Hernias in the Pediatric Population

46

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Introduction

Pediatric hernias, particularly indirect inguinal and umbilical hernias, compromise a large percentage of the pediatric surgeon's practice. This article will review the surgical management of the most common pediatric hernias.

Indirect Inguinal Hernia

Epidemiology

Indirect inguinal hernias are one of the most common congenital defects treated by pediatric surgeons worldwide. The overall incidence of inguinal hernias in pediatric patients ranges from 0.8 to 4.4% and is more commonly found in males compared to females. The highest incidence is found in premature and low birth weight infants, estimated between 9 and 30% [1, 2].

Embryology

Indirect inguinal hernias are congenital defects that result from failure of the processus vaginalis to close. During fetal development, the testes are guided down to the scrotum by the gubernaculum and a small outpouching of the peritoneum, which eventually forms the processus vaginalis. This process is similar in females, but the peritoneal outpouching is called the canal of Nuck and terminates in the labia majora. In normal fetal development, the canal of Nuck and processus vaginalis

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obliterate between 36 and 40 weeks of gestation. An arrest in this portion of development results in a patent processus vaginalis (PPV).

The incidence of PPV has been reported to be as high as 48–63% and decreases with age [3–5]. Rowe et al. reported that about 40% of PPV close within the first few months of life and an additional 20% close by 2 years of age [5]. While a PPV is a major risk factor in the development of an inguinal hernia, only 3.8–14.8% actually develop into inguinal hernias [6].

Clinical Presentation/Diagnosis

Pediatric patients present to a surgical clinic with a history of an intermittent groin bulge with straining. If the clinician is able to feel the upper edge of the bulge in the scrotum on physical examination, then it is likely a hydrocele or a retractile testis.

It is not uncommon for the surgeon to not see a bulge during their physical exam, so some surgeons will operate based on history alone or ask the parents to take a picture of the bulge and return to the clinic. A "silk glove" sign has been described as a tool to aid in inguinal hernia diagnosis, and it involves rolling the cord structures over the pubic tubercle to assess for thickening. The accuracy rate of this diagnostic tool is widely varied in the literature, ranging from 66 to 93% [7, 8].

While ultrasound is used as a tool to differentiate a hernia between a hydrocele, a retractile testis, and a lymphadenopathy, it has also been described in the diagnosis of a PPV in multiple studies [9–11].

While most patients present electively in the outpatient setting as described above, some patients may also present to the emergency room with an acute incarceration. This will be discussed in more detail below in the "Incarcerated Hernia" section.

Timing of Surgery

The incidence of incarceration ranges between 3 and 16%, with up to a 31% risk in premature infants [2, 12]. Stylanios et al. reported that 35% of their patients with an incarcerated hernia had a known inguinal hernia [13]. Also, the risk of complications after an incarcerated hernia is 11–31% [13, 14] (i.e., gonadal infarction, necrotic bowel, wound infections, and recurrence), compared to about 1% in elective hernia repairs [15]. For these reasons, inguinal hernias are repaired soon after diagnosis.

Timing of repair in premature and low birth weight infants is controversial given the risk of anesthesia-related cardiopulmonary complications, such as apnea [16]. Additionally, premature and low birth weight infants have a higher risk of recurrence, ranging from 2.6 to 12.1% [17]. However, the risk of incarceration in premature infants increases with time, and Lautz et al. found that the risk in fact doubled in patients that were repaired after 40 weeks postconception compared to those that were repaired 36–40 weeks [18]. At this time, there is no clear consensus in the

management of these patients, but a survey of pediatric surgeons found that 63% would repair the hernia prior to discharge from the NICU (in preterm infants >29 weeks postconception and minimum 1 kg weight) [19].

Treatment

Open Repair (High Ligation)

Technique

The key step in the repair of indirect inguinal hernias is high ligation of the sac. The procedure is typically performed under general anesthesia. The patient is placed in the supine position, and pubic tubercle and anterior superior iliac spine are used to identify the approximate location of the inguinal canal. The skin incision is created along the inguinal crease, superior and lateral to the pubic tubercle. The incision is carried down to the external oblique muscle, which is then divided up to the external ring, exposing the cord structures and the hernia sac. The cord structures and hernia sac are then cleared off the superior and inferior flaps of the external oblique muscle using blunt dissection. Afterward, the sac is then carefully dissected away from the cord structures until reaching the internal ring. The sac is then dissected to the level of the internal ring, divided and ligated. If the internal ring appears widened, then some place a single stitch to close it slightly to minimize the risk of recurrence.

Outcomes/Complications

Open repairs have an overall complication rate of about 1% [15, 20]. The risk of wound infection is 0.6–1.2%, and risk of recurrence is 0.4–1.2% [20, 21]. There is also a 0.3–2% risk of testicular injury, 0–0.5% risk of injury to the vas deferens, and 0.6–2.9% risk of iatrogenic cryptorchidism [22].

Laparoscopic Repair

Prep and Patient Positioning

The procedure is performed under general anesthesia. The patient should void prior to the procedure to avoid the need for a urinary catheter during the operation. The scrotum should be prepped in addition to the abdomen to allow the surgeon to push on the scrotum to remove pneumoperitoneum prior to ligating the hernia sac. The patient is placed in the supine position, and Trendelenburg may be used to improve visualization by moving the bowel caudally.

The author's preference is to stand on the patient's left side regardless of the side of the hernia, but the operating surgeon may also consider standing on the ipsilateral side of the hernia.

Anatomy

The deep internal ring has the spermatic cord running through it in males, and the round ligament runs through it in females. When visualizing it from inside the

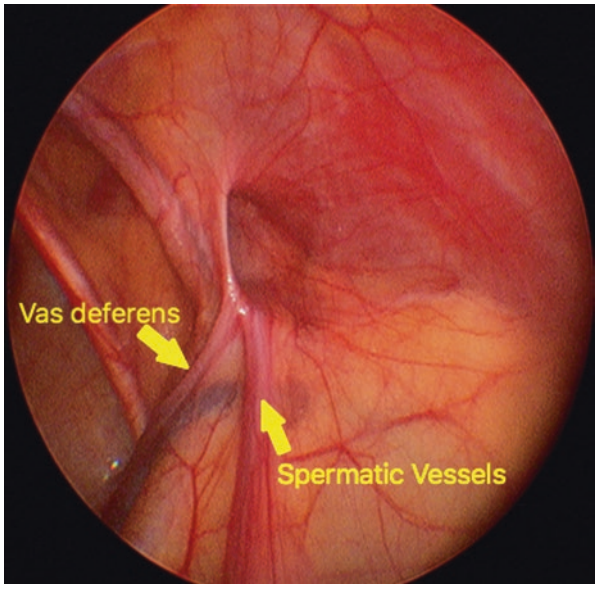

Fig. 46.1 The locations of the vas deferens and spermatic vessels on a right-sided inguinal hernia

abdomen, the inferior epigastric vessels are superior to the internal ring, the spermatic vessels are inferior/lateral, and the vas deferens is inferior/medial to the inguinal ring (Fig. 46.1). The genital branch of the genitofemoral nerve enters the internal ring alongside the spermatic vessels.

Approaches

There are multiple intraperitoneal and extraperitoneal laparoscopic techniques currently being used to repair inguinal hernias. The author's preferred technique is a two-port extraperitoneal approach, which is a variation of the percutaneous internal ring suturing technique (PIRS) [23], and will be described here in detail.

The key steps to this technique are hydrodissection of the peritoneum away from the cord structures, thermal injury to the peritoneum at the superior aspect of the internal ring, and suture ligation of the hernia. Thermal dissection is used to create scar tissue, which was found in a rabbit model to increase the strength of the closure [24].

Equipment

This procedure is performed using a laparoscope (3 mm/70-degree in neonates, 5 mm/30-degree in larger children), a Maryland dissector or hook cautery, a 25-gauge finder needle, an 18-gauge spinal needle, a 3-0 monofilament suture, and a 2-0 permanent braided suture.

Surgical Steps

- The 18-gauge needle is bent using two needle drivers to create a gentle curve. The 3-0 monofilament suture is folded in half, and the looped end is threaded

Fig. 46.2 The 3-0 monofilament suture is threaded through the 18-gauge needle, with the looped end just inside the tip of the needle

through the 18-gauge needle, with the looped end just inside the tip of the needle (Fig. 46.2).

- A trocar is placed infraumbilically, and the laparoscope is inserted after the desired pneumoperitoneum is reached (a 3-mm trocar is typically used unless it is a larger patient, i.e., >40 kg).
- A separate stab incision is placed in the lower abdomen for placement of the Maryland dissector or hook cautery. This stab incision may be placed on the ipsilateral side of the hernia, but the author's preference is to always place it in the left lower abdomen. This allows for the author's right hand to always be maneuvering the needle, while the left hand assists with the Maryland dissector.
- The Maryland dissector/hook cautery is used to cauterize the internal ring. This is performed from the 8 to 5 o'clock position only, so to avoid injuring the cord structures (Fig. 46.3).
- A 25-gauge finder needle is then used for hydrodissection. It is inserted until just anterior to the peritoneum, and either local anesthetic or normal saline is injected circumferentially around the internal ring to dissect the peritoneum away from the cord structure (Fig. 46.4).
- The 25-gauge finder needle is then used to identify the 12 o'clock position of the internal ring, and a 1-mm stab incision is made in the skin at this location.
- The spinal needle is then placed through the 1-mm stab incision and passed laterally around the internal ring in the hydrodissection place, over the spermatic vessels and also the vas deferens, if possible (Fig. 46.5). Maryland dissector may be used to aid pulling counter tension on the peritoneum to allow for easier and safer passage of the spinal needle.
- After passing the spermatic vessels (and possibly the vas deferens), the spinal needle is pushed through the peritoneum into the abdominal cavity, at approximately the 6 o'clock position. The loop of monofilament suture is pushed partially out of the needle, and the needle is removed, leaving the suture in place (Fig. 46.6).

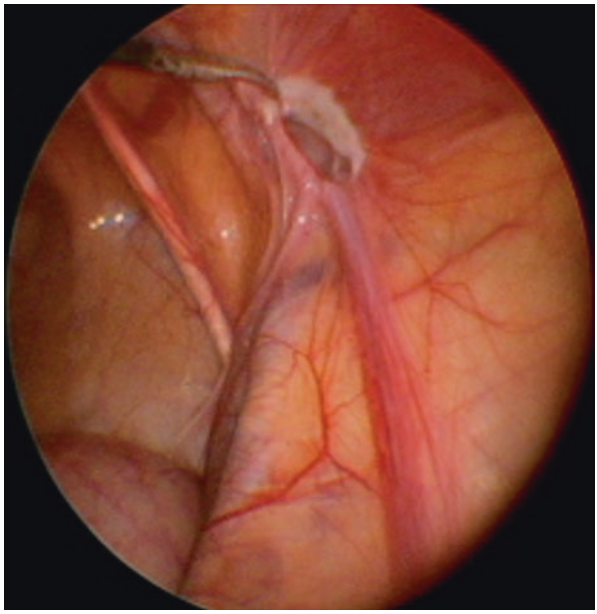

Fig. 46.3 The internal ring is cauterized using the Maryland dissector from approximately the 8 to 5 o'clock position

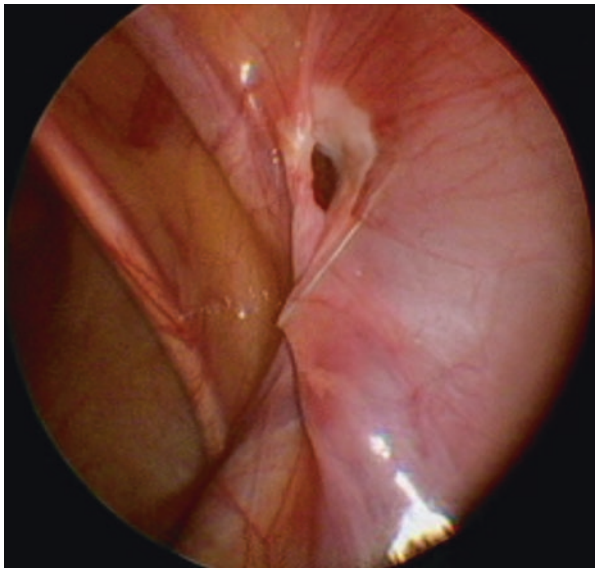

Fig. 46.4 The 25 G needle is used to perform hydrodissection to separate the peritoneum away from the cord structures

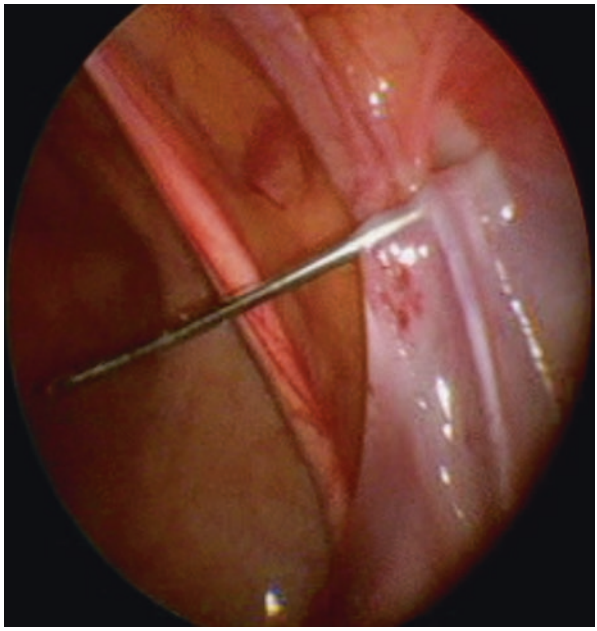

Fig. 46.5 The spinal needle is passed laterally around the internal ring in the hydrodissection plane and passed over the cord structures

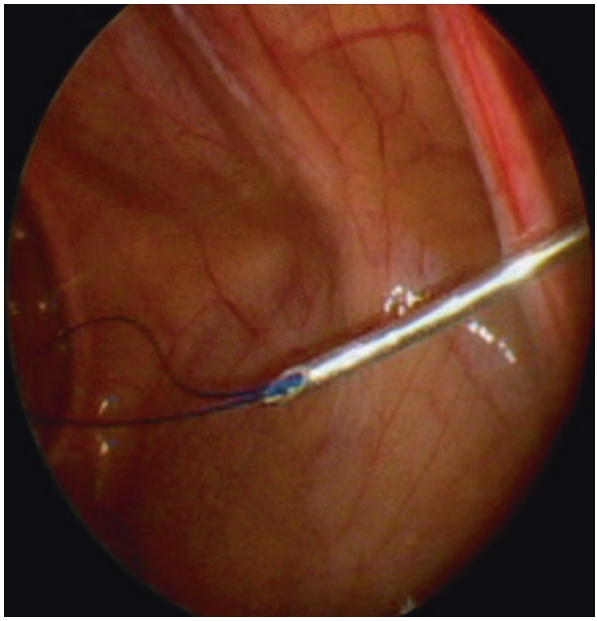

Fig. 46.6 The spinal needle is passed through the peritoneum around the 6 o'clock position, and the suture is pushed out of the needle end

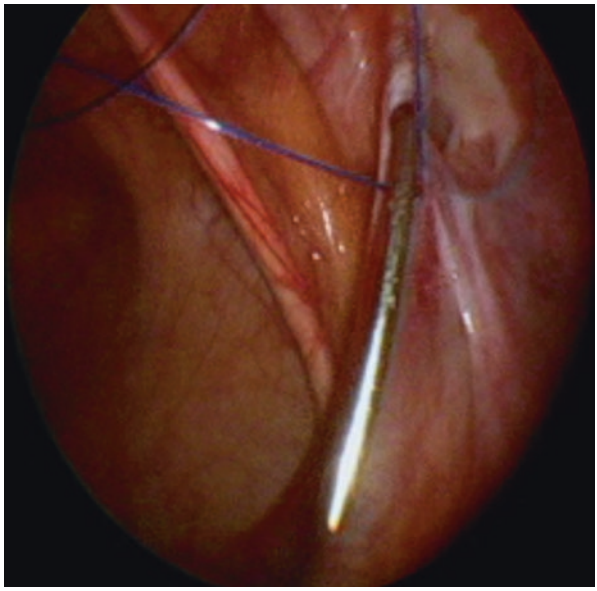

Fig. 46.7 The spinal needle is then passed medially around the ring and placed through the first loop of suture

- The spinal needle, with a new looped monofilament suture, is again placed through the same 1-mm stab incision and now advanced medially around the internal ring through the dissection plane. If the vas deferens was unable to be passed laterally, it should be attempted to pass it medially, with the goal to pierce the spinal needle through the peritoneum in the same location. If it is too difficult to pass over the vas deferens, then push the needle through the peritoneum medial to the vas deferens, and just leave the peritoneum over the vas deferens in place.
- Once the spinal needle is through the peritoneum, it is pushed through the first loop (Fig. 46.7). This first loop is then pulled snug against the needle, and then the second loop that is in the spinal needle is pushed out (Fig. 46.8). The needle is then removed while keeping the first loop snug. This first loop will act as a snare to pull the second loop laterally around the internal ring and out of the abdomen.
- The monofilament suture is then exchanged for the braided nonabsorbable suture by looping the braided suture around the monofilament suture and then using the monofilament suture to pull the braided suture around the internal ring (Fig. 46.9). The reason for this exchange is that the author has demonstrated in a rabbit model that nonabsorbable, braided suture is more effective than monofilament and this type of suture leaves a softer knot in the subcutaneous tissue postoperatively [24]. This suture, however, is too soft to slide easily through the spinal needle when it is looped, which is why we start with a stiff, monofilament suture.
- The looped end of the braided suture is then cut, and four ends of the suture are tied down to create two knots, double ligating the hernia. Make sure to apply pressure to the scrotum prior to tying down the sutures to evacuate any pneumoperitoneum. In infants, one of the sutures is removed, and only single ligation is performed to prevent a potential suture granuloma.

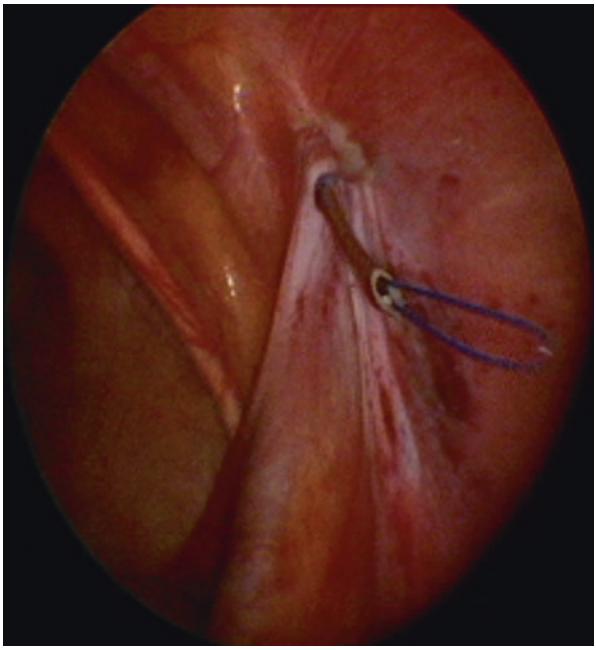

Fig. 46.8 The second looped suture is then passed through the spinal needle

Other Techniques

Intraperitoneal high ligation and closure of the ring may be performed using a variety of suturing methods such as the Z stitch, purse-string suture, or interrupted sutures [25]. Endoloop closure of the hernia has also been described, but this should only be used in females, given the risk of spermatic cord injury [26]. Riquelme et al. also described performing hernia sac dissection without closure of the ring in patients with an inguinal ring of <1 cm and report no recurrences in 91 patients [27]. It is thought that the scarring from the hernia sac dissection creates a sufficient enough closure that a suture is not necessary.

Additional percutaneous/extracorporeal approaches are the SEAL (subcutaneous endoscopically assisted ligation) and the PIRS technique. The SEAL technique involves placing the suture percutaneously and advancing it circumferentially around the internal ring avoiding the cord structures [28]. The PIRS technique uses the spinal needle to advance a suture circumferentially around the internal ring [23]. Additional instruments have been created, such as a blunt hook, to dissect around the internal ring [29].

Outcomes/Complications

In addition to the complications listed for open repair (wound infection, recurrence, testicular atrophy, injury to vas deferens), there is also risk of injury to surrounding structures, such as the inferior epigastric vessels, bladder, and bowel [30].

In a recent meta-analysis, the overall incidence of recurrence was 0.7%, incidence of injury to surrounding structures was 0.32%, and incidence of conversion was 0.05% [30]. It was also found that hydrodissection and the use of an assisting forceps significantly reduced the incidence of injury and recurrence.

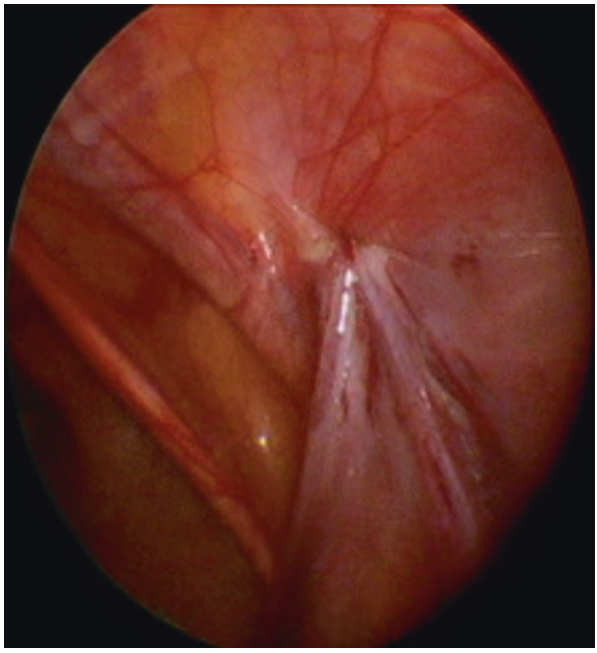

Fig. 46.9 Final appearance of the inguinal ring after suture ligation

Contralateral Groin Exploration

There is continued debate on the use of routine contralateral groin explorations during an open unilateral repair. Routine exploration evaluates for and treats a contralateral PPV or subclinical contralateral hernia, which would avoid a potential future operation, anesthesia exposure, and possible incarceration.

However, as discussed previously, PPV have the potential to close and of those that do not close, not all develop into clinical hernias. While the incidence of a PPV is reported up to 63% in the first 2 months of life, it steadily declines after that, and about 60% of them close by the age of 2 years [5]. Of those that don't close, about 3.8–14.3% develop into clinical hernias [1, 6, 31–33]. Additionally, Ron et al. also reported that 14 contralateral explorations are required to prevent one potential hernia [34], and Maillet et al. found that the risk of morbidity of a routine exploration is greater than potential morbidities of not exploring the contralateral side [35]. For these reasons, routine open exploration is no longer recommended.

Routine laparoscopic exploration of the contralateral side, including both a transumbilical and transinguinal approach, is more controversial. Some have advocated the use of a laparoscopic evaluation of the contralateral side through a transinguinal approach, which would avoid negative open explorations [36]. Additionally, laparoscopic exploration and repair of the contralateral side during a laparoscopic unilateral repair avoid the use of a separate incision, minimally increase operative time,

and may be cost-effective [37, 38]. Despite this, many still advocate against routine repair of contralateral PPV. While laparoscopy has a high sensitivity and specificity in diagnosing a contralateral PPV, it has a poor predictive value in detecting which PPV develop into clinical hernias [37, 39]. This would subject certain patients to an unnecessary procedure, and observation is found to have a lower incidence of complications, including injury and anesthesia risk, than a contralateral repair [35, 40]. However, a survey by Holcomb et al. found that 90% of parents request contralateral evaluation and repair at the time of a unilateral exploration [41]. At this time, there is no clear consensus on how to manage a contralateral PPV found on laparoscopic evaluation. The author always consents the patients undergoing the lap repair for a possibility of bilateral repair.

Incarcerated Hernias

Nonoperative reduction should first be attempted as it is successful in 70–95% of patients and may be performed using sedation or analgesia [42, 43]. If the hernia is unable to be reduced or if there is concern for an incomplete reduction, then emergent operative intervention is indicated. Otherwise, given the risk of recurrent incarceration, the hernia should be repaired during the same hospitalization. Many clinicians wait for 24–48 h after reduction to allow the edema to resolve and make the repair technically easier; however, this is not required with laparoscopic repair.

Laparoscopic repair is considered a safe alternative to an open repair and also offers potential advantages. These advantages include easier reduction of the hernia content because of the widening of the internal ring from pneumoperitoneum and allows for direct visualization of the hernia contents to assess for complete reduction and viability. The operation is also considered technically easier and may be performed immediately after reduction, since it avoids dissection of the edematous tissue [44–46].

Necrotic Gonads

Testicular infarction may occur from incarceration secondary to compression of the gonadal vessels by the hernia contents. The appearance of a necrotic testes does not necessary signify irreversible damage, and testes have been found to be functional in 25–50% of the cases, so orchiectomy is not recommended [47].

Uterine adnexa is found in about 15% of inguinal hernias and has a strangulation risk of 0.2–33% [21, 48]. Unlike the mechanism for testicular infarction, strangulation occurs from ovarian torsion. The angle between the suspensory ligament of the ovary and ovarian ligament becomes narrowed when the ovary enters the inguinal canal, predisposing it to torsion [48]. Like in males, the appearance of a necrotic ovary does not necessary mean irreversible damage, and multiple studies have found on follow-up that most ovaries were found to be viable [49, 50]. For this reason, oophorectomy is not indicated in these patients.

Umbilical Hernias

Anatomy and Pathophysiology

Umbilical hernias occur from incomplete closure of the fascial defect at the umbilicus after birth. The incidence is estimated at 26%, with higher incidences in black and premature infants [51, 52]. Walker found in an evaluation of black children that 84.7% of all umbilical hernias close spontaneously before the age of 6 and 96% of defects less than 0.5 cm close before the age of 6 years [53]. He additionally found that defects larger than 1.5 cm rarely close spontaneously.

Surgical Timing

The overall risk of incarceration is low, estimated at 1 per 1500 umbilical hernias or between 0.19 and 4.5% [54, 55]. Given the overall low risk of incarceration and the high likelihood of closure with time, most surgeons wait to operate until the age of 4–5 [55]. Indications to operate sooner are history of incarceration and presence of symptoms.

Surgical Technique

The procedure is performed in the supine position, and an infraumbilical or paraumbilical curvilinear incision is created. Dissection is carried down to the hernia sac, which is then freed up circumferentially from the fascia and subcutaneous tissue. The contents are then reduced back into the abdomen. There is no clear benefit to resecting the hernia sac [56]. The fascial defect is then closed using simple interrupted sutures and the skin is closed. An umbilicoplasty should be considered in patients with a large proboscis for cosmesis. Pressure dressings at the site of the umbilicus have not been found to decrease the risk of hematoma or seroma formation [57].

Epigastric Hernia

Epigastric hernias are midline fascial defects superior to the umbilicus. They represent 4% of all hernias and are a congenital defect from improper union of the rectus muscles to create the linea alba during development; however, some studies suggest that they may actually be acquired defects [58]. Epigastric hernias do not close spontaneously and are often scheduled for repair soon after diagnosis. They may be repaired either open or laparoscopically, and it is critical to mark the skin at the site of the epigastric hernia preoperatively to allow easier identification intraoperatively. The author does not usually operate on these hernias if they are asymptomatic given the exceedingly low risk of intestinal incarceration.

Direct Inguinal Hernia

Direct inguinal hernias are rare in the pediatric population, estimated between 0.2 and 4.5% [59]. These hernias are repaired primarily with or without the use of mesh, in a similar technique that is used in adults.

Femoral Hernia

Femoral hernias are also rare in children and comprise less than 1% of all hernias, with an incarceration risk between 15 and 20% [60]. They are often incorrectly diagnosed and repaired as an inguinal hernia, and the true diagnosis is not made until the patient presents with a recurrence. These hernias may be repaired open, using the standard McVay approach or laparoscopically using the mesh patch and plug technique [60, 61].

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