calcifications

Patient has meconium peritonitis. Treat surgically on urgent or emergency basis.

Abdominal x-ray shows low lesion

Patient has microcolon

Patient has jejunoileal atresia or meconium ileus. Treat jejunoileal atresia with primary repair. Treat meconium ileus with water-soluble enemas.

Patient has normal or dilated colon

Obtain lower GI contrast study. Consider rectal biopsy.

Rectal biopsy specimen contains no ganglion cells

Patient has Hirschsprung disease. Treat with pullthrough or colostomy.

Rectal biopsy specimen contains ganglion cells

Patient has meconium plug syndrome or small left colon syndrome. Treat with water-soluble enemas.
Common Surgical Problems in Infants and Children

PYLORIC STENOSIS

Hypertrophic pyloric stenosis affects between two and five of every 1,000 children; it is more common in white boys. Patients typically present with progressive, projectile, nonbilious emesis 2 to 6 weeks after birth. They may show signs of severe dehydration with a hypochloremic, hypokalemic metabolic alkalosis (though the literature suggests that the incidence of this finding may be decreasing). Medical approaches to managing this problem have been described, but surgical correction after resuscitation is the treatment of choice. The classic open pyloromyotomy developed by Fredet-Ramstedt is still widely performed, and advances in minimally invasive techniques have made it possible to perform laparoscopic pyloromyotomy with safety and efficacy.

GASTROESOPHAGEAL REFUX

For appropriate treatment of GER in infants, it is important to distinguish between uncomplicated physiologic GER and symptomatic GER. Symptoms that necessitate treatment include poor weight gain, esophagitis, apnea, apparent life-threatening events, and pulmonary complications. Upper GI contrast studies and 24-hour continuous pH monitoring are the gold standards for assessment. Endoscopy and esophageal biopsy may be useful for diagnosis and the evaluation of treatment. If GER does not resolve with simple feeding and positioning adjustments, acid suppressants, prokinetic therapy, or surface agents may prove effective. If GER is associated with anatomic abnormalities (e.g., hiatal hernia), apparent life-threatening events, or symptoms that persist despite optimal medical therapy, surgical intervention is usually indicated. In infants and younger children who require a feeding gastrostomy, a protective fundoplication is usually necessary if reflux is demonstrated on the upper GI study.

In the United States, the procedure most commonly performed to treat GER is a 360° Nissen fundoplication, though partial posterior (Toupet) fundoplication appears to yield comparable results. Both procedures can also be performed laparoscopically. Initial success rates with surgical treatment are high, but long-term complications (especially recurrent reflux) are frequent, resulting in redo rates ranging from 7% to 26%.

NECK AND SOFT TISSUE MASSES

A neck mass [see 2:3 Neck Mass] is a common reason for a child to be seen by a surgeon. Even though the vast majority of these masses are benign, they often cause significant worries for parents. A detailed history and a thorough physical examination are crucial for narrowing down the otherwise extensive differential diagnosis [see Table 4].

The masses that are most commonly encountered in infants and children are enlarged lymph nodes caused by reactive postinfectious hyperplasia. Such masses feel soft, are often slightly tender on palpation, and tend to shrink over time. A higher degree of concern is appropriate with neck masses that are located supracavicularly, grow rapidly, develop at multiple sites, are fixed to surrounding tissues, or feel hard. Swift diagnosis of the underlying process is crucial in this situation. Fine-needle aspiration (FNA) biopsy may render an initial diagnosis, but most treatment protocols require more tissue, which can be obtained through open surgical biopsy. Before the procedure, a chest x-ray should be obtained to determine whether the mass involves the mediastinum.

A mass in the anterior midline may be a remnant of the thyroglossal duct. Such masses should be excised at diagnosis to prevent any subsequent infectious complications. To minimize the risk of recurrence, the procedure includes the removal of the midportion of the hyoid bone. A lateral neck mass, with or without a sinus tract to the skin, may be a remnant of the fetal branchial apparatus. Such masses should also be completely excised to reduce the risk of complications.

ABDOMINAL WALL HERNIA

Inguinal and umbilical hernia repairs are among the most commonly performed procedures in pediatric surgery. Umbilical hernias are commonly diagnosed at birth but tend to close spontaneously. The complication rate is very low, and thus, most pediatric surgeons postpone surgical repair until the patient is 2 to 4 years old. Inguinal hernias, on the other hand, pose a substantial risk of incarceration, especially during infancy, and should therefore be repaired as soon as they are diagnosed. High ligation of the sac is the treatment of choice. This operation is usually straightforward, but it can be challenging at times, particularly in premature infants with large hernias. Complications are rare; they tend to occur more frequently if the infant is premature or if the procedure was done on an emergency basis. To minimize the risk of injury to the spermatic cord, a “no touch” technique should be employed. Whether the contralateral side should be explored remains controversial; some surgeons now use laparoscopy to assess the processus vaginalis of the opposite side.

UNDESCENDED TESTICLES

Approximately 4% of male neonates have an undescended testis at birth, but only about 1% still have this condition at the age of
ABDOMINAL PAIN

Abdominal pain is a common finding in children and may arise from any of a wide variety of causes. Among surgical diseases, acute appendicitis is the most common cause of abdominal pain. In addition, however, the differential diagnosis must include perforated duodenal ulcer, Meckel’s diverticulum, ulcerative colitis, Crohn disease, ruptured ovarian cyst, pelvic inflammatory disease, and, in younger children, intussusception. It is important to remember that medical problems (e.g., constipation, gastroenteritis, pancreatitis, and pneumonia) can also give rise to substantial abdominal discomfort.

Appendicitis

The diagnosis of appendicitis is based on the presence of localizing physical findings in the right lower quadrant of the abdomen. Even if the history and laboratory data are not typical, the presence of such findings should allow the surgeon to make the diagnosis and proceed with appropriate management.

If perforation of the appendix is suspected preoperatively, administration of broad-spectrum antibiotics should be started, and crystallloid should be infused. Intraoperative management of acutely perforated appendicitis varies widely among pediatric surgeons in the United States. The evidence published to date on the benefits of intraoperative drain placement, peritoneal cultures, and laparoscopic techniques remains controversial.

In most cases of perforated appendicitis, the wound can be closed primarily. Although there is some debate regarding the utility of imaging studies in patients with the classic findings of acute appendicitis, it appears that CT can be quite helpful in patients with delayed presentations or atypical symptoms. If perforated appendicitis with an abscess is identified, a safe and cost-effective treatment approach is to give antibiotics (first I.V., then oral), drain the collection percutaneously, and perform an interval appendectomy 6 weeks later.

Crohn Disease

Occasionally, a teenager who exhibits the classic signs and symptoms of appendicitis turns out to have Crohn disease of the terminal ileum. This condition will be obvious at operation, when the mesenteric fat is seen to be creeping up along the sides of the inflamed ileum. If the base of the appendix is free of disease, appendectomy should be performed at the time of exploration. When the child has fully recovered from the operation, a definitive workup, including a small bowel series and a colonoscopy with biopsy, should be performed to ascertain the extent of the Crohn disease. If an enterocutaneous fistula develops, TPN will be required for a prolonged period. If an intestinal stricture develops (typically, in the terminal ileum), resection may be required. Associated perianal Crohn disease can be very challenging to treat. Medical therapy and surgical therapy should be carried out conjointly. Conservative surgical options (e.g., local drainage, fistulotomy, and setons) are preferred; if sepsis does not resolve or if severe incontinence persists, a stoma may be required.

Intussusception

Idiopathic intussusception usually develops between the ages of 6 months and 2 years. The invagination of small bowel into the cecum results in severe, crampy, intermittent abdominal pain, often associated with obstructive symptoms and bloody stools. Marked lethargy is also a frequent symptom. Air enemas and ultrasound-guided hydrostatic reduction have both been employed to treat this condition, with great success. Surgical exploration should be reserved for patients in whom reduction is unsuccessful and patients in whom there is reason to suspect an anatomic lead point that is causing the intussusception.

Meckel’s Diverticulum and Lower GI Hemorrhage

Meckel’s diverticulum represents a remnant of the omphalomesenteric duct. It occurs in approximately 2% of the pediatric population. If symptomatic, it can be associated with acute and substantial lower GI bleeding, obstruction, or diverticulitis. The differential diagnosis of lower GI bleeding in children also includes GI infections, colonic polyps, duplication cysts, and inflammatory bowel disease. Meckel diverticulitis presents with symptoms very similar to those of acute appendicitis and should always be ruled out if the appendix appears normal on exploration. Management of an asymptomatic diverticulum discovered during an abdominal operation remains controversial, even though resection has been shown to carry a low risk of complications.

VENOUS ACCESS

To obtain venous access in an infant, a venous cutdown is performed, and a pediatric silicone (Broviac) catheter is passed through the common facial, external jugular, or internal jugular vein to the superior vena cava. This procedure is carried out in an OR or, if necessary, in the NICU. Adequate exposure must be obtained, proper instruments and fluoroscopy devices should be available, and strict aseptic conditions must be maintained. The venous catheter is tunneled from the point of entry into the vein to a skin exit site 5 to 10 cm away, with the aim of minimizing the likelihood of bloodstream contamination from dressing changes at the skin exit site. The catheter is brought out on the chest wall, where it is easily accessible and unlikely to be disrupted by an active patient. When no vein sites are available in the neck, the catheter may be advanced into the central venous circulation via a cutdown on the greater saphenous vein and tunneled to an exit site on the abdominal wall or the leg. In older children and adults, percutaneous puncture of the subclavian vein is often performed in place of venous cutdown; this technique can also be used in infants. Regardless of the technique employed, manipulation of the catheters must be done with close attention to asepsis and antisepsis to minimize the risk of bacterial and fungal infection.

Pediatric Trauma

Whereas accidents are the third most common cause of death in the United States population as a whole, they are the single most common cause of death in children between the ages of 1 and 15 years. Every year, about 20 million injuries occur in children, resulting in approximately 15,000 deaths and 100,000 cases of permanent disability. The first approach to be considered in...
managing pediatric trauma is clearly prevention. In fact, preventive efforts have been gaining momentum, thanks in part to support from federal funds and from dedicated individual advocates. These efforts have included greater emphasis on the use of pediatric restraint devices in automobiles, improvements in the design of motor vehicles, the wearing of helmets by bicycle and motorcycle riders, improvements in the design of space heaters, the use of fire-retardant material for children’s clothes (as dictated by the Flammable Fabrics Act), proper packing and labeling of poisons and medications, and the installation of appropriate fencing around swimming pools.

GENERAL PRINCIPLES

Although the general principles of trauma care are essentially the same for children as for adults, there are several significant differences that must be taken into account in the care of pediatric accident victims. For example, children do not react to trauma in the same way as adults do. They often have difficulty in expressing pain and in articulating their complaints. They are often extremely frightened after an accident, and this fear may cause them to give misleading signals (e.g., by exhibiting signs of an acute abdomen even though no intra-abdominal injury has occurred). Children who experience stress often undergo developmental regression, typically accompanied by severe depression. All these psychological factors must be considered in the treatment of a pediatric accident victim.

Another key difference between children and adults is that children are still growing. Postoperative metabolic management after any form of stress, whether from a surgical procedure, from trauma, or from some other event, must take this difference into account. Children can compensate for hypovolemia effectively and keep their vital signs in the normal range, even in the presence of shock. However, a small blood loss that would be insignificant in an adult can result in marked hemodynamic changes in a small child. Moreover, water and heat loss can be far more extensive in small children than in older children and adults because smaller children have a greater surface area in relation to their weight and have a relative lack of insulating subcutaneous fat. Hypothermia aggravates acidosis and makes hemodynamic resuscitation much more difficult. Gastric dilatation, which can result in vomiting and pulmonary aspiration, is very common in young children after all forms of trauma. Finally, the nutritional requirements of injured children are greater than those of injured adults because children, as growing organisms, naturally have a high metabolic rate. Consequently, TPN often must be started earlier in the treatment of a child than it would be in the treatment of an adult in a comparable condition.

Not only are there significant physiologic and psychological differences between children and adults after trauma but there also are differences in accident patterns. Most childhood injuries result from blunt trauma. Head trauma is far more common in children than in adults: in fact, it accounts for most of the morbidity and mortality in the pediatric population. After motor vehicle accidents, which are the major cause of trauma in both children and adults, the next most frequent causes of trauma in children are events that are less important causes in adults: falls, bicycle accidents, drowning, and burns from fires. Child abuse [see Child Abuse, below] is a unique and important cause of trauma in children.

Pediatric accident victims must be treated in centers that have experience in the care of traumatized children. Such centers must have an emergency department with a section that is specifically set aside for the care of children and is staffed by nurses and physicians who are familiar with the management of pediatric trauma. They must have a hospital with a pediatric ICU that is also staffed by experienced medical and paramedical personnel. Finally, they must have a transportation system that is capable of rapidly transporting critically ill pediatric trauma victims both by air and by land or water. The Pediatric Trauma Score [see Table 5] has been successfully used not only as a tool for grading severity of injury but also as a means of comparing trauma care across institutions.

AIRWAY MANAGEMENT, PAIN RELIEF, AND SEDATION

Establishing and maintaining a secure airway is of the utmost importance in treating any injured child. Most pediatric trauma programs have mechanisms in place that delegate this responsibility to the attending emergency physician or anesthesiologist so that the surgical team can continue assessing the patient. The airway team can also provide conscious sedation or elective intubation if a painful procedure (e.g., reduction of fractures or suturing of lacerations) proves necessary.

MANAGEMENT OF HEAD INJURY

Closed head injuries (CHIs) are the most common cause of death in children and account for close to 7,000 fatalities in the United States each year. Any child who had a witnessed loss of consciousness, is mentally altered, or has an abnormal Glasgow Coma Scale (GCS) score should undergo urgent CT scanning of the head. If the GCS score is lower than 8, intubation is necessary.

<p>| Table 5 Pediatric Trauma Score |</p>
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coded Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>&gt; 20 kg</td>
<td>+2</td>
</tr>
<tr>
<td>10–20 kg</td>
<td>+1</td>
</tr>
<tr>
<td>&lt; 10 kg</td>
<td>−1</td>
</tr>
<tr>
<td>Airway status</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>+2</td>
</tr>
<tr>
<td>Maintainable</td>
<td>+1</td>
</tr>
<tr>
<td>Not maintainable</td>
<td>−1</td>
</tr>
<tr>
<td>Systolic BP</td>
<td></td>
</tr>
<tr>
<td>&gt; 90 mm Hg</td>
<td>+2</td>
</tr>
<tr>
<td>50–90 mm Hg</td>
<td>+1</td>
</tr>
<tr>
<td>&lt; 50 mm Hg</td>
<td>−1</td>
</tr>
<tr>
<td>In the absence of proper size BP cuff, assess BP by assigning these values:</td>
<td></td>
</tr>
<tr>
<td>Pulse palpable at wrist</td>
<td>+2</td>
</tr>
<tr>
<td>Pulse palpable at groin</td>
<td>+1</td>
</tr>
<tr>
<td>Pulse not palpable</td>
<td>−1</td>
</tr>
<tr>
<td>CNS status</td>
<td></td>
</tr>
<tr>
<td>Awake</td>
<td>+2</td>
</tr>
<tr>
<td>Partially conscious or unconscious</td>
<td>+1</td>
</tr>
<tr>
<td>Comatose or decerebrate</td>
<td>−1</td>
</tr>
<tr>
<td>Open wounds</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>+2</td>
</tr>
<tr>
<td>Minor</td>
<td>+1</td>
</tr>
<tr>
<td>Major</td>
<td>−1</td>
</tr>
<tr>
<td>Skeletal injury</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>+2</td>
</tr>
<tr>
<td>Closed fracture</td>
<td>+1</td>
</tr>
<tr>
<td>Open/multiple fractures</td>
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</tr>
<tr>
<td>Range of possible scores</td>
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</tr>
<tr>
<td>−6 to +12</td>
<td></td>
</tr>
<tr>
<td>Scoring triage criterion for direct transport of patient to trauma center</td>
<td>&lt; 9</td>
</tr>
</tbody>
</table>
to protect the airway. The main focus of therapy for severe CHI is on minimizing secondary insult to the brain by optimizing oxygen delivery. Management involves close monitoring of cerebral perfusion pressure and judicious use of sedatives, anticonvulsants, pres- sors, intraventricular drainage, or even surgical decompression to optimize cerebral perfusion. Evidence-based practice guidelines for the management of pediatric CHI patients are now available.111

Because children with even minor structural injuries to the brain are at risk for hyponatremia, close monitoring of sodium levels is required.112,113 Patients who have postconcussive symptoms (e.g., vomiting, seizures, or headache) should be admitted, even if the head CT reveals no structural injury. It is our practice to follow these patients for 3 weeks after the injury to determine whether postconcussive symptoms are persisting. If these symp- toms have not resolved, patients undergo a more detailed cogni- tive evaluation.

CERVICAL SPINE CLEARANCE

Cervical spine injuries in children are very rare but can have cat- astrophic consequences if missed. As with adult trauma patients, it is crucial to follow established protocols for systematically clearing the cervical spine. Early immobilization, clinical examination, plain x-rays, and advanced imaging studies can all be useful. Because of the anatomic differences between children and adults, certain modifications to adult protocols are necessary.114,115

BLUNT SOLID-ORGAN INJURY

Abdominal trauma in children is usually blunt. Penetrating injuries occur in only about 20% of children who sustain trauma and are managed in essentially the same way as they are in adults [see Section 7 Trauma and Thermal Injury].

Children who sustain major trauma often have intra-abdominal injuries. Because gastric dilatation and reflex ileus are far more common in children than in adults after a major injury, the initial clinical evaluation of the child’s abdomen may be highly misleading. Early insertion of a nasogastric tube decompresses the stomach and allows more accurate physical examination of the abdo- men; in addition, it reduces the risk of aspiration pneumonitis. Once the child is stable with respect to hemodynamic and respi-
accepted method of management for most hepatic and splenic injuries. Associated fractures of the lower ribs are rare in children with injuries to the liver or the spleen, though they are fairly common in adults with such injuries.122

The initial plain film of the abdomen often demonstrates medi- and inferior displacement of the gastric bubble caused by accumula-
tion of blood under the left diaphragm. A CT scan will then accurately confirm the diagnosis of a splenic injury. A major reason why nonoperative treatment is recommended for pediatric splenic injuries is that the risk of overwhelming postsplenectomy infection (OPSI) is far higher in children than in adults; the younger the child, the higher the risk of OPSI. OPSI develops in 3.3% of pediatric patients who have undergone splenectomy and carries a mortality of 50%.123

Once a hepatic or splenic injury has been diagnosed, manage-ment should follow the established guidelines for treatment of blunt solid-organ injuries in children.124-126

Ongoing hemodynamic instability despite aggressive resuscita-
tion is the main indication for operative intervention; fortunately, it is a rare occurrence. The likelihood of successful nonoperative management of hepatic and splenic injuries continues to be higher in designated pediatric trauma centers.127

The finding of intra-peritoneal fluid on a CT scan without evi-
dence of solid-organ injury remains a challenging clinical prob-
lem. Management of patients with this finding should be individ-
ualized; treatment options include observation with serial exami-
inations, laparoscopy, and surgical exploration.117,128

Among the less common injuries to intra-abdominal organs that occur in children are perforation of the stomach when an acci-
dent occurs shortly after eating (while the stomach is distended), perforation of the small intestine and large intestine at a point of fixation (e.g., the ligament of Treitz or the cecum), rupture of the left diaphragm, and damage to the duodenum or pancreas. The likelihood of visceral injury increases dramatically if bruising from a lap belt or a chance fracture is present.129-131 Retroperitoneal perforation is suggested by the presence of air around the right kidney on a plain abdominal x-ray. Traumatic pancreatic injury is suggested by an elevation in serum amylase and lipase levels and by the presence of pancreatic edema on ultrasonography or CT. Obviously, perforations of the stomach, the intestine, or the du-
odenum call for exploratory laparotomy; in most cases, simple suture repair of the laceration is sufficient. Injury to the pancreas, on the other hand, can usually be managed nonoperatively with nasogastric decompression and I.V. fluids. Fracture of the pancre-
atic duct is quite rare in children and is usually secondary to com-
pression of the pancreas against the vertebral column. In the past, this injury was usually treated with exploratory laparotomy and distal pancreatectomy, but current experience indicates that it can often be successfully treated by nonoperative means, though there is a risk that pseudocysts will subsequently develop.132-134 Intramural duodenal hematoma is relatively uncommon in children and is usually well managed by providing nasogastric decompression for about 10 days and instituting TPN.135

In any child who has sustained abdominal trauma, the diagno-
sis of a pelvic fracture should be seriously considered. Pelvic frac-
tures can result in significant bleeding into the retroperitoneum, as well as injuries to the bladder and the urethra. The diagnosis can be confirmed by x-ray studies of the pelvis. In most cases, the fracture can be treated with bed rest, immobilization, and the replace-
ment of lost blood.136

Children with blunt multisystem trauma seldom die if they are alive when brought to an emergency department, unless they have sustained head injuries. Care of these patients requires aggressive, coordinated efforts on the part of a multispecialty team that is under the direction of a pediatric surgeon. The establishment of specifically designated pediatric trauma centers around the country was one of the most important developments in the care of children to occur in the 1980s; since then, multiple studies have demonstrated that this measure has substantially improved outcomes for injured children.137

CHILD ABUSE

One of the unique varieties of pediatric trauma is child abuse, or the battered-child syndrome. It is a sad fact that intentional trauma is the most common cause of fatal injury in children younger than 1 year. The exact incidence of child abuse is not known, but it is believed that in the United States, about 160,000 children are seriously injured by deliberate abuse each year.138 Risk factors include a low socioeconomic background, a single-
parent family, low birth weight, and multiple siblings.139,140 The victims tend to be younger than 2 years, except when sexual abuse is involved, in which case the average age is about 10 years. The abuse can take many different forms, such as physical or mental injury, nutritional or hygienic neglect, delayed or inadequate treat-
ment of disease, sexual abuse, and verbal abuse. Salient clues to the diagnosis include an unreasonable delay in seeking medical help for the child, inconsistencies between the trauma observed and the injury mechanism described, poor hygiene, and marked depression or lack of emotion in the child. The injuries most commonly seen are soft tissue injuries, burns, fractures, and head trauma. X-ray evidence of healing fractures of different ages (a finding described as long ago as 1946) and of rib fractures is highly cor-
related with abuse.122,141 Visceral injuries (e.g., hepatic fractures, splenic fractures, duodenal hematomas, and pancreatic fractures) are also associated with abuse, though less frequently.

Once a physician suspects child abuse, he or she is both legally and ethically obligated to report the situation to the appropriate hospital team and to the social services agency of the local juris-
diction. The typical hospital team usually includes a physician, a social worker, and a nurse. Prompt and full reporting often improves the chances that the parents will receive positive coun-
seling, which may well reduce their subsequent abuse of the child.
References


