

# Incarcerated Pediatric Hernias



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## KEYWORDS

- Incarcerated pediatric hernia • Inguinal hernia • Umbilical hernia • Spigelian hernia
- Femoral hernia

## KEY POINTS

- Indirect inguinal hernias are the most commonly incarcerated hernias in children, with a higher incidence in low birth weight and premature infants.
- Contralateral groin exploration to evaluate for a patent processus vaginalis or subclinical hernia is controversial, even laparoscopically, given that most never progress to clinical hernias.
- Most indirect inguinal hernias can be reduced nonoperatively. Given the high risk of recurrence and morbidity, it is recommended to repair them in a timely fashion, even in premature infants.
- Laparoscopic repair of incarcerated inguinal hernia repair is considered a safe and effective alternative to conventional open herniorrhaphy.
- Other incarcerated pediatric hernias (umbilical, femoral, spigelian, epigastric, lumbar, and direct inguinal), which are extremely rare, may be managed effectively with laparoscopy.

## INTRODUCTION

Indirect inguinal hernias are the most common incarcerated pediatric inguinal hernias, although incarceration of other pediatric hernias, such as femoral, umbilical, spigelian, epigastric, direct inguinal, and lumbar, has been reported in the literature. This article discusses the current literature on the diagnosis and management of incarcerated hernias.

## INDIRECT INGUINAL HERNIA

### *Epidemiology*

Indirect inguinal hernia is one of the most common surgical conditions seen by pediatric surgeons.<sup>1</sup> The overall incidence of indirect inguinal hernias ranges from 0.8% to 5% in full-term infants,<sup>2,3</sup> but the risk is significantly increased in low birth weight (<1 kg) and premature infants, with a prevalence up to 30%.<sup>3,4</sup> The risk of incarceration

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in children ranges from 3% to 16%, although it is as high as 31% in premature infants, with most occurring within the first year of life.<sup>5,6</sup> Inguinal hernias are more common in boys compared with girls (5:1 ratio), but girls have a higher incidence of bilateral inguinal hernias compared with boys (25.4% vs 12.9%). There does not seem to be a difference in rate of incarceration between boys and girls.<sup>2,7</sup>

### **Anatomy**

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An indirect inguinal hernia is a congenital abnormality from the failure of the processus vaginalis to close. The processus vaginalis is an outpouching of peritoneum that, along with the gubernaculum, guides the testes in their descent through the inguinal ring into the scrotum. In girls, the canal of Nuck, which is functionally similar to the processus vaginalis, terminates in the labia majora and assists in guiding the ovaries to their final location in the pelvis. The processus vaginalis and canal of Nuck both close between 36 and 40 weeks of gestation. The left testis descends before the right and commonly closes first, resulting in a higher incidence of right-sided inguinal hernias (60%).<sup>1,8</sup>

### **Clinical Presentation/Diagnosis**

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Most inguinal hernias are asymptomatic, and they are often found during routine physical examination, or by a parent. It presents as intermittent bulging in the groin, scrotum, or labia, often with straining. An incarcerated hernia presents as an irreducible nonfluctuant bulge that is tender and may be erythematous. The child is usually inconsolable, and may have obstructive symptoms such as nausea/vomiting, lack of bowel function, and abdominal distention. If incarceration progresses to strangulation, the child may have peritonitis, bloody stools, and hemodynamic instability.

Other conditions may be confused for an incarcerated hernia, such as a retractile testis, lymphadenopathy, and hydrocele.<sup>8</sup> Although ultrasonography has been described as a tool to help differentiate these causes,<sup>9</sup> physical examination can help make the correct diagnosis. For example, if the clinician's fingers can discretely feel the upper edge of the bulge in the scrotum, then it is likely a hydrocele because a hernia has bowel going up into the inguinal canal. Also, a hydrocele should not be tender. Abdominal radiograph may show dilated loops of bowel and/or air fluid levels consistent with a bowel obstruction.

### **Nonoperative Management**

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Unless there is evidence of bowel compromise, peritonitis, or hemodynamic instability, nonoperative reduction should be attempted because 70% to 95% of incarcerated inguinal hernias are successfully reduced.<sup>5,10,11</sup> Reduction attempts are usually performed using sedation and analgesics, although there is not a standardized protocol, and pharmacotherapy should be at the discretion of the provider.<sup>12</sup>

The following is the preferred technique of the authors for nonoperative reduction. The patient is placed in the supine position. One hand should be placed above the external ring, with fingers around the hernia neck to keep it fixed in place and prevent the hernia contents from sliding over the external ring. The other hand should provide simultaneous moderate and steady pressure on the hernia contents toward the abdominal cavity along the axis of the inguinal canal and internal ring. Continuous pressure may help push out some of the bowel edema and regular, delicate movement of the fingers on the hernia sac may move the hernia contents, both aiding in reduction.<sup>13</sup> It may take several minutes to successfully reduce the hernia.

If the inguinal hernia is unable to be reduced, or there is concern for an incomplete reduction, then operative reduction should be performed emergently. Although it is unlikely to reduce gangrenous bowel successfully, it has been reported to be possible in the literature, so there should be close observation of the patient afterward.<sup>14</sup>

### ***Timing of Surgery***

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Many children presenting with incarcerated hernias have a previously diagnosed inguinal hernia. Stylianou and colleagues<sup>5</sup> found that 35% of patients presenting with incarcerated hernias had a previously diagnosed inguinal hernia. Similarly, Niedzielski and colleagues<sup>15</sup> reported that 52.9% of their 153 patients with incarcerated inguinal hernias had a prior episode of incarceration. The risk of postoperative complications such as testicular atrophy, bowel ischemia, wound infections, and hernia recurrence are increased in incarcerated hernias (4.5%–33% compared with 1% in elective hernia repairs in healthy, full-term infants), with the highest risk being in those with irreducible inguinal hernias.<sup>5,15–17</sup> Given the risk of recurrent incarceration after a successful reduction, it is recommended that herniorrhaphy be performed during the same hospitalization after a period of time, from 24 hours to within 5 days, to allow edema to resolve.<sup>5,15,18,19</sup> Some clinicians choose to discharge home with a reliable family with plans for hernia repair in the very near future.

### ***Premature and low birth weight infants***

There is controversy as to the optimal timing of herniorrhaphy in premature and low birth weight infants. The current practice, according to a survey of pediatric surgeons by Antonoff and colleagues,<sup>20</sup> is that 63% operate before discharge from the neonatal intensive care unit (ICU), 18% operate depending on patient age and weight, and 5% operate when it is convenient. As stated earlier, premature and low birth weight infants have the highest risk of infarction, but they also have a risk of anesthesia-related postoperative cardiopulmonary issues such as apnea, bradycardia, and even cardiopulmonary arrest. This risk was initially reported to be as high as 49%, but more recent data show the risk closer to 5%, with these complications mainly occurring in patients with preexisting apnea.<sup>21</sup> Alternatively, by waiting, the patient has a higher risk of incarceration, with one study reporting double the risk after 40 weeks of age compared with those repaired before 39 weeks.<sup>4</sup> There is also a higher risk of postoperative complications with incarcerated hernias, although there are some data to suggest that prematurity may be a bigger risk factor for developing complications.<sup>18,22,23</sup>

There is no clear consensus on the optimal time for surgery in low birth weight and premature infants, so the decision needs to be made on a case-by-case basis by the surgeon.

### ***Anesthesia/Preoperative Planning***

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General anesthesia is more commonly used for inguinal herniorrhaphy, especially for acutely incarcerated and laparoscopic cases. Spinal anesthesia is being used in preterm infants, and, per a recent Cochrane Review, it may have a lower risk of postoperative cardiopulmonary issues when used without sedation.<sup>24</sup> Regional and local anesthetic may be used for postoperative pain control.

Patients need adequate intravenous access for fluid resuscitation and consideration of placement of a Foley catheter for close monitoring of urine output. A nasogastric tube should be placed before induction if the patient has symptoms of a bowel obstruction.

### ***Open Repair***

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The technique is similar to an elective open repair with high ligation of the sac, except a longer skin incision is usually needed with incarcerated hernias to adequately reduce and inspect the hernia contents.

The patient is placed in the supine position and the external landmarks, pubic tubercle, and anterior superior iliac spine are identified to approximate the location of the

inguinal canal. A skin incision is made along the inguinal crease superior and lateral to the pubic tubercle. The layers of the abdominal wall are dissected down until reaching the external oblique muscle. In incarcerated and strangulated hernias, the tissue may be extremely edematous and friable so extra care in identifying the cord structures is necessary. The external oblique muscle is then divided through the external ring, exposing the hernia sac and the cord structures. After clearing the superior and inferior flaps of the external oblique muscle using blunt dissection, the sac should be carefully dissected away from the cord structures up to the internal ring. The sac should then be opened to evaluate the hernia contents. If the bowel appears viable, it should be replaced intraperitoneally. If the internal ring appears widened from repeat episodes of incarceration, then it may need to be closed to minimize the potential for future episodes of recurrence. The incision is then closed in multiple layers and dressed according to the surgeon's preference.

### **Pitfalls**

**Irreducible hernia contents** If the hernia contents are unable to be reduced after opening the sac, consider placing the patient in Trendelenburg position and using gentle, steady pressure to again attempt to reduce the hernia. If the hernia contents are still irreducible, this may be secondary to a constricting internal ring, which needs to be divided. The ring should be divided sharply on the lateral edge to avoid injuring the inferior epigastric vessels and cord structures. Consider placement of your finger or an instrument through the internal ring to help dilate the ring, protect the hernia sac contents, and also guide the ligating instrument. The internal ring requires repair before the completion of the procedure.

**Nonviable hernia contents** If there is a question about the viability of the bowel post-reduction, then it is reasonable to cover it with moist, warm gauze and to reevaluate it after a few minutes. If it does not appear viable, then bowel resection with primary anastomosis may be performed through various approaches, including through the inguinal incision, a right lower quadrant incision, or midline laparotomy.

When performing the bowel resection through the inguinal incision, additional bowel proximal and distal to the necrotic section needs to be pulled out through the inguinal ring for inspection and also to allow for a tension-free anastomosis. The internal ring may need to be divided for ease of removal and subsequent reduction of the bowel, with the new anastomosis, back into the abdomen.

A right lower quadrant incision, such as a La Roque incision, may also be performed as an extension of the existing inguinal incision. A La Roque incision is a gridiron incision through the abdominal wall muscles and transversalis fascia above the internal ring.<sup>25</sup> This incision is performed by extending the incision laterally to the McBurney point through the external oblique muscle and then splitting the internal oblique, transversalis muscle, and fascia in a separate incision 2 to 3 cm above the internal ring, so as to prevent disrupting the entire inguinal floor.<sup>26</sup> This incision allows visualization of the hernia entering the internal ring directly above it, and provides sufficient exposure to perform a bowel resection.

Other options are a midline laparotomy and laparoscopy-assisted minilaparotomy, the latter resulting in a smaller midline incision but still allowing for a thorough inspection of the bowel.

A right lower quadrant incision, midline laparotomy, and laparoscopy-assisted minilaparotomy may be considered if there is concern about adequate width of the internal ring to allow for proper inspection of the bowel and also reduction of the new anastomosis back into the abdomen without putting it at risk of injury. Resecting the

compromised bowel through the inguinal incision and then transitioning to one of these other methods, such as the laparoscopy-assisted minilaparotomy, to perform the anastomosis is also an option.

**Spontaneous reduction of hernia contents before inspection** Placing the patient in reverse Trendelenburg during induction may avoid spontaneous reduction of the hernia contents. If the hernia contents do reduce before they can be fully inspected, it is reasonable to continue with the hernia repair and closely observe the patient for peritonitis postoperatively, unless there is evidence of foul-smelling or bloody fluid intraoperatively.<sup>16</sup> Laparoscopy through the hernia sac may also be used as an adjunct to evaluate the bowel in this situation.<sup>27</sup>

### **Girls**

Uterine adnexa are found in 15% to 31% of inguinal hernia sacs.<sup>28</sup> Incarceration risk is estimated to be between 4% and 15%, with strangulation occurring in 2% to 33% of incarcerated ovaries.<sup>7,28–30</sup> Unlike the mechanism of testicular infarction, which primarily occurs from compression of the gonadal vessels at the internal ring by incarcerated bowel, ovarian infarction primarily occurs secondary to ovarian torsion.<sup>29,31</sup> This higher risk of torsion in incarcerated ovaries is attributed to narrowing of the angle between the suspensory ligament of the ovary and the ovarian ligament, creating a bell-clapper-like deformity, so the ligaments are no longer able to properly support the ovary, predisposing it to twisting.<sup>29</sup>

There is no clear consensus on how urgently an asymptomatic incarcerated ovary requires surgery. Some studies recommend urgent intervention (within 24–48 hours),<sup>32,33</sup> whereas other studies recommend emergent intervention of all incarcerated ovaries, including asymptomatic and chronic incarcerations, given the higher risk of torsion.<sup>29,34,35</sup> Based on a 2005 survey of pediatric surgeons, 50% operate at the next available opportunity, whereas 32% operate urgently or emergently.<sup>20</sup>

Girls also have a higher risk of sliding hernias involving the uterus, fallopian tubes, ovaries, and/or bladder, so a more distal ligation of the hernia sac may be required to avoid injury to these structures. Goldstein and Potts<sup>37</sup> described a technique in which the portion of the sac that contains the sliding hernia is dissected along its border creating a flap, which is then folded and placed intraperitoneally. The remaining sac is closed with a purse-string suture.<sup>8,16,36,37</sup>

### **Management of necrotic gonads**

The appearance of necrotic ovaries and testes at the time of operation does not necessarily signify irreversible damage or predict future functionality. Multiple studies report that, even with evidence of ovarian ischemia (black or blue discoloration with failure to improve after detorsion), most ovaries are viable on follow-up with evidence of follicular development.<sup>38–40</sup> Similarly, ischemic-appearing testes after reduction of an incarcerated hernia may survive in 25% to 50% of cases.<sup>41</sup> Testicular atrophy is reported to result in 2.3% to 15% of incarcerated hernias (manually and operatively reduced), although some of these cases may be a result of the surgery.<sup>11</sup> Given the potential for retained functionality, the current recommendation is for close postoperative monitoring with avoidance of testicular resection, unless there is frank necrosis present.<sup>7,8</sup>

### **Laparoscopic Repair**

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Laparoscopy is now seen as a safe approach to the management of incarcerated inguinal hernias, and there are multiple laparoscopic intraperitoneal and extraperitoneal techniques being used.

### ***Intraperitoneal approach***

A Veress needle is often placed through an infraumbilical incision. Once the desired intra-abdominal pressure is achieved (usually 10–12 mm Hg), a laparoscope is inserted through a port at the umbilicus. Two additional trocars or 3-mm stab incisions are placed in the left and right lower quadrants. The hernia is then reduced using blunt graspers and possibly external compression. Insufflation may also make reduction technically easier because it widens the internal ring.<sup>42</sup> The abdominal cavity and bowel are then inspected. Bowel resection is performed intracorporeally or through a small umbilical incision extracorporeally as needed. Afterward, the herniorrhaphy is performed.

There are multiple techniques described to close the defect. High ligation and closure of the ring may be performed using a variety of suturing techniques, including a Z stitch, a purse-string suture, running suture, and interrupted sutures.<sup>43–46</sup> Endo-loop ligation has also been used to perform high ligation, but this is used in girls only, because there is a high risk of injury to the cord structures.<sup>47</sup> There is also the flip-flap technique, which is performed by raising a peritoneal flap anterolateral to the inguinal ring and rotating it medially over the ring and suturing it.<sup>48</sup> Resection of the hernia sac without ligation has also been described, and it is performed by dissecting the hernia sac away from the cord structures and then resecting the entire processus vaginalis with a rim of surrounding peritoneum. The defect is not closed and it is thought that peritoneal scarring closes the inguinal ring. Riquelme and colleagues<sup>49</sup> performed this procedure in 91 patients, excluding those who had a wide inguinal ring (>1 cm), and had no evidence of inguinal hernia recurrence during a follow-up period of 5 months to 4 years.

### ***Percutaneous/extracorporeal***

Single-port and 2-port techniques have both been described in repair of the inguinal ligament. The SEAL (subcutaneous endoscopically assisted ligation) and PIRS (percutaneous internal ring suturing) techniques are both variations of a single-port technique with placement of a laparoscope through the umbilicus and percutaneous placement of a suture around the internal ring.<sup>44,50,51</sup>

Variations of the single-port technique are the hook method and the author's variation of the PIRS technique, which include placement of a 3-mm grasper through a stab incision without placement of a trocar. The hook method is performed by using a hook to bluntly dissect around the internal ring and then looping a suture around the internal ring, which is then tied down to ligate the hernia sac.<sup>52</sup> The variation of the PIRS technique that is used by the author is described in detail elsewhere.<sup>53</sup> It involves cauterization of the internal ring using a 3-mm Maryland dissector, avoiding the portion near the cord structures. This variation, in theory, leads to scarring, which reinforces the closure and decreases the risk of recurrence. Hydrodissection is then performed using either saline or local anesthetic to create a plane between the cord structures and peritoneum. Using a combination of a curved needle and looped sutures, a double-suture ligation is performed around the inguinal ring. Two-port techniques are similar to these techniques but a trocar is placed to pass the additional instruments through.<sup>44,54</sup>

Single-port, 2-port, and 3-port techniques have all been effectively used in incarcerated inguinal hernia management.<sup>42,54–57</sup>

## ***Outcomes***

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### ***Recurrence***

Recurrence rates of elective open inguinal hernia repair have been reported between 0.3% and 3.8%, with a more recent case series showing a recurrence rate of

1.2%.<sup>7,30,58,59</sup> Recurrence rates for laparoscopic repair are reported between 0.73% and 4.1%.<sup>60–63</sup> Incarcerated inguinal hernias have higher recurrence rates, reported between 1.2% and 20%.<sup>15,30,64</sup>

### **Complications**

Perioperative complications (ischemia of testis, ovary, or bowel; surgical site infection; injury to surrounding structures) are reported between 4.5% and 33% in incarcerated hernias compared with between 0.6% and 1% in elective hernia repairs in healthy full-term infants.<sup>5,15–17</sup> Testicular atrophy after testicular infarction is estimated between 2.3% and 15%<sup>5,11</sup> compared with 0.3% in elective hernia repairs.<sup>7</sup> Wound infection rates are between 0.8% and 2%,<sup>5,7,65</sup> with higher rates in incarcerated hernias. Other complications include injury to surrounding structures, such as the vas deferens and bladder, which are reported to be higher in incarcerated hernias because of the edema, which may increase the difficulty of the dissection.<sup>10</sup>

### **Laparoscopic Versus Open Repair**

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Both techniques have been compared in the management of incarcerated inguinal hernias and have similar outcomes<sup>66</sup>; however, laparoscopy may have advantages compared with the conventional open repair. These advantages include easier reduction because of mechanical widening of the internal ring from pneumoperitoneum, direct visualization of the bowel to ensure complete reduction and viability, and easier visualization of the contralateral groin. It is also described as technically easier because it requires minimal dissection of the edematous tissue.<sup>42</sup> Laparoscopy has also been associated with a shorter hospital stay, decreased postoperative pain, and better cosmetic results,<sup>56</sup> although other studies report comparable hospital stays and postoperative complications.<sup>66</sup> There are also data suggesting possible decreased recurrence rates in laparoscopic resection compared with open resection, which is attributed to the lack of dissection of the friable hernia sac.<sup>64,67</sup>

### **Contralateral Groin Exploration**

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The incidence of a contralateral inguinal hernia is cited as between 5.6% and 31%, with higher incidences found in younger children (aged <2 years) and premature infants.<sup>3,7,10,30,68,69</sup> There is ongoing debate about whether contralateral groin exploration should be performed, especially in premature infants, given their high incidence of a contralateral hernia or patent processus vaginalis (PPV). Routine exploration evaluates for and treats a subclinical contralateral hernia and PPV, avoiding a repeat operation and future risk of incarceration. However, because not all PPVs develop into clinical hernias and there is currently no way of predicting which ones are at risk, this may result in a large number of unnecessary operations and expose patients to unnecessary surgical risks.

The incidence of PPV in infants is reported between 48% and 63%, with the highest incidence found in patients within the first 2 months of life. Rowe and colleagues<sup>70</sup> studied the incidence of contralateral PPV during routine open exploration and found that the incidence of PPV decreased with age. Based on this, they concluded that up to 40% of PPVs close within the first few months of life, and a subsequent 20% close by 2 years of age. Surana and Puri<sup>71</sup> also showed a similar trend with open explorations. Some investigators argue that open exploration may overestimate the incidence of PPV, but laparoscopic explorations also found a similar incidence of 46% to 48% in children less than 2 years of age,<sup>72–74</sup> also showing a decreasing incidence in older children. Furthermore, PPV is less frequently found in adults (15%–37% in autopsy studies<sup>75</sup> and 12% in laparoscopic studies<sup>76</sup>), which further supports that they may

close. In addition, multiple studies have reported a low risk of developing a contralateral inguinal hernia. Clark and colleagues<sup>77</sup> found, in a retrospective review of more than 7000 patients, that only 3.8% develop a contralateral inguinal hernia at 10 years. Similarly, Ron and colleagues<sup>78</sup> found that 14 contralateral explorations are required to prevent 1 hernia. Given this, routine contralateral open groin exploration is not recommended.<sup>75,79–83</sup>

Laparoscopic evaluation (transumbilical or transinguinal) for a contralateral PPV has been described as a safe and effective alternative to open exploration because it does not require a separate incision and minimally increases the overall operation time.<sup>72,74,84,85</sup> Laparoscopic evaluation has been found to have a high sensitivity and specificity in diagnosing a contralateral PPV and hernia (99.4% and 99.5% respectively<sup>85</sup>), but has poor predictive value in identifying which PPV will develop into clinical hernias (11%<sup>86</sup>). Given this poor positive predictive value, and the potential risk of cord injury in boys, there is debate about laparoscopic repair of a PPV. Burd and colleagues<sup>87</sup> argue that the risks of observation, which are morbidity from incarceration and repeat anesthesia exposure, are less than the risk of perioperative complications that may occur from laparoscopic repair. Lee and colleagues<sup>88</sup> alternatively argue that laparoscopic repair of a contralateral PPV is more cost-effective to the patient compared with a subsequent repair, although it does subject some patients to unnecessary operations. Despite these risks, if given the option, most parents prefer to have the contralateral PPV repaired at the time of the initial operation, mainly citing convenience as the reason.<sup>89</sup> At this time, there does not seem to be agreement on routine laparoscopic repair of contralateral PPV, except in patients at a higher risk of developing a contralateral hernia (ie, those with left-sided hernia, connective tissue disorders, higher intra-abdominal pressure) and in patients with a higher anesthesia risk (ie, cardiopulmonary issues).<sup>68,83,85</sup>

### **Postoperative Care**

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Most patients are discharged home on postoperative day 0 to 1 unless additional interventions, such as bowel resection, were performed. Close monitoring for postoperative apnea is recommended in premature infants, with overnight ICU care recommended in high-risk patients.<sup>21</sup>

## **UMBILICAL HERNIA**

### **Anatomy and Pathophysiology**

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The classic description of in utero intestinal development states that the primitive intestine herniates through the umbilical ring where it elongates and rotates 270° before returning to the abdominal cavity.<sup>90–92</sup> Following this, the physiologic diastasis recti gradually resolves as the left and right rectus abdominis muscles migrate medially to occlude the umbilical ring. Disruptions to this process are thought to cause umbilical hernia.<sup>93</sup>

### **Clinical Presentation and Evaluation**

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Although umbilical hernia is a common entity in children,<sup>94</sup> the overall rate of incarceration is traditionally thought to be extremely low, estimated at 0.07% to 0.3%.<sup>95–97</sup> However, the rate of incarceration in some African populations has been observed to be as high as 40%.<sup>98–100</sup>

Presenting symptoms of umbilical hernia incarceration are those seen commonly with bowel obstruction, namely abdominal pain, nausea, and vomiting. Physical examination shows umbilical hernia, abdominal distention, and abdominal tenderness



to palpation. There may be skin changes, such as erythema, associated with the umbilicus.<sup>94,101–104</sup> Although the traditional presentation is that of acute umbilical hernia incarceration, some patients have been observed to experience symptomatic, recurrent incarceration of umbilical hernia followed by spontaneous reduction.<sup>100</sup>

### **Diagnosis**

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Diagnosis of incarcerated umbilical hernia may be made via history and physical examination alone. However, plain abdominal radiographs may show radiographic evidence of bowel obstruction.<sup>104,105</sup>

### **Surgical Timing**

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In patients with peritonitis or evidence of perforated or gangrenous bowel, surgery should not be delayed. Otherwise, reduction of the incarcerated bowel from the umbilical hernia should be performed and the surgery performed at the earliest convenience. Surgery should also be performed in an emergent fashion if attempts at hernia reduction fail.<sup>100</sup>

### **Surgical Technique**

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The technique for repair of umbilical hernia is straightforward and has been well described.<sup>106,107</sup> The presence of incarcerated material does not necessarily change this technique.

The patient is placed in the supine position. The entire abdomen should be draped and prepped in case a larger incision is required. An infraumbilical or paraumbilical incision is performed. Dissection, either sharply or with electrocautery, is carried down to the level of the hernia sac. The umbilical hernia may contain preperitoneal adipose tissue, omentum, small bowel, large bowel, or a combination of these.<sup>104,105</sup> The viability of any involved bowel must be determined. This, along with any bowel resection and anastomosis, may be possible through the initial incision, or may require enlarging the fascial opening and skin incision. The hernia sac is freed circumferentially from the fascia and subcutaneous tissues, before it and its contents are reduced into the abdomen. There is no proven benefit to resection of the hernia sac.<sup>108</sup> The linea alba is closed in a simple fashion and the skin is closed over this. Umbilicoplasty may be performed for improved cosmetic results, particularly for very large hernias.

Minimally invasive technique for repair has been described,<sup>109</sup> but this technique requires modification to fully assess the bowel and/or perform a bowel resection and anastomosis.

Postoperatively, patients may benefit from a period of nil per os with nasogastric decompression, particularly if an ileus is anticipated (eg, in patients who underwent bowel resection, those with significantly dilated bowel, or individuals who experienced delayed diagnosis and treatment).

## **FEMORAL HERNIA**

A femoral hernia is a protrusion through the femoral ring into the femoral canal. These hernias make up less than 1% of groin hernias<sup>110</sup> and there have only been a limited number of case reports published describing incarceration.<sup>111</sup> Diagnosis can be challenging, with femoral hernia often misdiagnosed as inguinal hernia, because both may present with groin pain and bulge.<sup>112</sup> Definitive diagnosis sometimes may only occur at the time of surgery.<sup>113</sup>

Open repair occurs via an inguinal incision. The femoral defect is closed by suturing the inguinal ligament to the pectineal ligament.<sup>114</sup> Laparoscopic repair may be

accomplished by dissecting the hernia sac from the femoral canal followed by patch and plug with prosthetic material. If the defect is very large, the iliopubic tract may be approximated to the pectineal ligament with intracorporeal suture and prosthetic patch placement over this.<sup>115</sup> Similarly, a laparoscopic percutaneous extracorporeal closure needle may be used to percutaneously suture the pectineal ligament to the iliopubic tract.<sup>116</sup> In addition, repair may be accomplished in a laparoscopic-assisted fashion with 1 abdominal incision and 1 groin incision.<sup>117,118</sup>

### **SPIGELIAN HERNIA**

Spigelian hernia, also known as lateral ventral hernia, is a rare entity in pediatric surgery. Herniation occurs through the aponeurosis of the transverse abdominis, between the rectus abdominis muscle medially and the linea semilunaris laterally.<sup>119</sup> Patients typically present with complaints of abdominal pain and abdominal tenderness to palpation on examination. Patients may have a history of abdominal trauma.<sup>120</sup> Repair is effected by incision directly over, or in close proximity to, the hernia with evaluation of the bowel and a subsequent tissue repair to close the hernia defect.<sup>120,121</sup>

### **EPIGASTRIC HERNIA**

Epigastric hernia typically occurs in the midline, superior to the umbilicus. These lesions tend to be solitary, but may be multiple. They comprise up to 4% of pediatric abdominal wall hernias.<sup>122</sup> There are no reports of bowel incarceration within an epigastric hernia, possibly because of the falciform ligament covering the visceral side of the fascial defect.<sup>109</sup> However, incarcerated preperitoneal fat may be encountered.<sup>109,123,124</sup>

Whether repaired in an open or laparoscopic fashion, the epigastric hernia must be marked at the skin level before induction of anesthesia, otherwise the hernia may become difficult to identify intraoperatively. Open repair is achieved by transverse skin incision over the hernia, reduction of any incarcerated fat and hernia sac, and primary closure of the fascial defect.<sup>109</sup> Laparoscopic repair may be accomplished via intracorporeal suturing of the defect<sup>109</sup> or percutaneous suturing.<sup>123,124</sup>

### **DIRECT INGUINAL HERNIA**

Direct inguinal hernia, which is a herniation through the Hesselbach triangle, comprises less than 1% of pediatric inguinal hernias. Diagnosis is difficult, both preoperatively and intraoperatively.<sup>125–127</sup> Furthermore, incarcerated pediatric direct inguinal hernia is extremely rare.<sup>128</sup>

Open techniques for repair are similar to those described in adults, using a tissue-only approach. Laparoscopic approaches have also been described.<sup>127,129</sup>

### **LUMBAR**

Fewer than 100 cases of congenital lumbar hernia have been described<sup>130</sup> with only 1 case of incarceration.<sup>131</sup> Repair may be performed in an open fashion, with incision over the hernia,<sup>130</sup> or laparoscopically.<sup>132</sup>

### **SUMMARY**

Indirect inguinal hernias are the most commonly incarcerated pediatric hernias, with a high risk of recurrence and increased perioperative morbidity compared with elective

hernia repair. Laparoscopy is increasingly being used in the management of incarcerated pediatric hernias with similar outcomes to open surgery.

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