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Pediatric Hernias

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Indirect inguinal herniorrhaphy is one of the most frequently performed surgical procedures in children. The overall incidence of inguinal hernias in childhood ranges from 0.8% to 4.4% [1,2]. The incidence is up to 10 times higher in boys than in girls [3]. The incidence is much higher in premature infants; inguinal hernias develop in 13% of infants born before 32 weeks gestation and in 30% of infants weighing less than 1000 g [4].

Embryology of indirect inguinal hernias

Indirect inguinal hernias in children are basically an arrest of embryologic development rather than an acquired weakness, which explains the increased incidence in premature infants. The formation of inguinal hernias in children is directly linked to descent of the developing gonads. The descent of the testes from the embryologic retroperitoneum begins early in gestation. In this early stage, testicular position is not so much a descent as a parting of the ways with the developing kidney. As the mesonephros (developing kidney) ascends into its usual position in the retroperitoneum, the testes remain at the level of the internal rings. The final descent of the testes into the scrotum occurs late in gestation between weeks 28 and 36. The testes are preceded in this descent by the gubernaculum and a "finger" of peritoneum, which ultimately forms the processus vaginalis. This finger or "diverticulum" of peritoneum is first visible around the 12th week of gestation [4]. In normal development, the processus vaginalis closes, obliterating the peritoneal opening of the internal ring between the 36th and 40th week of gestation [5]. The distal portion of the processus vaginalis obliterates, except for the part that becomes the tunica vaginalis. This process is often incomplete, leaving a small patent processus in many newborns. However, closure continues postnatally, and the rate of patency is inversely

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proportional to the age of the child [1,6,7]. Although the data are somewhat variable, approximately 40% of patent processus vaginalis close during the first months of life and an additional 20% close by 2 years of age [7]. This closure is asymmetric; the left testis descends before the testis on the right. The closure of the patent processus vaginalis on the left also precedes closure on the right; therefore, it is not surprising that 60% of indirect inguinal hernias occur on the right side [4].

Much of the confusion about indirect inguinal hernias in children stems from the assumption that a patent processus vaginalis is the same as an inguinal hernia. The presence of a patent processus vaginalis is a necessary but not sufficient variable in developing a congenital indirect inguinal hernia. In other words, all congenital indirect inguinal hernias are preceded by a patent processus vaginalis, but not all patent processus vaginalis go on to become inguinal hernias. The classic teaching has been that approximately 20% of boys have a patent processus vaginalis at 2 years of age [7]. It is assumed that closure will continue during childhood for some but not all patients. Van Veen and colleagues [8] studied over 300 adults undergoing unilateral hernia repair. These patients had laparoscopic exploration of the contralateral side; 12% of these patients had a patent processus vaginalis. With a 5.5-year average follow-up, inguinal hernias developed in 12% of adult patients with a patent processus vaginalis, a rate four times greater than in the adults in the study who had a closed ring. An incidence of 12% to 14% has been confirmed in other studies of adults as well [9]. Because the overall incidence of indirect inguinal hernias in the population is approximately 1% to 2% and the incidence of a patent processus vaginalis is approximately 12% to 14%, clinically appreciable inguinal hernias should develop in approximately 8% to 12% of patients with a patent processus vaginalis.

Although the embryology is well described, the molecular basis for closure of the patent processus vaginalis is not known. Work by Tanyel has suggested that failure of regression of smooth muscle (present to provide the force for testicular descent) may have a role in the development of indirect inguinal hernias [10,11]. Smooth muscle is present in inguinal hernia sacs in children but absent in the wall of hydroceles and hernia sacs associated with undescended testes [10,12]. The mechanism for disappearance of the smooth muscle is not yet elucidated, although mediators of autonomic tone have been suggested to have a role [11,13,14]. Several studies have investigated genes involved in the control of testicular descent for their role in closure of the patent processus vaginalis, for example, hepatocyte growth factor [14,15] and calcitonin gene-related peptide [14,16,17]. Unlike in adult hernias, there does not appear to be any change in collagen synthesis associated with inguinal hernias in children [12].

The genetics of inguinal hernias, like the molecular biology, are also poorly understood. 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 [18]. In general, the risk for brothers of a sibling is around 4 to 5, as is the risk for a sister of an affected brother [18]. 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 [19,20].

Diagnosis

The diagnosis of inguinal hernias in children is traditionally suggested by the history of a bulge in the groin with crying and is confirmed on physical examination (Fig. 1). For children too small to cough on command, other methods can be used to increase intra-abdominal pressure. For babies, holding their legs and arms gently against the examination table so they cannot move invariably results in crying. For slightly older children, blowing bubbles, tickling them to make them laugh, or having them blow up balloons (eg, examination gloves) will increase intra-abdominal pressure [3]. Despite these maneuvers, it is not uncommon for the surgeon not to see the bulge. Although some surgeons will operate based on a classic description by parents or a referring physician, most, having been tricked by a retractile testes, will insist on seeing the hernia themselves.

The use of the ''silk purse'' or ''silk glove'' sign has been suggested as an alternative to seeing the bulge. This sign can be elicited by gently rolling the cord structures across the pubic tubercle. The feeling of the sac moving on itself during this maneuver is considered a positive finding. Published reports from the 1950s to 1970s showed a wide variation in diagnostic accuracy using the silk purse sign [6]; however, a recent prospective study from China of 1040 patients showed this physical finding to have a sensitivity of 91% and specificity of 97.3% in diagnosing inguinal hernias [21]. Currently, the most reasonable approach is to consider the silk purse sign as supporting but not conclusive evidence that there is an inguinal hernia.

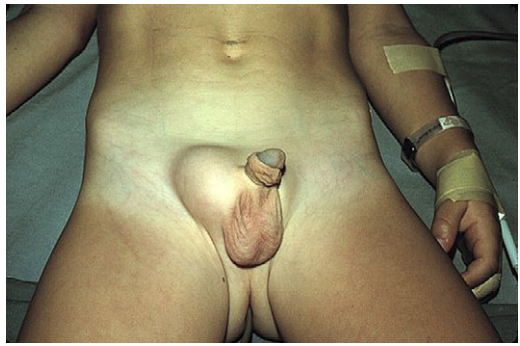

Fig. 1. Inguinal bulge seen with inguinal hernias.

An interesting new approach to diagnosis that has been used primarily in Asia is the performance of office ultrasound to differentiate between a patent processus vaginalis and an inguinal hernia [22]. Chen and colleagues were able to use office ultrasound to increase diagnostic accuracy from 84% (on physical examination alone) to 97.9% [23,24]. Erez performed preoperative ultrasound on 642 children scheduled for inguinal hernia repair and showed, by comparing preoperative and operative findings, that a hypoechoic structure in the midinguinal canal measuring 4 to 6 mm was a patent processus vaginalis, and that structures greater than 6 mm were hernias [23].

Isolated congenital hydroceles, that is, hydroceles present at birth, usually resolve in the first 2 years of life and do not necessarily increase the likelihood that a patent processus vaginalis or hernia is present [25]; however, hydroceles that develop after birth are more likely to be associated with a patent processus vaginalis that is less likely to close [25]. Communicating hydroceles can be distinguished from noncommunicating hydroceles by a history of enlargement in the evening (with standing) and a smaller size in the morning (after being supine). On physical examination, the sensation of fluid passing into the abdomen with scrotal pressure may be appreciated as well. If a hydrocele is communicating, it should be considered a hernia, and repair is indicated regardless of the age. For noncommunicating hydroceles, most pediatric surgeons recommend waiting until the child is between 1 and 2 years of age because spontaneous resolution is the rule rather than the exception.

Treatment

Open repair of inguinal hernias

Once an inguinal hernia is diagnosed, the treatment is surgical repair. Unlike in adults, all hernias in children are repaired at the time they are diagnosed, even if they are asymptomatic. Although inguinal hernia repair is not by any definition an emergency, repair should take place in a timely manner to eliminate any risk of incarceration, particularly in infants less than 12 months of age [26]. The initial description of repair of a pediatric inguinal hernia was by Celsus in 25 A.D. who removed the sac and the testes through a scrotal incision [3]. The classic contemporary description of the repair of indirect inguinal hernias in children is attributed to Potts, although the original description of high ligation of the sac was by Czerny in 1887 [3,27]. High ligation of the sac is practiced by all pediatric surgeons. Even though minor changes in technique have evolved, the current technique is directly descended from the procedure taught by Ladd and Gross, the founders of North American pediatric surgery [28].

A skin incision is made in the inguinal crease overlying the internal ring. Scarpa's fascia and the external oblique are opened. The cremasteric fibers are bluntly dissected until the sac can be seen. The sac is then gently separated from the cord structures, divided, dissected to the level of the internal

ring, and ligated at this level. In patients with a dilated internal ring, a Marcy repair (closure of a widely dilated internal ring) can be added to the high ligation [29]. Hydroceles, which are present 19% of the time, are either split anteriorly or excised [30]. In one prospective randomized trial of excision versus splitting of a distal sac/hydrocele, there was no difference in recurrence of the hydrocele or complications, suggesting that simply opening the anterior wall is effective [31]. Skin closure in children can be done with subcuticular sutures or Dermabond; however, two different prospective studies have shown that Dermabond has no improved outcome, takes longer than subcuticular sutures, and has slightly more complications [32,33]. The use of an ''L-stitch'' may decrease the risk of stitch abscess after subcuticular closure [30,34]. Anesthesia and pain control during and after inguinal hernia repair have evolved with contemporary techniques of pediatric anesthesia. Caudal blocks are used routinely in most children's hospitals because they result in decreased emergence time and better pain control [35]. Intraoperative injection of the ilioinguinal nerve (lateral to the internal ring) and the ileohypogastric nerve (beneath the external oblique) can be performed in patients who do not undergo a caudal block [30]. Postoperatively, most children do well with acetominophen alone, although the addition of codeine may be necessary for some.

The classic open repair with high ligation of the sac has excellent results. In the largest series reported by a single surgeon (6361 patients), there was a 1.2% recurrence rate, a 1.2% wound infection rate, and a 0.3% rate of testicular atrophy. Other series report a recurrence rate of approximately 1% as well [30,36,37]. Factors that may contribute to recurrence in open inguinal hernia repair in children include failure to ligate the sac high enough, an excessively dilated internal ring injury to the floor of the canal (with subsequent development of a direct inguinal hernia), and the presence of comorbid conditions (eg, collagen disorders, malnutrition, or pulmonary disease) [38]. Other complications that occur after inguinal hernia repair in children include testicular atrophy, injury to the vas deferens, and iatrogenic cryptorchidism. Testicular atrophy occurs in 1% to 2% and decreased testicular size in 2.7% to 13% of patients [39]. Iatrogenic cryptorchidism occurs in 0.6% to 2.9% of patients [39]. Injury to the vas deferens has been reported to occur in as many as 1.6% of patients based on findings on pathology [39]. A more realistic risk of injury to the vas deferens is 0.13% to 0.53% [40–42]. Higher numbers may represent inexperienced surgeons or pathologists, because embryologic remnants may be misinterpreted as vas deferens [41,42]. Although extremely rare, infertility as a result of injury to the fallopian tubes has been reported in girls as well [43,44]. Mesh repair in children is ill advised and may even be contraindicated. Although there are conflicting data [45], many animal studies have demonstrated that polypropylene mesh results in an inflammatory reaction which causes changes in the vas deferens and testes [46,47]. In addition, infertility in men as a direct result of herniorrhaphy with mesh has been reported [48].

Contralateral exploration in children with unilateral hernias

In 1952 Duckett reported that contralateral hernias were present in as many as 30% of children presenting with unilateral hernias. We now know that these "hernias" were often the processus vaginalis and that, had they been left alone, many would not have become clinically significant hernias. Duckett's report was followed by an article in 1955 by Rothenberg who recommended "prophylactic" contralateral exploration in all children [49]. These reports became the basis for the recommendation that all children undergo a contralateral exploration when a unilateral hernia was diagnosed. This standard of care persisted until the 1990s when this classic teaching began to be questioned. The debate about contralateral exploration involves a choice between treating only obvious hernias (and dealing with a metachronous hernia later) versus preventing metachronous hernias by closing any patent processus vaginalis that is found. After weighing the risks and benefits, most pediatric surgeons now believe that routine open contralateral exploration is not indicated. Testicular atrophy occurs in 2% to 30% of children undergoing open groin exploration or hernia repair [50]. Open exploration is associated with an increased risk of infertility; as many as 40% of infertile males who had bilateral hernia repairs as children have bilateral obstruction of the vas deferens [51] Vas deferens injury can also result in sperm-agglutinating antibodies which influence fertility [52]. Even minor inadvertent pinching of the vas or stretching of the cord can result in injury, which also increases the risk of infertility [53–56] This inadvertent injury may be more likely when there is no true hernia sac present because the vas is more exposed. When boys were studied 8 to 20 years after inguinal hernia repair, 5.8% of them had decreased testicular size on the side of the repair and 1% had testicular atrophy [37].

For surgeons who opt to treat only the symptomatic side and to follow the patient for a possible metachronous hernia, the benefit is avoiding any risk of injury to cord structures, which might affect future fertility. The risk of this approach is that the patient will develop a metachronous hernia with an accompanying, albeit small, risk of incarceration. Incarceration may also lead to infertility through vascular compromise to the testes [57]. In 1997 Miltenberg and colleagues [58] published a meta-analysis of over 13,000 patients who had undergone repair of a unilateral hernia. The rate of metachronous hernia in children undergoing unilateral repair in this large meta-analysis was 7%. The risk was slightly higher if the initial presenting hernia was on the left (11%). Other large studies have shown that metachronous hernias occur in 3.6% to 11.6% of children after unilateral inguinal hernia repair [1,22,30,39,59–62]. In a study from New Zealand following the publication of Miltenberg's study, 264 patients were followed prospectively after unilateral hernia repair rather than routinely exploring the contralateral side. Metachronous hernias developed in 5% of these patients. This approach also resulted in decreased operating room time and decreased overall cost [1].

The advent of laparoscopic exploration has added a middle ground to the debate, because the laparoscope allows evaluation of the contralateral side without significant risk of injury to the vas and vessels. The percentage of pediatric surgeons using laparoscopic exploration is increasing [37]. The downside of this approach is that laparoscopic exploration cannot differentiate between a patent processus vaginalis and a true hernia. Some surgeons use a ''significant'' peritoneal opening [59], lack of termination of the visualized opening [59], or the visualization of bubbles internally with external pressure [59] as demonstration of a true hernia (Figs. 2 and 3). Most surgeons proceed with repair if there is any finding of patency, regardless of whether it is thought to be a patent processus vaginalis or true hernia. Approximately 50% of these procedures will be ''unnecessary'' because the findings would have remained an asymptomatic patent processus vaginalis. Alternatively, this approach avoids the small risk of incarceration of a metachronous hernia as well as the cost and anxiety of a second operation [3,50]. Different techniques have been described for exploring the contralateral internal ring, including placing an umbilical port for a 5-mm laparoscope, placing an umbilical port for the laparoscope and using a ''probe'' placed through a 14-gauge Angiocath to assess patency [63], insufflation through the ipsilateral sac and then placement of a lateral upper port (16-gauge Angiocath) for in-line inspection with a 1.2-mm camera [64], and insertion of a 30-, 70-, or 120-degree laparoscope through the ipsilateral hernia sac [59,65]. Other approaches to evaluate the contralateral side, which should be mentioned for historical interest only, include herniography, the use of Bakes dilators, and the Goldstein test (diagnostic pneumoperitoneum) [66,67].

Currently, both unilateral repair with waiting or laparoscopic exploration with repair of a patent processus vaginalis or hernia are considered the standard of care. The most ethical approach in the setting of inadequate data is to present the pros and cons of each approach to the families and allow them to participate in the decision. In some situations, the risk-benefit ratio may warrant the more aggressive approach of laparoscopic exploration

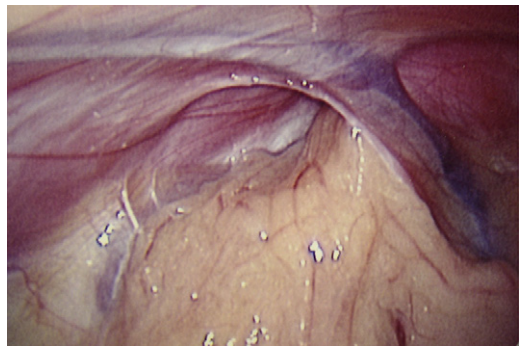

Fig. 2. Laparoscopic view of a left inguinal hernia.

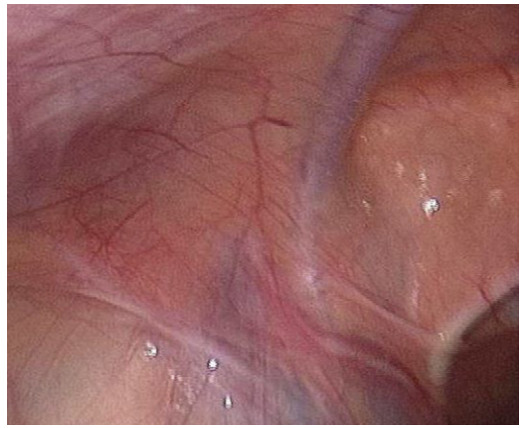

Fig. 3. Laparoscopic view of a normal left internal ring.

rather than opting to observe the contralateral side. For example, preterm infants have an additional risk of postoperative apnea and higher risk of incarceration; therefore, they should probably undergo laparoscopic exploration. Exploration may also be justified in patients known to be at higher risk for bilateral hernias or at increased operative risk, such as patients with cystic fibrosis, ventriculoperitoneal shunts, peritoneal dialysis catheters, or connective tissue disorders [59,65].

The preterm infant

The preterm infant represents a unique combination of operative and perioperative risks, which changes the basic algorithm for management. Hernias are more common in premature infants, and there is an increased risk of incarceration, as high as 31% in some series [5,68]; however, other studies have suggested that the risk may not be as great as previously thought. In one prospective study of 51 premature infants who were observed to watch the natural history of their patent processus vaginalis and hernias, only 1 (2%) experienced an incarceration [5]. The hernia sac in premature infants is more fragile than in older infants and children, and, not surprisingly, the recurrence rate and complication rate after repair are slightly higher [69]. In addition, premature infants have an added risk of postoperative apnea and bradycardia. This risk decreases as the infant matures. There are limited data based on prospective studies, but current recommendations include using regional anesthesia to limit or eliminate the need for general anesthesia, and admission for observation for infants less than 46 weeks postconceptional age [70]. Children under 60 weeks postconceptional age who have a history of lung disease, apnea at home, or other comorbidities also should be monitored after surgery. Balancing the increased risk of incarceration against the risk of perioperative

complications in premature infants has led to two distinct schools of thought in pediatric surgery—to repair the hernia before the infant is discharged from the hospital or to wait until they reach enough maturity to decrease the risk of postoperative apnea [30,71–73]. Premature infants who have symptomatic hernias, who have hernias that are difficult to reduce, or who have families without the means to quickly follow-up with the surgeon should undergo repair before discharge. Otherwise, there are no good data to suggest that early repair versus waiting is superior, and both options should be discussed with the family.

Incarcerated hernias

Unless there is clear peritonitis or bowel compromise, incarcerated hernias can usually be reduced manually using a technique called taxis. In this technique, with the infant relaxed (using sedation if necessary), gentle inferolateral pressure is applied to the incarcerated hernia with some pressure from above to straighten the canal. Approximately 80% of incarcerated inguinal hernias can be reduced using this technique [3]. Because of the high rate of early recurrent incarceration, most of these children are admitted to the hospital and undergo surgery 24 to 48 hours later after the edema has subsided. Any child with an incarcerated hernia that cannot be reduced must undergo immediate operative repair. It is important not to reduce the hernia under anesthesia before the incision in order to inspect the incarcerated bowel for evidence of strangulation. In girls, an incarcerated ovary may be present in the hernia sac. If reduction is unsuccessful, many surgeons plan for surgery the next day because the classic teaching is that the risk of vascular compromise is exceedingly low. Nevertheless, some data suggest that the risk of vascular compromise from ovarian torsion is significant, occurring in as many as 33% of cases. Immediate repair can prevent this complication and is recommended by multiple authorities [3,26,74,75]. A recently suggested alternative to open repair is to laparoscopically reduce and repair the hernia immediately [76]. The pneumoperitoneum, according to these authors, helped with reduction of the incarcerated organs and allowed inspection for vascular compromise. In addition, the intracorporeal repair is performed in nonedematous tissue at the internal ring. There are no data on the long-term outcome, but this technique offers an interesting alternative.

Laparoscopic inguinal hernia repair

Although the classic open inguinal hernia repair remains the gold standard for most pediatric surgeons, laparoscopic repair is being performed in many centers. The first reported laparoscopic repair in girls was by El-Gohary in 1997 [77]. He successfully everted the sac into the peritoneal cavity and closed it using an Endoloop. The first successful laparoscopic repair in boys was reported in 1999 by Montupet [77,78].

Like the open technique, the laparoscopic technique is fundamentally a high ligation of the indirect hernia sac. The advantages of the laparoscopic approach include the ease of examining the contralateral internal ring, the avoidance of "access" damage to the vas and vessels during mobilization of the cord, decreased operative time, and an ability to identify unsuspected direct or femoral hernias [36,79]. In a prospective, randomized, single-blind study of 97 patients, the laparoscopic approach was associated with decreased pain, parental perception of faster recovery, and parental perception of better wound cosmesis [80].

There are two basic laparoscopic approaches—a purely intracorporeal ligation and a laparoscopic-assisted extracorporeal ligation. The first large series of intracorporeal repair was reported by Schier, with primary closure of the peritoneum lateral to the cord with interrupted sutures [81]. This technique was then modified by Schier to use a Z-suture closure rather than interrupted sutures [82]. In his series of 403 patients, the recurrence rate was 2.6%, which is slightly higher than that seen with the open repair. In girls, in whom injury to the vas deferens and vessels is not an issue, laparoscopic inversion and ligation [83] or excision and closure of the sac can be used [84]. Other modifications include an N-suture instead of a purse-string suture [79] and the "flip-flap" hernioplasty, in which two folds of peritoneum are used to cover the inguinal ring similar to the "vest over pants" repair [85]. This technique theoretically has an advantage of allowing the scrotum to drain through the "slit" that is created, preventing postoperative hydroceles; however, there is only short follow-up, and there are no reports of the incidence of recurrence for this procedure.

In laparoscopic-assisted extracorporeal closures, a small stab wound is made over the inguinal ring, and a suture is passed through the abdominal wall behind the peritoneum. It is then directed around the internal ring, avoiding the vas deferens and vessels, and passed out the same stab wound. It is tied extracorporeally under laparoscopic visualization [36]. Initial reports of this technique showed complications in 32 of 204 patients (15.7%) and a recurrence rate of 4.8%, which is significantly higher than in the open or intracorporeal laparoscopic repairs [36]. Variations on the extracorporeal technique have included passing the suture into the abdomen through an 18-gauge hollow needle [86], using a "Lapher closure," which consists of a wire on the end of a 19-gauge needle that allows the purse-string suture to be passed [87], and using an Obwegeser maxillary awl to pass the suture [77].

Direct inguinal hernias

Although they are rare, congenital direct inguinal hernias in children do occur; approximately 2% to 5% of groin hernias in children are direct [82,88,89]. The principles of repair and the techniques used are identical to that for adult direct inguinal hernias. Pediatric tissues have greater elasticity, and primary repair is usually much more straightforward than

in the adult population. Concern about the lifelong effect of prosthetic material has led most pediatric surgeons to repair direct inguinal hernias primarily rather than with prosthetic materials.

Femoral hernias

Femoral hernias in children are rare, occurring in less than 1% of children with groin hernias [88]. These hernias are exceedingly rare in infants, usually presenting in older children [90]. They often present as recurrent hernias after inguinal hernia repair, most likely because the surgeon was misled by the findings of a processus vaginalis at the initial surgery and missed the actual hernia defect [91]. Techniques of repair include the classic McVay repair, a transversalis pedicle flap to close the femoral canal [92], laparoscopic mesh plug or patch repair [93,94], and use of the umbilical ligament as a plug for laparoscopic repair [95].

Umbilical hernias

By definition, all newborns have a small defect in the umbilicus at birth through which the umbilical vessels pass. Closure of the umbilical ring is spontaneous and represents the only ''hernia'' in the body that is genetically programmed to close. The molecular basis of closure of the umbilical ring is poorly understood but fascinating. Solving this relative mundane mystery could lead to the ability to induce genes to close other fascial defects. There are clearly genetic influences that affect umbilical ring closure; African American and African children have a much higher incidence of umbilical hernias [96]. Numerous syndromes are associated with an increased risk of umbilical hernia, including Beckwith-Wiedemann and Down syndrome [97].

The rate of closure of the umbilical ring is variable. Arrested closure results in a clinically significant umbilical hernia. Clear indications to repair an umbilical hernia in children include incarceration or the presence of symptoms [98]. Incarceration has traditionally been thought to be rare in children, but at least one study suggests that the incidence may be higher (5%) than previously reported [99]. Less clear but equally acceptable indications for umbilical hernia repair include children who experience psychologic ''complications'' such as excessive playing with the hernia or other socially handicapping behaviors. The least clear indication is failure to close. In general, the larger the fascial defect and the older the child, the less likely the hernia is to close. Based on this principle, most pediatric surgeons will close lesions 1.5 to 2.0 cm in diameter after 2 to 3 years of age, ''significant'' (1–1.5 cm) fascial defects that fail to decrease in size over 6 to 12 months of observation in children over 3 years of age, and fascial defects that persist at 5 to 6 years of age [96,97]. Based on observations made in Nigeria, fascial

defects continue to close until at least 14 years of age; therefore, continued observation can be offered to families as well [100].

Umbilical hernia repair is performed through an infraumbilical, curvilinear incision. The stalk is divided and the peritoneum removed from the dermal surface. The fascial defect can be closed with interrupted transverse sutures or a vest over pants repair. The dermis is tacked to the fascia and the skin closed. Some children with large proboscoid hernias may require umbilicoplasty to achieve a cosmetically acceptable appearance [101,102]. Although many pediatric surgeons have been taught to use a pressure dressing to prevent hematoma or seroma formation, this has been shown to be unnecessary in a prospective randomized trial of patients with routine umbilical hernias [103].

Ventral and lumbar hernias

Congenital ventral hernias, also called epigastric hernias, occur due to failure of approximation of the midline (linea alba) during the final stages of formation of the abdominal wall. Congenital ventral hernias are almost exclusively located in the epigastric region, and approximately 50% of them are symptomatic [104]. The incidence of these hernias has been reported to be as high as 5% [97]. Most epigastric hernias are solitary and are usually approached using a small midline incision. Epigastric hernias may be present just above the umbilical ring and may be falsely diagnosed as umbilical hernias. These supraumbilical hernias will not close and should be repaired when diagnosed. They can be approached through a supraumbilical curvilinear incision rather than a midline incision. At the time of repair of epigastric hernias, it is important to mark the palpable mass (usually herniated preperitoneal fat) before induction of anesthesia, because the hernia may be difficult to identify with the patient asleep. Once the incarcerated preperitoneal fat is removed, the fascial defect is usually only 1 to 2 mm in diameter and can be closed with a single suture. Occasionally, there may be multiple fascial defects, in which case a laparoscopic approach to avoid a long or multiple incisions may be indicated [105]. Spigelian hernias, or herniation at the lateral edge of the rectus, usually at the arcuate line, are rare in children, but have been reported [106,107]. Congenital lumbar hernias are exceedingly rare, with less than 50 cases reported in the literature [108,109].

Summary

Almost all groin hernias in children are indirect inguinal hernias and occur as a result of incomplete closure of the processus vaginalis. The treatment is repair by high ligation of the hernia sac, which can be done by an open or laparoscopic technique. The contralateral side can be explored by laparoscopy or left alone; open exploration is no longer indicated due to

the potential risk of infertility. Umbilical hernias are common in infants but usually close with time. Surgery is indicated if the umbilical hernia is symptomatic or if the fascial defect fails to decrease in size over time.

References

[1] Manoharan S, Samarakkody U, Kulkarni M, et al. Evidence-based change of practice in the management of unilateral inguinal hernia. J Pediatr Surg 2005;40(7):1163–6.

[2] Glick PL, Boulanger S. Inguinal hernias and hydroceles. In: Grosfeld JL, O'Neill J, Coran A, et al, editors. Pediatric surgery. Philadelphia: Elsevier; 2006. p. 1172–92.

[3] Lloyd D. Inguinal and femoral hernia. In: Ziegler M, Azizkhan R, Weber T, editors. Operative pediatric surgery. New York: McGraw-Hill; 2003. p. 543–54.

[4] Kurkchubasche A, Tracy T. Unique features of groin hernia repair in infants and children. In: Fitzgibbons R, Greenburg A, editors. Nyhus and Condon's hernia. Philadelphia: Lippincott Williams & Wilkins; 2002. p. 435–51.

[5] Toki A, Watanabe Y, Sasaki K, et al. Adopt a wait-and-see attitude for patent processus vaginalis in neonates. J Pediatr Surg 2003;38(9):1371–3.

[6] Miltenburg DM, Nuchtern JG, Jaksic T, et al. Laparoscopic evaluation of the pediatric inguinal hernia: a meta-analysis. J Pediatr Surg 1998;33(6):874–9.

[7] Rowe MI, Copelson LW, Clatworthy HW. The patent processus vaginalis and the inguinal hernia. J Pediatr Surg 1969;4(1):102–7.

[8] van Veen RN, van Wessem KJ, Halm JA, et al. Patent processus vaginalis in the adult as a risk factor for the occurrence of indirect inguinal hernia. Surg Endosc 2007;21(2):202–5.

[9] van Wessem KJ, Simons MP, Plaisier PW, et al. The etiology of indirect inguinal hernias: congenital and/or acquired? Hernia 2003;7(2):76–9.

[10] 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 1999;34(4):552–5.

[11] Tanyel FC, Okur HD. Autonomic nervous system appears to play a role in obliteration of processus vaginalis. Hernia 2004;8(2):149–54.

[12] 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 2004;39(7):1024–9.

[13] Hosgor M, Karaca I, Ozer E, et al. The role of smooth muscle cell differentiation in the mechanism of obliteration of processus vaginalis. J Pediatr Surg 2004;39(7):1018–23.

[14] Cook BJ, Hasthorpe S, Hutson JM. Fusion of childhood inguinal hernia induced by HGF and CGRP via an epithelial transition. J Pediatr Surg 2000;35(1):77–81.

[15] Ting AY, Huynh J, Farmer P, et al. The role of hepatocyte growth factor in the humoral regulation of inguinal hernia closure. J Pediatr Surg 2005;40(12):1865–8.

[16] Hutson JM, Albano FR, Paxton G, et al. In vitro fusion of human inguinal hernia with associated epithelial transformation. Cells Tissues Organs 2000;166(3):249–58.

[17] Clarnette TD, Hutson JM. The genitofemoral nerve may link testicular inguinoscrotal descent with congenital inguinal hernia. Aust N Z J Surg 1996;66(9):612–7.

[18] Jones ME, Swerdlow AJ, Griffith M, et al. Risk of congenital inguinal hernia in siblings: a record linkage study. Paediatr Perinat Epidemiol 1998;12(3):288–96.

[19] Gong Y, Shao C, Sun Q, et al. Genetic study of indirect inguinal hernia. J Med Genet 1994; 31(3):187–92.

[20] Czeizel A, Gardonyi J. A family study of congenital inguinal hernia. Am J Med Genet 1979; 4(3):247–54.

[21] 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 2007;166(7): 667–9.

[22] Toki A, Watanabe Y, Sasaki K, et al. Ultrasonographic diagnosis for potential contralateral inguinal hernia in children. J Pediatr Surg 2003;38(2):224–6.
[23] Erez I, Rathause V, Vacian I, et al. Preoperative ultrasound and intraoperative findings of inguinal hernias in children: a prospective study of 642 children. J Pediatr Surg 2002;37(6): 865–8.
[24] Chen KC, Chu CC, Chou TY, et al. Ultrasonography for inguinal hernias in boys. J Pediatr Surg 1998;33(12):1784–7.
[25] Katz DA. Evaluation and management of inguinal and umbilical hernias. Pediatr Ann 2001;30(12):729–35.
[26] Stylianos S, Jacir NN, Harris BH. Incarceration of inguinal hernia in infants prior to elective repair. J Pediatr Surg 1993;28(4):582–3.
[27] Potts WJ, Riker WL, Lewis JE. The treatment of inguinal hernia in infants and children. Ann Surg 1950;132(3):566–76.
[28] Levitt MA, Ferraraccio D, Arbesman MC, et al. Variability of inguinal hernia surgical technique: a survey of North American pediatric surgeons. J Pediatr Surg 2002;37(5):745–51.
[29] Yokomori K, Ohkura M, Kitano Y, et al. Modified Marcy repair of large indirect inguinal hernia in infants and children. J Pediatr Surg 1995;30(1):97–100.
[30] Ein SH, Njere I, Ein A. Six thousand three hundred sixty-one pediatric inguinal hernias: a 35-year review. J Pediatr Surg 2006;41(5):980–6.
[31] Gahukamble DB, Khamage AS. Prospective randomized controlled study of excision versus distal splitting of hernial sac and processus vaginalis in the repair of inguinal hernias and communicating hydroceles. J Pediatr Surg 1995;30(4):624–5.
[32] Ong CC, Jacobsen AS, Joseph VT. Comparing wound closure using tissue glue versus subcuticular suture for pediatric surgical incisions: a prospective, randomised trial. Pediatr Surg Int 2002;18(5–6):553–5.
[33] van den Ende ED, Vriens PW, Allema JH, et al. Adhesive bonds or percutaneous absorbable suture for closure of surgical wounds in children: results of a prospective randomized trial. J Pediatr Surg 2004;39(8):1249–51.
[34] Mahabir RC, Christensen B, Blair GK, et al. Avoiding stitch abscesses in subcuticular skin closures: the L-stitch. Can J Surg 2003;46(3):223–4.
[35] Conroy JM, Othersen HB Jr, Dorman BH, et al. A comparison of wound instillation and caudal block for analgesia following pediatric inguinal herniorrhaphy. J Pediatr Surg 1993; 28(4):565–7.
[36] Ozgediz D, Roayaie K, Lee H, et al. Subcutaneous endoscopically assisted ligation (SEAL) of the internal ring for repair of inguinal hernias in children: report of a new technique and early results. Surg Endosc 2007;21(8):1327–31.
[37] Antonoff MB, Kreykes NS, Saltzman DA, et al. American Academy of Pediatrics section on surgery hernia survey revisited. J Pediatr Surg 2005;40(6):1009–14.
[38] Grosfeld JL, Minnick K, Shedd F, et al. Inguinal hernia in children: factors affecting recurrence in 62 cases. J Pediatr Surg 1991;26(3):283–7.
[39] Tackett LD, Breuer CK, Luks FI, et al. Incidence of contralateral inguinal hernia: a prospective analysis. J Pediatr Surg 1999;34(5):684–7 [discussion: 687–8].
[40] Partrick DA, Bensard DD, Karrer FM, et al. Is routine pathological evaluation of pediatric hernia sacs justified? J Pediatr Surg 1998;33(7):1090–2 [discussion: 1093–4].
[41] Popek EJ. Embryonal remnants in inguinal hernia sacs. Hum Pathol 1990;21(3):339–49.
[42] Steigman CK, Sotelo-Avila C, Weber TR. The incidence of spermatic cord structures in inguinal hernia sacs from male children. Am J Surg Pathol 1999;23(8):880–5.
[43] Hansen KA, Eyster KM. Infertility: an unusual complication of inguinal herniorrhaphy. Fertil Steril 2006;86(1):217–8.
[44] Urman BC, McComb PF. Tubal occlusion after inguinal hernia repair: a case report. J Reprod Med 1991;36(3):175–6.
[45] Kolbe T, Lechner W. Influence of hernioplastic implants on male fertility in rats. J Biomed Mater Res B Appl Biomater 2007;81(2):435–40.

[46] Maciel LC, Glina S, Palma PC, et al. Histopathological alterations of the vas deferens in rats exposed to polypropylene mesh. BJU Int 2007;100(1):187–90.
[47] Peiper C, Junge K, Klinge U, et al. Is there a risk of infertility after inguinal mesh repair? Experimental studies in the pig and the rabbit. Hernia 2006;10(1):7–12.
[48] Shin D, Lipshultz LI, Goldstein M, et al. Herniorrhaphy with polypropylene mesh causing inguinal vasal obstruction: a preventable cause of obstructive azoospermia. Ann Surg 2005; 241(4):553–8.
[49] Rothenberg RE, Barnett T. Bilateral herniotomy in infants and children. Surgery 1955; 37(6):947–50.
[50] Marulaiah M, Atkinson J, Kukkady A, et al. Is contralateral exploration necessary in preterm infants with unilateral inguinal hernia? J Pediatr Surg 2006;41(12):2004–7.
[51] Matsuda T, Muguruma K, Hiura Y, et al. Seminal tract obstruction caused by childhood inguinal herniorrhaphy: results of microsurgical reanastomosis. J Urol 1998;159(3):837–40.
[52] Friberg J, Fritjofsson A. Inguinal herniorrhaphy and sperm-agglutinating antibodies in infertile men. Arch Androl 1979;2(4):317–22.
[53] Ceylan H, Karakok M, Guldur E, et al. Temporary stretch of the testicular pedicle may damage the vas deferens and the testis. J Pediatr Surg 2003;38(10):1530–3.
[54] Abasiyanik A, Guvenc H, Yavuzer D, et al. The effect of iatrogenic vas deferens injury on fertility in an experimental rat model. J Pediatr Surg 1997;32(8):1144–6.
[55] Janik JS, Shandling B. The vulnerability of the vas deferens (II): the case against routine bilateral inguinal exploration. J Pediatr Surg 1982;17(5):585–8.
[56] Shandling B, Janik JS. The vulnerability of the vas deferens. J Pediatr Surg 1981;16(4): 461–4.
[57] Le Coultre C, Cuendet A, Richon J. Frequency of testicular atrophy following incarcerated hernia. Z Kinderchir 1983;38(Suppl):39–41.
[58] Miltenburg DM, Nuchtern JG, Jaksic T, et al. Meta-analysis of the risk of metachronous hernia in infants and children. Am J Surg 1997;174(6):741–4.
[59] Sozubir S, Ekingen G, Senel U, et al. A continuous debate on contralateral processus vaginalis: evaluation technique and approach to patency. Hernia 2006;10(1):74–8.
[60] Nassiri SJ. Contralateral exploration is not mandatory in unilateral inguinal hernia in children: a prospective 6-year study. Pediatr Surg Int 2002;18(5–6):470–1.
[61] Kemmotsu H, Oshima Y, Joe K, et al. The features of contralateral manifestations after the repair of unilateral inguinal hernia. J Pediatr Surg 1998;33(7):1099–102 [discussion: 1102–3].
[62] Given JP, Rubin SZ. Occurrence of contralateral inguinal hernia following unilateral repair in a pediatric hospital. J Pediatr Surg 1989;24(10):963–5.
[63] Geiger JD. Selective laparoscopic probing for a contralateral patent processus vaginalis reduces the need for contralateral exploration in inconclusive cases. J Pediatr Surg 2000; 35(8):1151–4.
[64] Bhatia AM, Gow KW, Heiss KF, et al. Is the use of laparoscopy to determine presence of contralateral patent processus vaginalis justified in children greater than 2 years of age? J Pediatr Surg 2004;39(5):778–81.
[65] Tamaddon H, Phillips JD, Nakayama DK. Laparoscopic evaluation of the contralateral groin in pediatric inguinal hernia patients: a comparison of 70- and 120-degree endoscopes. J Laparoendosc Adv Surg Tech A 2005;15(6):653–60.
[66] Timberlake GA, Ochsner MG, Powell RW. Diagnostic pneumoperitoneum in the pediatric patient with a unilateral inguinal hernia. Arch Surg 1989;124(6):721–3.
[67] Christenberry DP, Powell RW. Intraoperative diagnostic pneumoperitoneum (Goldstein test) in the infant and child with unilateral inguinal hernia. Am J Surg 1987;154(6):628–30.
[68] Rajput A, Gauderer MW, Hack M. Inguinal hernias in very low birth weight infants: incidence and timing of repair. J Pediatr Surg 1992;27(10):1322–4.
[69] Rathauser F. Historical overview of the bilateral approach to pediatric inguinal hernias. Am J Surg 1985;150(5):527–32.

[70] Walther-Larsen S, Rasmussen LS. The former preterm infant and risk of postoperative apnoea: recommendations for management. Acta Anaesthesiol Scand 2006;50(7):888–93.
[71] Gonzalez Santacruz M, Mira Navarro J, Encinas Goenechea A, et al. Low prevalence of complications of delayed herniotomy in the extremely premature infant. Acta Paediatr 2004;93(1):94–8.
[72] Misra D. Inguinal hernias in premature babies: wait or operate? Acta Paediatr 2001;90(4): 370–1.
[73] Uemura S, Woodward AA, Amerena R, et al. Early repair of inguinal hernia in premature babies. Pediatr Surg Int 1999;15(1):36–9.
[74] Marinkovic S, Kantardzic M, Bukarica S, et al. When to operate nonreducible ovary? Med Pregl 1998;51(11–12):537–40.
[75] Boley SJ, Cahn D, Lauer T, et al. The irreducible ovary: a true emergency. J Pediatr Surg 1991;26(9):1035–8.
[76] Kaya M, Huckstedt T, Schier F. Laparoscopic approach to incarcerated inguinal hernia in children. J Pediatr Surg 2006;41(3):567–9.
[77] Spurbeck WW, Prasad R, Lobe TE. Two-year experience with minimally invasive herniorrhaphy in children. Surg Endosc 2005;19(4):551–3.
[78] Montupet P, Esposito C. Laparoscopic treatment of congenital inguinal hernia in children. J Pediatr Surg 1999;34(3):420–3.
[79] Schier F. Laparoscopic inguinal hernia repair: a prospective personal series of 542 children. J Pediatr Surg 2006;41(6):1081–4.
[80] Chan KL, Hui WC, Tam PK. Prospective randomized single-center, single-blind comparison of laparoscopic vs open repair of pediatric inguinal hernia. Surg Endosc 2005;19(7):927–32.
[81] Schier F. Laparoscopic surgery of inguinal hernias in children: initial experience. J Pediatr Surg 2000;35(9):1331–5.
[82] Gorsler CM, Schier F. Laparoscopic herniorrhaphy in children. Surg Endosc 2003;17(4): 571–3.
[83] Zallen G, Glick PL. Laparoscopic inversion and ligation inguinal hernia repair in girls. J Laparoendosc Adv Surg Tech A 2007;17(1):143–5.
[84] Becmeur F, Philippe P, Lemandat-Schultz A, et al. A continuous series of 96 laparoscopic inguinal hernia repairs in children by a new technique. Surg Endosc 2004;18(12):1738–41.
[85] Yip KF, Tam PK, Li MK. Laparoscopic flip-flap hernioplasty: an innovative technique for pediatric hernia surgery. Surg Endosc 2004;18(7):1126–9.
[86] Oak SN, Parelkar SV, K R, et al. Large inguinal hernia in infants: is laparoscopic repair the answer? J Laparoendosc Adv Surg Tech A 2007;17(1):114–8.
[87] Takehara H, Yakabe S, Kameoka K. Laparoscopic percutaneous extraperitoneal closure for inguinal hernia in children: clinical outcome of 972 repairs done in 3 pediatric surgical institutions. J Pediatr Surg 2006;41(12):1999–2003.
[88] Schier F, Klizaite J. Rare inguinal hernia forms in children. Pediatr Surg Int 2004;20(10): 748–52.
[89] Schier F. Direct inguinal hernias in children: laparoscopic aspects. Pediatr Surg Int 2000; 16(8):562–4.
[90] Ollero Fresno JC, Alvarez M, Sanchez M, et al. Femoral hernia in childhood: review of 38 cases. Pediatr Surg Int 1997;12(7):520–1.
[91] Al-Shanafey S, Giacomantonio M. Femoral hernia in children. J Pediatr Surg 1999;34(7): 1104–6.
[92] Haberlik A, Sauer H. [Treatment of femoral hernia in children]. Chirurg 1990;61(4):289–91.
[93] Ceran C, Koyluoglu G, Sonmez K. Femoral hernia repair with mesh-plug in children. J Pediatr Surg 2002;37(10):1456–8.
[94] Lee SL, DuBois JJ. Laparoscopic diagnosis and repair of pediatric femoral hernia: initial experience of four cases. Surg Endosc 2000;14(12):1110–3.
[95] Ikossi DG, Shaheen R, Mallory B. Laparoscopic femoral hernia repair using umbilical ligament as plug. J Laparoendosc Adv Surg Tech A 2005;15(2):197–200.

[96] Cilley R. Disorders of the umbilicus. In: Grosfeld JL, O'Neill J, Coran A, et al, editors. Pediatric surgery. Philadelphia: Elsevier; 2006. p. 1143–56.
[97] Kokoska E, Weber T. Umbilical and supraumbilical disease. In: Ziegler M, Azizkhan R, Weber T, editors. Operative pediatric surgery. New York: McGraw-Hill; 2003. p. 543–54.
[98] Brown RA, Numanoglu A, Rode H. Complicated umbilical hernia in childhood. S Afr J Surg 2006;44(4):136–7.
[99] Fall I, Sanou A, Ngom G, et al. Strangulated umbilical hernias in children. Pediatr Surg Int 2006;22(3):233–5.
[100] Meier DE, OlaOlorun DA, Omodele RA, et al. Incidence of umbilical hernia in African children: redefinition of "normal" and reevaluation of indications for repair. World J Surg 2001;25(5):645–8.
[101] Ikeda H, Yamamoto H, Fujino J, et al. Umbilicoplasty for large protruding umbilicus accompanying umbilical hernia: a simple and effective technique. Pediatr Surg Int 2004; 20(2):105–7.
[102] el-Dessouki NI, Shehata SM, Torki AM, et al. Double half-cone flap umbilicoplasty: a new technique for the proboscoid umbilical hernia in children. Hernia 2004;8(3):182–5.
[103] Merei JM. Umbilical hernia repair in children: is pressure dressing necessary. Pediatr Surg Int 2006;22(5):446–8.
[104] Coats RD, Helikson MA, Burd RS. Presentation and management of epigastric hernias in children. J Pediatr Surg 2000;35(12):1754–6.
[105] Albanese CT, Rengal S, Bermudez D. A novel laparoscopic technique for the repair of pediatric umbilical and epigastric hernias. J Pediatr Surg 2006;41(4):859–62.
[106] Graivier L, Bronsther B, Feins NR, et al. Pediatric lateral ventral (spigelian) hernias. South Med J 1988;81(3):325–6.
[107] Losanoff JE, Richman BW, Jones JW. Spigelian hernia in a child: case report and review of the literature. Hernia 2002;6(4):191–3.
[108] Wakhlu A, Wakhlu AK. Congenital lumbar hernia. Pediatr Surg Int 2000;16(1–2):146–8.
[109] Pul M, Pul N, Gurses N. Congenital lumbar (Grynfelt-Lesshaft) hernia. Eur J Pediatr Surg 1991;1(2):115–7.