Chapter 346

Inguinal Hernias

John J. Aiken and Keith T. Oldham

Inguinal hernias are one of the most common conditions seen in pediatric practice and the most common surgical procedure performed in pediatric surgical practice. The frequency of this condition in concert with its potential morbidity of ischemic injury to the intestine, testis, or ovary makes proper diagnosis and management an important part of daily practice for pediatric practitioners and pediatric surgeons. The overwhelming majority of inguinal hernias in infants and children are congenital **indirect** hernias (99%) as a consequence of a patent processus vaginalis (PV); a developmental structure important in testicular descent. The incidence of inguinal hernia in children is up to 10 times higher in boys than in girls. Two other types of inguinal hernia are **direct** (acquired) hernia (0.5-1.0%) and **femoral** hernia (<0.5%). Approximately 50% of inguinal hernias manifest clinically in the 1st yr of life, most in the 1st 6 mo. Premature infants have an incidence of

inguinal hernia approaching 30%. The risk of incarceration and possible strangulation of an inguinal hernia is also greatest in the 1st yr of life (30-40%) and mandates prompt identification and operative repair to minimize morbidity and complications.

EMBRYOLOGY AND PATHOGENESIS

Indirect inguinal hernias in infants and children are congenital and result from an arrest of embryologic development; failure of obliteration of the PV rather than a weakness in the inguinal musculature. The pertinent developmental anatomy of indirect inguinal hernia relates to development of the gonads and descent of the testis through the internal ring and into the scrotum late in gestation. The testes descend from the urogenital ridge in the retroperitoneum to the area of the internal ring by about 28 wk of gestation. The final descent of the testes into the scrotum occurs late in gestation between weeks 28 and 36. The testis is preceded in descent to the scrotum by the gubernaculum and the PV. The PV, an outpouring of peritoneum in the lower abdomen, is present in the developing fetus at 12 wk gestation that develops lateral to the deep inferior epigastric vessels and descends anteriorly along the spermatic cord within the cremasteric fascia through the internal inguinal ring. The testis accompanies the PV as it exits the abdomen and descends into the scrotum. The gubernaculum testis forms from the mesonephros (developing kidney), attaches to the lower pole of the testis, and directs the testis through the internal ring, inguinal canal and into the scrotum. The testis passes through the inguinal canal in a few days but takes about 4 wk to migrate from the external ring to the scrotum. The cord-like structures of the gubernaculum occasionally pass to ectopic locations (perineum or femoral region), resulting in ectopic testes.

In the last few weeks of gestation or shortly after birth, the layers of the PV normally fuse together and obliterate the patency from the peritoneal cavity through the inguinal canal to the testis. The PV also obliterates just above the testes, and the portion of the PV that envelops the testis becomes the tunica vaginalis. In girls, the PV obliterates earlier, at approximately 7 mo of gestation, and may explain why girls demonstrate a much lower incidence of inguinal hernia. *Failure of the PV to close permits fluid or abdominal viscera to escape the peritoneal cavity into the extraabdominal inguinal canal and accounts for a variety of inguinal–scrotal abnormalities seen in infancy and childhood.* The ovaries descend into the pelvis from the urogenital ridge but do not exit from the abdominal cavity. The cranial portion of the gubernaculum in girls differentiates into the ovarian ligament, and the inferior aspect of the gubernaculum becomes the round ligament, which passes through the internal ring and attaches to the labia majora. The PV in girls extends into the labia majora through the inguinal canal and is also known as the canal of Nuck. Involution of the left-sided PV precedes that of the right; which is consistent with the increased incidence of indirect inguinal hernias on the right side (60%).

Androgenic hormones, adequate end-organ receptors, and mechanical factors such as increased intra-abdominal pressure influence complete descent of the testis through the inguinal canal. The testes and spermatic cord structures (spermatic vessels and vas deferens) are located in the retroperitoneum but are affected by increases in intraabdominal pressure as a consequence of their intimate attachment to the descending PV. The genitofemoral nerve also has an important role: It innervates the cremaster muscle, which develops within the gubernaculum, and experimental division or injury to both nerves in the fetus prevents testicular descent. Failure of regression of smooth muscle (present to provide the force for testicular descent) might have a role in the development of indirect inguinal hernias. Several studies have investigated genes involved in the control of testicular descent for their role in closure of the patent PV, for example, hepatocyte growth factor and calcitonin gene-related peptide. Unlike in adult hernias, there does not appear to be any change in collagen synthesis associated with inguinal hernias in children (Fig. 346-1).

A **direct inguinal hernia** originates medial to the deep inferior epigastric vessels and is external to the cremasteric fascia; the hernia sac directly through the posterior wall of the inguinal canal. A **femoral hernia** originates medial to the femoral vein and descends inferior to the inguinal ligament along the femoral canal.

GENETICS

There is some genetic risk incurred for siblings of patients with inguinal hernias; the sisters of affected girls are at the highest risk, with a relative risk of 17.8. In general, the risk of brothers of a sibling is approximately 4-5, as is the risk of a sister of an affected brother. Both a multifactorial threshold model and autosomal dominance with incomplete penetrance and sex influence have been suggested as an explanation for this pattern of inheritance.

PATHOLOGY

Failure of closure of the PV leads to a number of common inguinal–scrotal conditions in infants and children including; inguinal hernia, scrotal hydrocele (communicating and noncommunicating), and hydrocele of the spermatic cord. Closure of the PV is often incomplete at birth and continues postnatally; the rate of patency is inversely proportional to the age of the child. It has been estimated that the patency rate of the PV is as high as 80% at birth and decreases to ≈40% during the 1st yr of life, and that ≈20% of boys have a persistent patency of the PV at 2 yr of age. Patency of the PV after birth is an opening from the abdominal cavity to the inguinal region and therefore a potential hernia, but not all patients will develop a clinical hernia. An inguinal hernia occurs clinically when intraabdominal contents escape

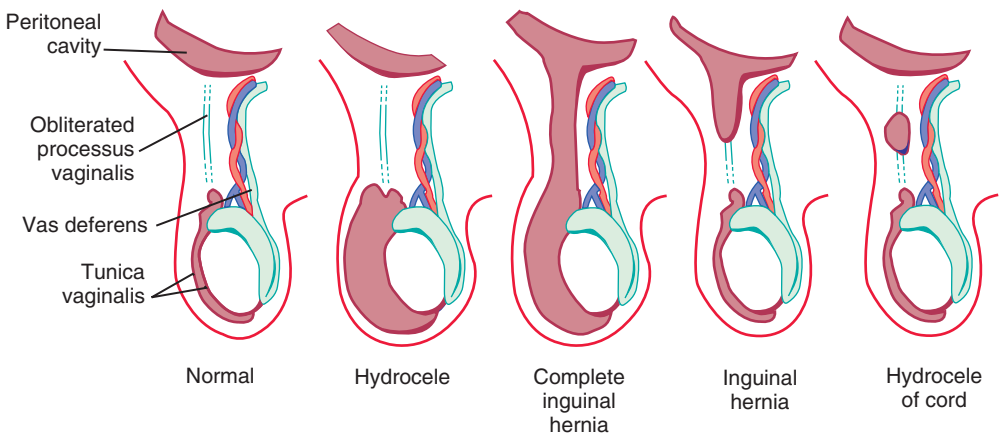

Figure 346-1 Hernia and hydroceles. *(Modified from Scherer LR III, Grosfeld JL: Inguinal and umbilical anomalies,* Pediatr Clin North Am *40:1121–1131, 1993.)*

Table 346-1 Predisposing Factors for Hernias

Prematurity
Urogenital
• Cryptorchidism
• Exstrophy of the bladder or cloaca
• Ambiguous genitalia
• Hypospadias/epispadius
Increased peritoneal fluid
• Ascites
• Ventriculoperitoneal shunt
• Peritoneal dialysis catheter
Increased intraabdominal pressure
• Repair of abdominal wall defects
• Severe ascites (chylous)
• Meconium peritonitis
Chronic respiratory disease
• Cystic fibrosis
Connective tissue disorders
• Ehlers-Danlos syndrome
• Hunter-Hurler syndrome
• Marfan syndrome
• Mucopolysaccharidosis

the abdominal cavity and enter the inguinal region through the patency. Based on their location in the inguinal canal (lateral to the inferior epigastric vessels), these are **indirect** inguinal hernias but are rarely associated with a muscular weakness or defect, as is typical of an adult hernia. Depending on the extent of patency of the PV, the hernia may be confined to the inguinal region or pass down into the scrotum. Complete failure of obliteration of the PV, mostly seen in infants, predisposes to a complete inguinal hernia characterized by a protrusion of abdominal contents into the inguinal canal and possibly extending into the scrotum. Obliteration of the PV distally (around the testis) with patency proximally results in the classic indirect inguinal hernia with the protrusion in the inguinal canal.

A **hydrocele** is when only fluid enters the patent PV; the swelling may exist only in the scrotum (scrotal hydrocele), only along the spermatic cord in the inguinal region (hydrocele of the spermatic cord), or extend from the scrotum through the inguinal canal and even into the abdomen (abdominal–scrotal hydrocele). A hydrocele is termed a *communicating hydrocele* if it demonstrates fluctuation in size, often increasing in size after activity and, at other times, being smaller when the fluid decompresses into the peritoneal cavity. Occasionally, hydroceles develop in older children following trauma, inflammation, or tumors affecting the testis. Although reasons for failure of closure of the PV are unknown, it is more common in cases of testicular nondescent (cryptorchidism) and prematurity. In addition, persistent patency of the PV is twice as common on the right side, presumably related to later descent of the right testis and interference with obliteration of the PV from the developing inferior vena cava and external iliac vein. Table 346-1 lists the risk factors identified as contributing to the development of clinical inguinal hernia and that relate to conditions that predispose to failure of obliteration of the PV. Incidence of inguinal hernia in patients with cystic fibrosis is approximately 15%, believed to be related to an altered embryogenesis of the wolffian duct structures, which leads to an absent vas deferens in males with this condition. There is also an increased incidence of inguinal hernia in patients with **testicular feminization syndrome** and other disorders of sexual development. The rate of recurrence after repair of an inguinal hernia in patients with a connective tissue disorder approaches 50%, and often the diagnosis of connective tissue disorders in children results from investigation after development of a recurrent inguinal hernia.

INCIDENCE

The incidence of congenital indirect inguinal hernia in full-term newborn infants is estimated at 3.5-5.0%. The incidence of hernia in preterm and low birthweight infants is considerably higher, ranging from 9-11%, and approaches 30% in very-low birthweight infants (<1,000 g) and preterm infants (<28 wk of gestation). Inguinal hernia is much more common in boys than girls, with a male : female ratio of approximately 8 : 1. Approximately 60% of inguinal hernias occur on the right side, 30% are on the left side, and 10% are bilateral. The incidence of bilateral hernias is higher in girls and appears to be 20-40%. An increased incidence of congenital inguinal hernia has been documented in twins and in family members of patients with inguinal hernia. There is a history of another inguinal hernia in the family in 11.5% of patients.

CLINICAL PRESENTATION

An inguinal hernia typically appears as a bulge or mass in the inguinal region. In boys, the mass potentially extends through the inguinal area into the scrotum; in girls the mass typically occurs in the upper portion of the labia majora. The bulge or mass is most visible at times of irritability or increased intraabdominal pressure (crying, straining, coughing). It may be present at birth or might not appear until weeks, months, or years later. The bulge is most often first noted by the parents or on routine examination by the primary care physician. The classic history from the parents is of intermittent groin, labial, or scrotal swelling that spontaneously reduces but that is gradually enlarging or is more persistent and is becoming more difficult to reduce. The **hallmark signs** of an inguinal hernia on physical examination are a smooth, firm mass that emerges through the external inguinal ring lateral to the pubic tubercle and enlarges with increased intraabdominal pressure. When the child relaxes, the hernia typically reduces spontaneously or can be reduced by gentle pressure, first posteriorly to free it from the external ring and then upward toward the peritoneal cavity. In boys, the hernia sac contains intestines; female infants often have an ovary and fallopian tube in the hernia sac.

Methods used to demonstrate the hernia on examination vary depending on the age of the child. A quiet infant can be made to strain the abdominal muscles by stretching the infant out supine on the bed with legs extended and arms held straight above the head. Most infants struggle to get free, thus increasing the intraabdominal pressure and pushing out the hernia. Older patients can be asked to perform the Valsalva maneuver by blowing up a balloon or coughing. The older child should be examined while standing and examination after voiding also can be helpful. With increased intraabdominal pressure, the protruding mass is obvious on inspection of the inguinal region or can be palpated by an examining finger invaginating the scrotum to palpate at the external ring. Another test is the **"silk glove sign,"** which describes the feeling of the layers of the hernia sac as they slide over the spermatic cord structures with rolling of the spermatic cord beneath the index finger at the pubic tubercle. A femoral hernia appears as a protrusion on the medial aspect of the thigh, below the inguinal region and does not enter the scrotum or labia. In the absence of a bulge, the finding of increased thickness of the inguinal canal structures on palpation also suggests the diagnosis of an inguinal hernia. It is important on examination to note the position of the testes because retractile testes are common in infants and young boys and can mimic an inguinal hernia with a bulge in the region of the external ring. Because in the female patient approximately 20-25% of inguinal hernias are sliding hernias (the contents of the hernia sac are adherent within the sac and therefore not reducible), a fallopian tube or ovary can be palpated in the inguinal canal as a firm, slightly mobile, nontender mass in the labia or inguinal canal.

As the majority of young child hernias reduce spontaneously, the physical examination in the office can be equivocal. Infants and children with a strong history suggestive of inguinal hernia and an equivocal clinical examination may be offered ultrasound or referral to a pediatric surgeon. In recent years, diagnostic laparoscopy has been increasingly used to evaluate for suspected inguinal hernia; particularly in infants where the risk of incarceration and potential injury to the intestines or testis is high. In an older child with low risk of

incarceration, the parents can be educated and asked to observe for the bulge and take a digital image at home.

EVALUATION OF ACUTE INGUINAL–SCROTAL SWELLING

Commonly in pediatric practice, an inguinal–scrotal mass appears suddenly in an infant or child and is associated with discomfort. The **differential diagnosis** includes incarcerated inguinal hernia, acute hydrocele, torsion of an undescended testis, and suppurative inguinal lymphadenitis. Differentiating between the incarcerated inguinal hernia and the acute hydrocele is probably the most difficult. The infant or child with an incarcerated inguinal hernia is likely to have associated findings suggesting intestinal obstruction, such as colicky abdominal pain, abdominal distention, vomiting, and cessation of stool, and might appear ill. The infant with an acute hydrocele might have discomfort but is consolable and tolerates feedings without signs or symptoms suggesting intestinal obstruction. When the diagnosis is incarcerated inguinal hernia, plain radiographs typically demonstrate distended intestines with multiple air–fluid levels.

On examination of the child with the acute hydrocele, the clinician may note that the mass is somewhat mobile. In addition, in the area between the suspected hydrocele mass and the internal ring, the cord structures can appear only slightly thickened. With the incarcerated hernia, there is a lack of mobility of the groin mass and marked swelling or mass extending from the scrotal mass through the inguinal area and up to and including the internal ring. An experienced clinician can selectively use a bimanual examination to help differentiate groin abnormalities. The examiner palpates the internal ring per rectum, with the other hand placing gentle pressure on the inguinal region over the internal ring. In cases of an indirect inguinal hernia, an intraabdominal organ can be palpated extending through the internal ring.

Another method used in evaluation is **transillumination.** It must be noted that transillumination can be misleading because the thin wall of the infant's intestine can approximate that of the hydrocele wall and both might transilluminate. This is also the reason aspiration to determine the contents of a groin mass is discouraged. **Ultrasonography** can help distinguish between a hernia, a hydrocele, and lymphadenopathy. An expeditious diagnosis is important to avoid the potential complications of an incarcerated hernia, which can develop rapidly. Diagnostic laparoscopy has emerged as an effective and reliable tool in this setting by pediatric surgeons but requires general anesthesia.

The occurrence of suppurative adenopathy in the inguinal region can be confused with an incarcerated inguinal hernia. Examination of the watershed area of the inguinal lymph node might reveal a superficial infected or crusted lesion. In addition, the swelling associated with inguinal lymphadenopathy is typically located more inferior and lateral than the mass of an inguinal hernia, and there may be other associated enlarged nodes in the area. Torsion of an undescended testis can manifest as a painful erythematous mass in the groin. The absence of a gonad in the scrotum in the ipsilateral side should clinch this diagnosis.

Incarcerated Hernia

Incarceration is a common consequence of untreated inguinal hernia in infants and presents as a nonreducible mass in the inguinal canal, scrotum, or labia. Contained structures can include small bowel, appendix, omentum, colon, or, rarely, Meckel diverticulum. In girls, the ovary, fallopian tube, or both are commonly incarcerated. Rarely, the uterus in infants can also be pulled into the hernia sac. A **strangulated hernia** is one that is tightly constricted in its passage through the inguinal canal and, as a result, the hernia contents have become ischemic or gangrenous.

Although incarceration may be tolerated in adults for years, most nonreducible inguinal hernias in children, unless treated, rapidly progress to strangulation with potential infarction of the hernia contents or intestinal obstruction. Initially, pressure on the herniated viscera leads to impaired lymphatic and venous drainage. This leads, in turn, to swelling of the herniated viscera, which further increases the compression in the inguinal canal, ultimately resulting in total occlusion of the arterial supply to the trapped viscera. Progressive ischemic changes take place, culminating in gangrene and/or perforation of the herniated viscera. The testis is at risk of ischemia because of compression of the testicular blood vessels by the strangulated hernia. In girls, herniation of the ovary places it at risk of strangulation and torsion. The incidence of incarceration of an inguinal hernia is between 12% and 17% throughout childhood; two-thirds of incarcerated hernias occur in the 1st yr of life. The greatest risk is in infants younger than 6 mo of age, with reported incidences of incarceration between 25% and 30%. The incidence of incarceration is slightly less in premature infants, although the reasons are unclear.

The symptoms of an incarcerated hernia are irritability, feeding intolerance, and abdominal distention in the infant; pain in the older child. Within a few hours, the infant becomes inconsolable; lack of flatus or stool signals complete intestinal obstruction. A somewhat tense, nonfluctuant mass is present in the inguinal region and can extend down into the scrotum or labia. The mass is well defined, firm, and does not reduce. With the onset of ischemic changes, the pain intensifies, and the vomiting becomes bilious or feculent. Blood may be noted in the stools. The mass is typically tender, and there is often edema and erythema of the overlying skin. The testes may be normal, demonstrate a reactive hydrocele, or may be swollen and hard on the affected side because of venous congestion resulting from compression of the spermatic veins and lymphatic channels at the inguinal ring by the tightly strangulated hernia mass. Abdominal radiographs demonstrate features of partial or complete intestinal obstruction, and gas within the incarcerated bowel segments may be seen below the inguinal ligament or within the scrotum.

Ambiguous Genitalia

Infants with disorders of sexual development commonly present with inguinal hernias, often containing a gonad, and require special consideration. In female infants with inguinal hernias, particularly if the presentation is bilateral inguinal masses, **testicular feminization syndrome** should be suspected (>50% of patients with testicular feminization have an inguinal hernia) (see Chapter 588). Conversely, the true incidence of testicular feminization in all female infants with inguinal hernias is difficult to determine but is approximately 1%. In phenotypic females, if the diagnosis of testicular feminization is suspected preoperatively, the child should be screened with a buccal smear for Barr bodies and appropriate genetic evaluation before proceeding with the hernia repair. The diagnosis of testicular feminization is occasionally made at the time of operation by identifying an abnormal gonad (testis) within the hernia sac or absence of the uterus on laparoscopy or rectal exam. In the normal female infant, the uterus is easily palpated as a distinct midline structure beneath the symphysis pubis on rectal examination. Preoperative diagnosis of testicular feminization syndrome or other disorders of sexual development such as mixed gonadal dysgenesis and selected pseudohermaphrodites enables the family to receive genetic counseling, and gonadectomy can be accomplished at the time of the hernia repair.

MANAGEMENT

The presence of an inguinal hernia in the pediatric age group constitutes the indication for operative repair. An inguinal hernia does not resolve spontaneously, and early repair eliminates the risk of incarceration and the associated potential complications, particularly in the 1st 6-12 mo of life. The timing of operative repair depends on several factors, including age, general condition of the patient, and comorbid conditions. In infants (younger than 1 yr old) with an inguinal hernia, repair should proceed promptly (within 2-3 wk) because as many as 70% of incarcerated inguinal hernias requiring emergency operation occur in infants younger than 11 mo. In addition, the incidence of complications associated with *elective* hernia repair (intestinal injury, testicular atrophy, recurrent hernia, wound infection) are low (≈1%), but rise to as high as 18-20% when repair is performed at the time of

incarceration. The incidence of testicular atrophy after incarceration in infants younger than 3 mo of age has been reported as high as 30%. Therefore, an approach emphasizing prompt elective repair in infants is warranted. In children older than 1 yr, the risk of incarceration is less and the repair can be scheduled with less urgency. For the routine reducible hernia, the operation should be carried out electively shortly after diagnosis. Elective inguinal hernia repair can be safely performed in an outpatient setting with an expectation for full recovery within 48 hr. The operation should be performed at a facility with the ability to admit the patient to an inpatient unit as needed. Certain conditions can dictate postponement of repair, such as marked prematurity, intercurrent pneumonia (especially respiratory syncytial virus), other infections, or severe congenital heart disease. In cases of prematurity (1,800-2,000 g), repair is typically performed before discharge from the neonatal ICU.

The operation is most often performed under general anesthesia, but it can be performed under spinal anesthesia in selected high-risk infants in whom avoidance of intubation is preferable (because of, e.g., chronic lung disease or bronchopulmonary dysplasia). A regional caudal block or local inguinal nerve block using local anesthetic is useful to diminish perioperative pain and increase patient comfort. These techniques, along with the use of rapid-acting general anesthetics, allow the majority of infants to be discharged home within hours of operation. Prophylactic antibiotics are not routinely used except for associated conditions, such as congenital heart disease or the presence of a ventriculoperitoneal shunt. Preterm infants mandate special consideration because of their higher risk for apnea and bradycardia following general anesthesia (see Chapter 61). Infants younger than 44 wk postconceptional age and full-term infants younger than 3 mo of age and with comorbid conditions should be observed overnight with appropriate apnea and cardiorespiratory monitors.

An incarcerated, irreducible hernia without evidence of strangulation in a clinically stable patient should initially be managed nonoperatively. Unless there is clear peritonitis or bowel compromise, incarcerated hernias can usually be reduced manually using a technique called *taxis*. Manual reduction is performed first with traction caudad and posteriorly to free the mass from the external inguinal ring, and then upward to reduce the contents back into the peritoneal cavity. The attempt should not be continued if the infant is crying and resisting the pressure on the hernia. The use of cautious sedation or analgesia with experienced monitoring before attempting reduction can be helpful; this reduces intraabdominal pressure and relieves the pressure on the neck of the hernia sac at the inguinal ring. Care must be taken to avoid respiratory depression, especially common in the premature infant. Other techniques advocated to assist in the nonoperative reduction of an incarcerated inguinal hernia include elevation of the lower torso and legs. Ice packs should be avoided in infants because of the risk of hypothermia but may be used for brief periods in the older child. If reduction is successful but difficult, the patient should be observed (several hours) to ensure that feedings are tolerated and there is no concern that necrotic intestine was reduced; fortunately, this is an uncommon occurrence. Because of the high risk for early recurrent incarceration, surgical repair is performed 24-48 hr later, by which time there is less edema, handling of the sac is easier, and the risk of complications is reduced.

A common presentation in female patients is an irreducible ovary in the inguinal hernia in an otherwise asymptomatic patient. The inguinal mass is soft and nontender to gentle exam, and there is no swelling or edema; thus, there are no findings suggesting strangulation. This represents a **"sliding"** hernia with the fallopian tube and ovary fused to the wall of the hernia sac. Overzealous attempts to reduce the hernia are unwarranted and potentially harmful to the tube and ovary. The risk that incarceration of the ovary in this setting will lead to strangulation is not known. Most pediatric surgeons recommend elective repair of the hernia within 24-48 hr. For any patient who presents with a prolonged history of incarceration, signs of peritoneal irritation, or small bowel obstruction, surgery and operative reduction and repair of the hernia should be urgently performed.

Operative Management

When the hernia cannot be reduced or signs of strangulation are present, immediate operation is indicated to prevent further damage to the contents of the hernia sac or testis. If there are signs of intestinal obstruction or strangulation, urgent, initial management includes nasogastric intubation, intravenous fluids, and administration of broad-spectrum antibiotics. When fluid and electrolyte imbalance has been corrected and the child's condition is satisfactory, exploration is undertaken. The operation consists of opening of the inguinal canal, reduction of the contents of the hernia sac, separation of the hernia sac from the spermatic cord vessels and vas deferens in the inguinal canal, and high ligation of the hernia sac at the internal ring. Resection of nonviable structures within the hernia sac or of an infarcted testis may be indicated based on the experience and judgment of the surgeon. Although often the testis might appear ischemic, most testes recover after the incarceration is relieved and should not be removed.

The elective operative repair of a congenital indirect inguinal hernia is straightforward and consists of high ligation of the hernia sac (PV) at the level of the internal ring, thus preventing protrusion of abdominal contents into the inguinal canal. In boys, this requires careful separation of the sac from the spermatic cord structures and avoidance of injury to these vital structures. An associated hydrocele, present approximately 20% of the time, is released anteriorly to avoid injury to the spermatic cord structures located posteriorly. In girls, surgical repair is simpler because the hernia sac and round ligament can be ligated without concern for injury to the ovary and its blood supply, which generally remain within the abdomen. If the ovary and fallopian tube are within the sac and not reducible, the sac is ligated distal to these structures and the internal ring is closed after reducing the sac and its contents to the abdominal cavity.

Laparoscopic Inguinal Hernia Repair

Although the classic open inguinal hernia repair is most commonly performed, laparoscopic repair is increasingly used by pediatric surgeons experienced in the technique. Like the open technique, the laparoscopic technique is fundamentally a **high ligation** of the indirect inguinal hernia sac. In the open surgical technique, a small inguinal skin crease incision is employed, the inguinal canal is opened and careful identification and separation of the hernia sac from the vas deferens and the testicular blood supply is performed, followed by high ligation of the sac at the level of the internal ring (entrance point to the peritoneal cavity). In female infants, opening of the sac to visualize the ovary and fallopian tube may help avoid injury to these structures during suture ligation of the sac and also rule out testicular feminization syndrome. In laparoscopic inguinal hernia repair, the hernia sac, anterior to the vas deferens and the testicular blood vessels, is suture-ligated at the internal ring without inguinal exploration or handling of the spermatic cord structures. Proponents of the laparoscopic approach cite ease of examining the contralateral internal ring, decreased manipulation of the vas deferens and spermatic vessels, decreased operative time, and an ability to identify unsuspected direct or femoral hernias. In a prospective, randomized study, the laparoscopic approach was associated with decreased pain, parental perception of faster recovery, and parental perception of better wound cosmesis; however, complication and recurrence rates have been slightly higher for the laparoscopic approach and the approach has yet to gain wide acceptance. Laparoscopic procedures in infants should always be performed expeditiously and with low insufflations pressure to avoid the risk of cardiorespiratory compromise. Postoperative pain in both techniques is managed with oral acetaminophen for 24-48 hr; older children may require a brief period of postoperative narcotics.

Contralateral Inguinal Exploration

Controversy exists regarding when to proceed with contralateral groin exploration in infants and children with a unilateral indirect inguinal hernia. The only purpose of contralateral exploration is to avoid the occurrence of a hernia on that side at a later date. The advantages of contralateral exploration include avoidance of parental anxiety and

possibly a second anesthesia, the cost of additional surgery, and the risk of contralateral incarceration. The disadvantages of exploration include potential injury to the spermatic cord vessels, vas deferens, and testis; increased operative and anesthesia time; and the fact that, in many infants, it is an unnecessary procedure. The relevant issues in the debate revolve around the frequency of occurrence of contralateral hernias after one-sided hernia repair and the relation of this to age, gender, and side of the clinically apparent hernia. Most large series noted a chance of developing a contralateral hernia following inguinal hernia repair as 30-40% in children younger than 2 yr of age; leading most pediatric surgeons to recommend routine contralateral exploration in this age group. Unfortunately, infants and young children have delicate spermatic cord structures and when boys were studied 8-20 yr after inguinal hernia repair, 5.8% of them had decreased testicular size on the side of the repair and 1% had testicular atrophy. In girls, because of the higher incidence of bilateral inguinal hernias and elimination of concern for injury to the spermatic cord or testis, routine contralateral exploration is recommended up to age 5 or 6 yr. Laparoscopy enables assessment of the contralateral side without risk of injury to the spermatic cord structures or testis. This procedure can be performed through an umbilical incision or by passing a 30-degree or 70-degree oblique scope through the open hernia sac just before ligation of the hernia sac on the involved side. If patency of the contralateral side is demonstrated, the surgeon can proceed with bilateral hernia repair, and if the contralateral side is properly obliterated, exploration and potential complications are avoided. The downside of this approach include the risks associated with laparoscopy, and that laparoscopy cannot differentiate between a patent PV and a true hernia (Figs. 346-2 and 346-3). Infants and children with risk factors for development of an inguinal hernia or with medical conditions that increase the risk of general anesthesia should be approached with a low threshold for routine contralateral exploration.

DIRECT INGUINAL HERNIA

Direct inguinal hernias are rare in children; approximately 0.5-1%. Direct hernias appear as groin masses that extend toward the femoral vessels with exertion or straining. The etiology is from a muscular defect or weakness in the floor of the inguinal canal *medial* to the epigastric vessels. Thus, direct inguinal hernias in children are generally considered an acquired defect. In one-third of cases, the patient has a history of a prior indirect hernia repair on the side of the direct hernia, which suggests a possible injury to the floor muscles of the inguinal canal at the time of the first herniorrhaphy. Patients with **connective tissue disorders** such as Ehlers-Danlos syndrome or Marfan syndrome and mucopolysaccharidosis such as Hunter-Hurler syndrome are at increased risk for the development of direct inguinal hernias either independently or after indirect inguinal hernia repair.

Operative repair of a direct inguinal hernia involves strengthening of the floor of the inguinal canal, and many standard techniques have been described, similar to repair techniques used in adults. The repair can be performed through a single limited incision and, therefore, laparoscopic repair does not offer significant advantage. Recurrence after repair, in contrast to that in adults, is extraordinarily rare. Because typically the area of muscular weakness is small and pediatric tissues have greater elasticity, primary repair is usually possible. Prosthetic material for direct hernia repair or other approaches, such as preperitoneal repair, are rarely required in the pediatric age group. The older child with a direct inguinal hernia and a connective tissue disorder may be the exception, and a laparoscopic approach and prosthetic material in such a case can be useful for repair.

FEMORAL HERNIA

Femoral hernias are also rare in children (<1% of groin hernias in children). They are more common in girls than boys, with a ratio of 2:1. They are extremely rare in infancy and occur typically in older children. Femoral hernias represent a protrusion through the femoral canal. The bulge of a femoral hernia is located below the inguinal ligament and typically projects toward the medial aspect of the proximal thigh. Femoral hernias are more often missed clinically than direct hernias on physical examination or at the time of indirect hernia repair. Repair of a femoral hernia involves closure of the defect at the femoral canal, generally suturing the inguinal ligament to the pectineal ligament/fascia.

COMPLICATIONS

Complications after elective inguinal hernia repair are uncommon (≈1.5%) but significantly higher in association with incarceration (≈10%). The major risk of elective inguinal hernia repair in infants and children relates to the need for general anesthesia. Surgical complications can be related to technical factors (recurrence, iatrogenic cryptorchidism, inadvertent injury to the vas deferens or spermatic vessels), or to the underlying process, such as bowel ischemia, gonadal infarction, and testicular atrophy following incarceration.

Wound Infection

Wound infection occurs in <1% of elective inguinal hernia repairs in infants and children, but the incidence increases to 5-7% in association with incarceration and emergent repair. The patient typically develops fever and irritability 3-5 days after the surgery, and the wound demonstrates warmth, erythema, and fluctuance. Management consists of opening and draining the wound, a short course of antibiotics, and a

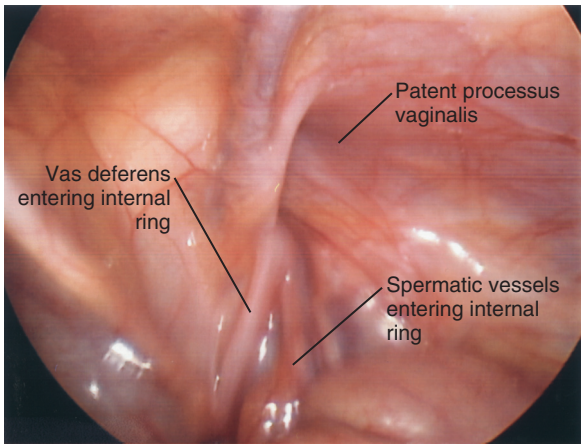

Figure 346-2 Image on laparoscopy of patent processus vaginalis on right side.

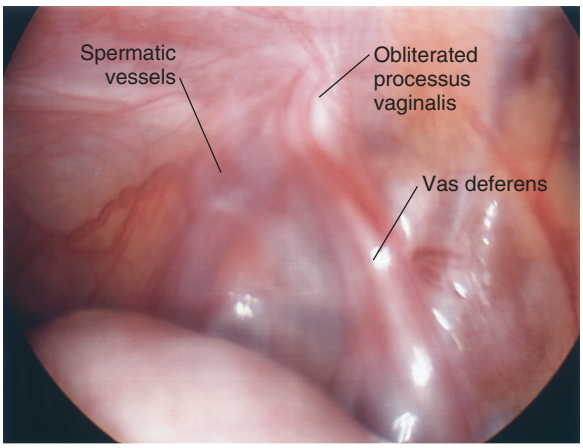

Figure 346-3 Image on diagnostic laparoscopy of obliterated processus vaginalis on left side.

daily wound dressing. Most common organisms are Gram-positive (*Staphylococcus* and *Streptococcus* spp.), and consideration should be given to coverage of methicillin-resistant *Staphylococcus aureus*. The wound generally heals in 1-2 wk with low morbidity and a good cosmetic result.

Recurrent Hernia

The recurrence rate of inguinal hernias after elective inguinal hernia repairs is generally reported as 0.5-1.0%, with rates as high as 2% for premature infants. The rate of recurrence after emergency repair of an incarcerated hernia is much higher; reported as 3-6% in most large series. The true incidence of recurrence is most certainly even higher, given the problem of accurate long-term follow-up. In the group of patients who develop recurrent inguinal hernia, the recurrence occurs in 50% within 1 yr of the initial repair and in 75% by 2 yr. Recurrence of an indirect hernia is most likely the result of a technical problem in the original procedure, such as failure to identify the sac properly, failure to perform high ligation of the sac at the level of the internal ring, or a tear in the sac that leaves a strip of peritoneum along the cord structures. Recurrence as a direct hernia can result from injury to the inguinal floor (transversalis fascia) during the original procedure or failure to identify a direct hernia during the original exploration. Patients with connective tissue disorders (collagen deficiency) or conditions that cause increased intraabdominal pressure (ventriculoperitoneal shunts, ascites, peritoneal catheter for dialysis) are at increased risk for recurrence.

Iatrogenic Cryptorchidism

Iatrogenic cryptorchidism describes malposition of the testis after inguinal hernia repair. This complication is usually related to disruption of the testicular attachment in the scrotum at the time of hernia repair or failure to recognize an undescended testis during the original procedure, allowing the testes to retract, typically to the region of the external ring. At the completion of inguinal hernia repair, the testis should be placed in a dependent intrascrotal position. If the testis will not remain in this position, proper fixation in the scrotum should be performed at the time of the hernia repair.

Incarceration

Incarceration of an inguinal hernia can result in injury to the intestines, the fallopian tube and ovary, or the ipsilateral testis. The incidence of incarceration of a congenital indirect inguinal hernia is reported as 6-18% throughout childhood and as high as 30% for infants younger than 3 mo of age. Intestinal injury requiring bowel resection is uncommon, occurring in only 1-2% of incarcerated hernias. In cases of incarceration in which the hernia is reduced nonoperatively, the likelihood of intestinal injury is low; however, these patients should be observed closely for 6-12 hr following reduction of the hernia persistent for signs and symptoms of intestinal obstruction, such as fever, vomiting, abdominal distention, or bloody stools.

The reported incidence of testicular infarction and subsequent testicular atrophy with incarceration is 4-12%, with higher rates among the irreducible cases requiring emergency operative reduction and repair. The testicular insult can be caused by compression of the gonadal vessels by the incarcerated hernia mass or as a result of damage incurred during operative repair. Young infants are at highest risk, with testicular infarction rates reported as high as 30% in infants younger than 2-3 mo of age. These problems underscore the need for prompt reduction of incarcerated hernias and early repair once the diagnosis is known to avoid repeat episodes of incarceration.

Injury to the Vas Deferens and Male Fertility

Similar to the gonadal vessels, the vas deferens can be injured as a consequence of compression from an incarcerated hernia or during operative repair. This injury is almost certainly underreported because it is unlikely to be recognized until adulthood and, even then, possibly only if the injury is bilateral. Although the vulnerability of the vas deferens has been documented in many studies, no good data exist as to the actual incidence of this problem. One review reported an incidence of injury to the vas deferens of 1.6% based on pathology demonstrating segments of the vas deferens in the hernia sac specimen; this may be overstated, because others have shown that small glandular inclusions found in the hernia sac can represent müllerian duct remnants and are of no clinical importance. The relationship between male fertility and previous inguinal hernia repair is also unknown. There appears to be an association between infertile males with testicular atrophy and abnormal sperm count and a previous hernia repair. A relationship has also been reported between infertile males with spermatic autoagglutinating antibodies and previous inguinal hernia repair. The proposed etiology is that operative injury to the vas deferens during inguinal hernia repair might result in obstruction of the vas with diversion of spermatozoa to the testicular lymphatics, and this breach of the blood–testis barrier produces an antigenic challenge, resulting in formation of spermatic autoagglutinating antibodies.

Bibliography is available at Expert Consult.

Bibliography

Chan KL, Chan HY, Tam PKH: Towards a near-zero recurrence rate in laparoscopic inguinal hernia repair for pediatric patients of all ages, *J Pediatr Surg* 42:1993–1997, 2007.

Chang YT, Lin JY, Lee JY, et al: Comparative mid-term results between inguinal herniotomy and single-port laparoscopic herniorrhaphy for pediatric inguinal hernia repair, *Surg Laparosc Endosc Percutan Tech* 22(6):526–531, 2012.

Chou TY, Chu CC, Diau GY, et al: Inguinal hernia in children: US vs exploratory surgery and intraoperative contralateral laparoscopy, *Radiology* 201:385–388, 1996.

Gallagher TM: Regional anesthesia for surgical treatment of inguinal hernia in preterm babies, *Arch Dis Child* 69:623–624, 1993.

Geiger JD: Selective laparoscopic probing for a contralateral patent processus vaginalis reduces the need for contralateral exploration in inconclusive cases, *J Pediatr Surg* 35:1151–1154, 2000.

Hamad MA, Osman MA, Abdelhamed M: Laparoscopic-assisted percutaneous internal ring ligation in children, *Ann Pediatr Surg* 7(2):66–69, 2011.

Holcomb GW: Laparoscopic evaluation for a contralateral inguinal hernia or a nonpalpable testis, *Pediatr Ann* 22:678–684, 1993.

Hosgor M, Karaca I, Ozer E, et al: Do alterations in collagen synthesis play an etiologic role in childhood inguinoscrotal pathologies: an immunohistochemical study, *J Pediatr Surg* 39:1024–1029, 2004.

Jenkins JT, O'Dwyer PJ: Inguinal hernias, *BMJ* 336:269–272, 2008.

Lobe TE, Schropp KP: Inguinal hernias in pediatrics: initial experience with laparoscopic inguinal exploration of the asymptomatic contralateral side, *J Laparoendosc Surg* 2:135–140, 1992.

Luo CC, Chao HC: Prevention of unnecessary contralateral exploration using the silk glove sign (SGS) in pediatric patients with unilateral inguinal hernia, *Eur J Pediatr* 166:667–669, 2007.

Manoharan S, Samarakkody U, Kulkarni M, et al: Evidence-based change of practice in the management of unilateral inguinal hernia, *J Pediatr Surg* 40:163–166, 2005.

Marulaiah M, Atkinson J, Kukkady A, et al: Is contralateral exploration necessary in preterm infants with unilateral inguinal hernia? *J Pediatr Surg* 41:2004–2007, 2006.

Owings EF, Georgeson KE: A new technique for laparoscopic exploration to find contralateral patent processus vaginalis, *Surg Endosc* 14:114–116, 2000.

Rescorla FJ: Hernias and umbilicus. In Oldham KT, Colambani PM, Foglia RP, et al, editors: *Principles and practice of pediatric surgery*, Philadelphia, 2005, Lippincott Williams & Wilkins, pp 1087–1101.

Ron O, Eaton S, Pierro A: Systemic review of the risk of developing a metachronous contralateral inguinal hernia in children, *Br J Surg* 94:804–811, 2007.

Rowe MI, Copelson LW, Clatworthy HW: The patent processus vaginalis and the inguinal hernia, *J Pediatr Surg* 4:102–107, 1969.

Sato TT, Oldham Kt: Pediatric abdomen. In Mulholland MW, Lillemoe KD, Doherty Gm, et al, editors: *Greenfield's surgery: scientific principles and practice*, ed 5, Philadelphia, 2011, Lippincott Williams & Williams.

Shier F, Montupet P, Esposito C: Laparoscopic inguinal herniorrhaphy in children: a three center experience with 933 repairs, *J Pediatr Surg* 37:395–397, 2002.

Skandalakis JE, Gray SW: *Embryology for surgeons: the embryologic basis for the treatment of congenital anomalies*, ed 2, Baltimore, 1994, Williams & Wilkins, pp 184–241.

Spurbeck WW, Prasad R, Lobe TE: Two year experience with minimally invasive herniorrhaphy in children, *Surg Endosc* 19:551–553, 2005.

Stergman C, Sotelo-Avila C, Weber TR: The incidence of spermatic cord structures in inguinal hernia sacs from male children, *Am J Surg Pathol* 23:883–885, 1999.

Tacket LD, Breuer CK, Luks FI, et al: Incidence of contralateral inguinal hernia: a prospective analysis, *J Pediatr Surg* 34:684–687, 1999.

Tanyel FC, Dagdeviren A, Muftuoglu S, et al: Inguinal hernia revisited through comparative evaluation of peritoneum, processus vaginalis, and sacs obtained from children with hernia, hydrocele, and undescended testis, *J Pediatr Surg* 34(4):552–555, 1999.

Tanyel FC, Okur HD: Autonomic nervous system appears to play a role in obliteration of processus vaginalis, *Hernia* 8(2):149–154, 2004.

Wang KS, Committee on Fetus and Newborn and Section on Surgery: Assessment and management of inguinal hernia in infants, *Pediatrics* 130:768–773, 2012.

Weber TR, Tracy TF Jr, Keller MS: Groin hernias and hydroceles. In Ashcraft KW, Holcomb GW III, Murphy JP, editors: *Pediatric surgery*, ed 4, Philadelphia, 2005, WB Saunders, pp 697–705.

Wiener ES, Touloukian RJ, Rodgers BM, et al: Hernia survey of the Section on Surgery of the American Academy of Pediatrics, *J Pediatr Surg* 31:1166–1169, 1996.