

Inguinal Hernia in Premature Infants

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Education Gaps

1. The ideal timing for surgical repair of inguinal hernia is not known.
2. The ideal method for repair of inguinal hernia is not well-defined.
3. The risks and benefits of interventions for preventing metachronous hernia are not clear.

Abstract

Inguinal hernia is a common problem affecting infants in the NICU. As a group, preterm infants have the highest incidence of inguinal hernia and this risk increases as gestational age decreases. The etiopathologic factors leading to the development of an inguinal hernia are not clear and interventions to alter these factors have not been thoroughly investigated. Diagnosis of an inguinal hernia is often straightforward, but occasionally it may be difficult to determine if the hernia is strangulated or simply obstructed. Rarely, investigative modalities, such as ultrasonography, may be needed to rule out other potential causes. The ideal timing of surgical repair in this population is unknown and complicated by comorbid conditions and limited randomized controlled trials. During surgery, the choice of regional versus general anesthesia requires a team-based approach and studies have found that greater clinical experience is associated with lower morbidity. The techniques of hernia surgery range from open to laparoscopic repair and have been investigated in small prospective studies, while larger databases have been used to analyze outcomes retrospectively.

Objectives

After completing this article, readers should be able to:

1. Identify different abdominal wall hernias in infants.
2. Recognize the risk of anesthetic complications in relation to the timing of inguinal hernia surgery.
3. Describe the advantages and disadvantages of laparoscopic surgery for repair of inguinal hernias in preterm infants.

AUTHOR DISCLOSURE Drs Ramachandran, Edwards, and Bichianu have disclosed no financial relationships relevant to this article. This commentary does not contain a discussion of an unapproved/investigative use of a commercial product/device.

INTRODUCTION

Abdominal wall hernias that are visible externally can occur at multiple sites, including through defects in the lumbar musculature in the flank (eg, upper lumbar triangle of Grynfeltt or lower lumbar triangle of Petit) or in the groin (direct, indirect inguinal, or femoral; Fig 1). Midline hernias include those at the umbilicus and fatty herniation in the epigastric region. The Spigelian hernia is located off the midline, is rare, and in neonates, is associated with undescended testes. This review will focus on indirect inguinal hernias, which are common in preterm infants in the NICU. Although inguinal hernia repair is one of the most frequent procedures performed by general pediatric surgeons, there are many practice variations. Some surgeons advocate for early repair to prevent patients from returning with an episode of incarceration after discharge from the NICU; others prefer to delay surgery until after discharge to minimize anesthetic complications and decrease the risk of recurrent hernias that may occur with early repair. Very few publications have focused on hernias in preterm infants, though it is generally accepted that the anatomy, epidemiology, and outcomes of inguinal hernias are very different in this population compared with older children and even term neonates. The focus of this review is to evaluate the current literature and highlight areas of ambiguity.

INCIDENCE AND ETIOLOGIC FACTORS

The incidence of inguinal hernia in preterm infants varies with gestational age. A 1986 study showed that the

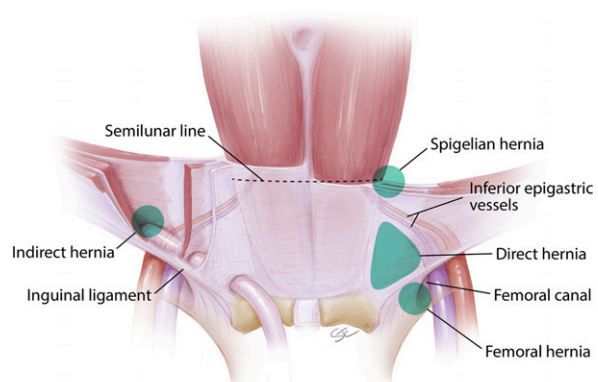


Figure 1. Hernia locations. A. Right groin indirect hernia location lateral to inferior epigastric and over the iliac vessels. B. Femoral left side lower circle below the inguinal ligament and medial to the femoral vein. C. Indirect hernia found in patients with connective tissue disorders or with recurrent hernia after surgery for indirect hernia. D. Spigelian upper circle occurs at the junction of the semilunar line and lateral border of the rectus; this is associated with cryptorchidism. Image courtesy of medical illustrator Stacy Cheavens at the University of Missouri School of Medicine.

incidence of inguinal hernias in preterm infants increases as gestational age decreases. (1) For example, a male infant born at 24 weeks' gestation has a 40% risk of developing an inguinal hernia, whereas the incidence in male infants born after 32 weeks' gestation falls to 4%. (1) Race does not appear to be a risk factor. Approximately 80% of inguinal hernia repairs are performed in male infants. Male preponderance exists because the inguinal canal remains open longer in boys to allow the final descent of the testes between 25 and 30 weeks of gestation. Compared with girls, male infants have a 3- to 5-fold higher incidence of inguinal hernias. (2)(3)(4)

When stratified based on birthweight, the incidence of inguinal hernias gradually decreases as the birthweight increases. Infants with a birthweight between 500 and 1,000 g had an incidence of inguinal hernia between 30% and 42%, whereas those with a birthweight between 1,000 and 1,500 g had an incidence of 10% and a birthweight over 1,500 g correlated with the incidence in term infants, approximately 3%. (5) Interestingly, intrauterine growth restriction was associated with a 2-fold increased risk of hernia. (1) A population-based review of Taiwan's National Health Database found that the incidence of inguinal hernia from birth to 15 years of age was 6.62% and 0.74% in boys and girls, respectively. (6) The incidence of inguinal hernia in adults is 3% to 5%, with a lifetime risk of developing a hernia being 27% in men and 3% in women. (7)

It is not known why only some preterm infants develop an inguinal hernia. Increased abdominal pressure has been postulated to predispose infants to hernia formation, and chronic respiratory distress (as occurs with bronchopulmonary dysplasia) as well as constipation have been associated with a higher incidence of hernia. Poor nutrition may hinder the closure of the patent processus vaginalis (described later in this article). (8) Using weight gain expressed in grams per kilogram per day as a surrogate for nutritional status, Kumar et al did not find any correlation with the incidence of hernia in a multivariate analysis. (9) A 2006 retrospective case-control study evaluated male infants born at less than 35 weeks' gestational age. (10) This study found that the development of a hernia was significantly associated with dexamethasone exposure, use of high-frequency ventilation, and duration of mechanical ventilation. In the multivariate analysis, the odds ratio for the diagnosis of hernia with dexamethasone exposure was 13.9. (10)

Preterm infants are more likely to have bilateral hernias than term infants and older children. (11) In a recent report of 90 preterm infants from Spain, bilateral involvement was observed preoperatively in 57.5% of patients. (12) At

laparoscopic evaluation, an additional hernia and patent processus vaginalis were observed, leading to bilateral repair in 73.3% of patients. In a study that included mostly older children, the incidence of bilateral hernias was reported as 6.78%. (13) In a study from Canada, Ein et al reported bilateral hernias in only 6% of teenagers. (4) This is in contrast to the high detection of a patent processus vaginalis, which is frequently found if the groin is explored. In a group of 245 infants, 88% had a patent processus vaginalis. In adults undergoing laparoscopic evaluation, patency of the processus vaginalis is found in less than 10%. Direct inguinal hernias in children are rare. In 2 studies that included more than 6,000 patients each, the incidence was 0.3% (4)(13)

ANATOMY AND EMBRYOLOGY

The processus vaginalis, a tongue of the peritoneal membrane, develops in both males and females in utero and passes through a small opening in the muscular layer of the abdominal wall. The testes also descend through this opening alongside the processus vaginalis. The descent of the testes into the scrotum has been described in 2 phases. In the initial phase, the undifferentiated gonad is present close to the diaphragm attached to a craniosuspensory ligament. As the abdominal cavity enlarges and the developing intestines are returning to the coelomic cavity, the gonad descends into the lower abdomen between 8 and 15 weeks of gestation. At this point, the development in the male and female fetus diverges. The gubernaculum thickens and is attached to both the testis and the processus vaginalis in boys, guiding both structures through the inguinal canal. In girls, the ovary retains its attachment to the round ligament and remains intra-peritoneal. The final descent of the testes is delayed until 25 to 35 weeks' gestation while the scrotum develops. Experimental animal models in which the genitofemoral nerve is divided have demonstrated the critical role that this nerve plays in directing the descent of the testes. Calcitonin gene-related peptide has been shown to assist with this process. The last important event is the closure of the processus vaginalis. Although the details of the molecular changes are not fully known, the thickening of the peritoneal membrane has been associated with smooth muscle differentiation at the neck of the hernial sac, and the involvement of hepatocyte growth factor has been demonstrated in experimental models. (14)(15) This has led to the speculation that inguinal hernias may be amenable to medical treatment in the future. (16) The processus vaginalis closes earlier on the left than on the right side,

leading to a slightly higher incidence of right-sided inguinal hernias.

A family history of inguinal hernia has been identified as a risk factor for developing an inguinal hernia in infants and also for persistence of the processus vaginalis. In 2017, Oberg et al published a summary of the etiologic factors in adults. (17) Using genome-wide analysis, 4 genes were identified in the development of inguinal hernias. An imbalance between tissue breakdown and rebuilding has been suggested as a possible mechanism as well as decreased strength of the inguinal tissues as a result of defective oxidation of lysine involved in cross-linking of proteins. (17) It is not clear if these genetic factors contribute to the development of inguinal hernias in infants. Infants with significant stress from comorbid conditions

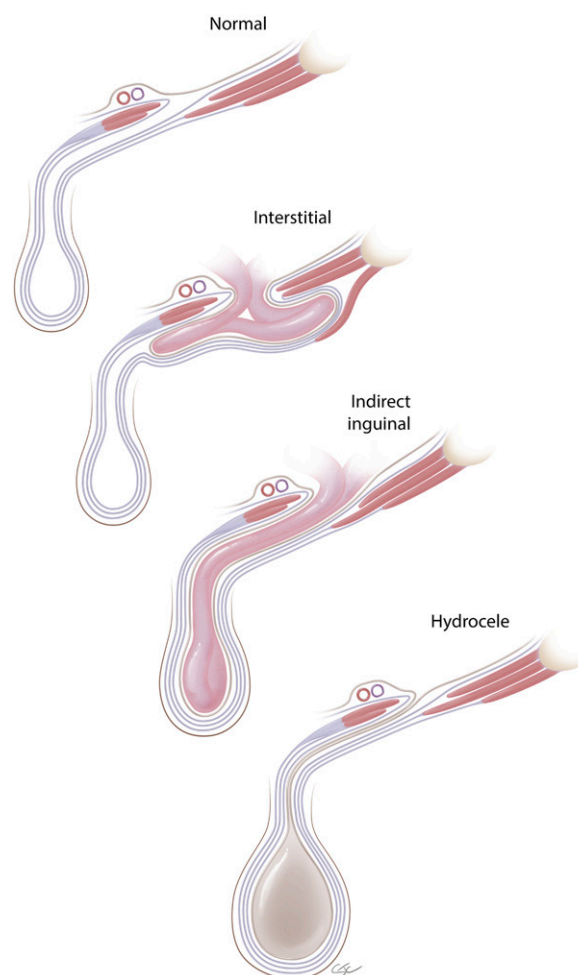


Figure 2. Anatomy of inguinal canal and the hernias. In the normal groin, a potential space exists that can open and allow intra-abdominal contents to leave the abdominal boundaries. A. Normal inguinal canal without hernia. B. Hernia contents dissecting through muscle planes of the abdominal wall. C. Typical indirect hernia due to an open processus vaginalis. D. Processus vaginalis is open but small and allows for fluid to fill the scrotum, leading to a congenital hydrocele. Image courtesy of medical illustrator Stacy Cheavens at the University of Missouri School of Medicine.

and nutritional difficulties such as necrotizing enterocolitis may share a similar pathophysiology for hernia formation as hypothesized by Kumar et al. (9)

Indirect inguinal hernias go through the internal and external rings and are responsible for the vast majority of groin hernias in male and female preterm infants. (Fig 2) Direct inguinal hernias (occurring through the floor of the inguinal canal and medial to the inferior epigastric vessels) as well as femoral hernias are mostly found in children with recurrences after repair of indirect hernias. The inguinal anatomy of the premature infant also predisposes the infant to hernia formation. The external ring is situated directly over the internal ring because the inguinal area has not elongated adequately. This allows for any intra-abdominal pressure to directly enlarge the 2 rings simultaneously. Spigelian hernias are also rare and occur at the outer border of the rectus in the lower abdomen (Fig 1). Intraoperative findings of inguinal hernias in preterm infants are notable for the extremely thin peritoneum, lack of surrounding supportive connective tissue, and after an episode of incarceration, edema of the entire sac within the inguinal region as well as the scrotum.

DIFFERENTIAL DIAGNOSIS OF INGUINAL HERNIA

The diagnosis of inguinal hernia in preterm infants is based on clinical findings and rarely requires further investigation. Congenital hydroceles may become firm or tense enough to simulate an irreducible hernia. Transillumination is useful to recognize if bowel is present in the scrotum though this may be difficult to discern in the extremely premature infant. Hydroceles are generally restricted to the scrotum (Fig 2) but occasionally they may extend into the inguinal canal and can even extend into the intermuscular plane. In these instances, differentiation from a hernia may be difficult without ultrasound imaging.

A hard scrotal swelling should raise concerns for neonatal testicular torsion or testicular tumor and both can be diagnosed with ultrasonography. (18)(19) The neonate born with prenatal testicular torsion may not show any signs of pain or distress. In contrast, infants with postnatal testicular torsion present with an acutely inflamed scrotum with erythema and tenderness. In this situation, the scrotum is usually reported to be normal at delivery. A diagnosis of postnatal torsion should prompt emergent exploration with detorsion and fixation of both testes. Recovery of the torsed testis has been reported to be as high as 40% to 50%. In girls, the presence of a hard swelling in the groin should raise suspicion for an incarcerated ovary or even a portion of the uterus. (20) When the

hernia is not visible, the clinician can infer its presence by a characteristic smooth feel when the cord structures are rolled between the examiner's thumb and index fingers. This is called the "silk glove sign" and is attributed to the presence of the peritoneal sac extending into the scrotum. A recent study including 1,074 groin examinations evaluated the accuracy of this physical sign by correlating it with laparoscopic findings. (21) A patent processus vaginalis or a hernia was found on laparoscopy in 86.5% of infants with a positive silk sign. (21)

The appendix testis represents a vestigial remnant of the müllerian duct. Infants with a torsed appendix testis present with acute pain and a "blue dot" sign on examination (the inflamed and ischemic appendage can be seen through the scrotal skin as a blue mass). Epididymitis/orchitis is not a common condition in newborns. It has been diagnosed in the context of sepsis (with *Escherichia coli* or *Neisseria meningitidis*) or in association with a urinary tract infection (*E coli* or *Enterococcus faecalis*). (22)(23) Several case reports describe neonatal epididymo-orchitis caused by *Salmonella*, (23)(24) *Pseudomonas*, (25) or *Streptococcus agalactiae*. (26)

HERNIAS IN SPECIAL SITUATIONS

Neonates with severe congenital or posthemorrhagic hydrocephalus may require treatment with a ventriculoperitoneal shunt. In these circumstances, any patent processus in the inguinal region will open up further, allowing for hydroceles and hernias to form. It is not unusual for the shunt tubing to be palpable in the scrotum. Similarly, an umbilical hernia is likely to enlarge and some patients also may develop an incisional hernia at the site of the peritoneal entry of the shunt tube. (27)(28) These increased hernia risks are also found in infants with ascites and those with peritoneal dialysis catheters.

Patients with connective tissue disorders such as Ehlers-Danlos syndrome may present with multiple hernias and are at risk of recurrence after repair.

Androgen insensitivity is associated with a female phenotype in genetically male infants. Affected patients often have inguinal hernias (76%). Among female patients presenting with inguinal hernia, 1% to 2.4% have testes in the hernial sac. (29)

The association of undescended testes with an inguinal hernia in preterm infants can be anticipated in view of the closely related processus vaginalis that promotes descent and later closure of the peritoneal opening. A review by Sijstermans et al reported a 1% to 3% rate of cryptorchidism in term male infants, with a rate of 15% to 30% in

preterm infants. (30) Although the processus vaginalis is patent in 90% of patients with undescended testes, only about 10% are associated with a clinical inguinal hernia. In a recent report by Wright et al in 2017, a 10-year retrospective review from 4 major United Kingdom centers identified only 41 infants with clinical diagnoses of both undescended testes and inguinal hernia. (31) Other studies have also corroborated that about 1% to 3% of children with inguinal hernias have associated cryptorchidism. (2)(4)

RISK OF STRANGULATION

The incidence of strangulation in preterm infants is reported between 14% and 31%. Some reports have observed a lower incidence in preterm infants compared with term infants. Strangulation occurs when the fascial tissue at the internal or external inguinal ring obstructs the venous return, followed by increasing edema and pressure in the hernial sac; this causes the arterial supply to be compromised (Table 1). This can lead to loss of blood supply to the herniated bowel or infarction of the ovary or testis that may be present in the hernial sac. Older infants and children may have omentum that becomes necrotic; however, preterm infants do not have enough bulk in the omentum. Repeated episodes of irreducibility of the hernia may also cause intermittent loss of blood supply to the testis and result in later testicular atrophy. Infants who have fussy periods can increase their abdominal pressure and force abdominal contents to protrude through the hernial defect and cause strangulation. A history of strangulation and prematurity are the 2 main risk factors for testicular atrophy later in life.

In a case of strangulated hernia, the clinician must immediately attempt to reduce the hernial contents into the abdomen. Figure 3 illustrates a method commonly

used to reduce an incarcerated inguinal hernia. In this technique, the infant is placed supine and the hip flexed and adducted to decrease tension on the anterior abdominal wall. Gentle pressure is applied at the base of the hernia toward the neck of the hernia in the inguinal canal while the second hand directs pressure toward the abdomen. During the procedure, opioid administration or sedation should be considered. When the bowel is completely ischemic, manual reduction will be unsuccessful and immediate surgical intervention is warranted. Approximately 80% to 95% of obstructed hernias can be reduced to allow for a delay in surgery by 24 to 48 hours.

An inguinal abscess, and very rarely, vascular malformations or tumors may present as inguinal swellings that are mistaken for hernias. An infant with a cystic fluid-filled hernial sac in the inguinal canal (encysted hydrocele of the cord in boys and cyst of the canal of Nuck in girls) will present with irreducible swelling in the groin. These diagnoses can be easily distinguished from an obstructed hernia by transillumination at the bedside or ultrasound examination, if needed. A dark scrotum may represent blood from intra-abdominal or adrenal bleeding associated with birth trauma and may be mistaken for a strangulated bowel. (32)

TIMING OF INGUINAL HERNIA REPAIR

The debate over early surgery (ie, before discharge from the NICU) versus repair after 55 weeks' postmenstrual age has been addressed in 2 reviews. (33)(34) No recommendations could be made based on available data as to which strategy was better. Since then, further reports have been published that show good results can be obtained even with early intervention, but delayed repair does not result in additional risk of incarceration as originally feared. Bawazir retrospectively reviewed his experience with 127 infants and noted increased risk of apnea and ventilator dependence in the early group and a 3.2% incarceration rate in the delayed cohort. (35) Aneiros Castro et al compared 90 preterm infants (mean age at operation, 62 days) with 66 term infants (mean age at operation, 138 days) without any difference in postoperative complications. (12) Recurrences were noted in 3.2% of preterm infants compared with 0.9% in the term group. (12) A retrospective study by Khan et al compared results of 115 neonates operated on as inpatients and 148 operated on as outpatients and found no higher risk of surgical complications or recurrence but did show a greater need for postoperative ventilation in the early group. (36) Sulkowski et al queried the database of the Pediatric Health Information System of 44 children's hospitals to assess practice variation and outcomes of early versus late

TABLE 1. **Hernia Strangulation**

- Strangulation is defined as loss of blood supply to the hernial contents.
- Hernias that are incarcerated (difficult to reduce) cannot be easily differentiated from strangulated ones.
- The majority of incarcerated hernias (>95%) can be reduced using the correct technique (Fig 3).
- Inguinal hernias with nonviable bowel or ovary generally cannot be reduced manually.
- The exact rate of strangulation of inguinal hernia has not been prospectively studied.

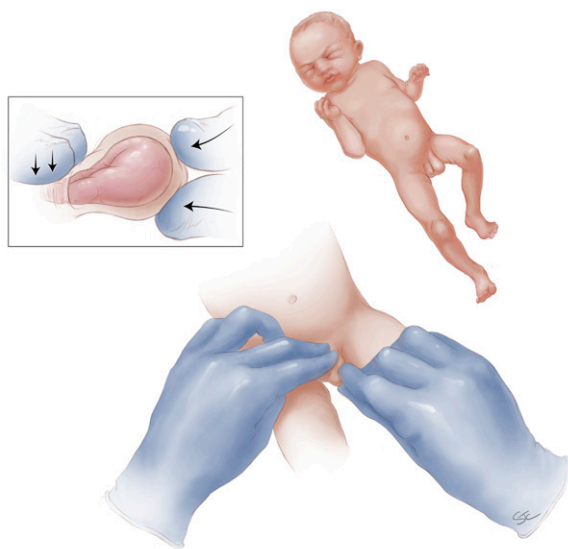


Figure 3. Technique of reduction of hernia in a neonate. The infant is placed in the supine position with flexion of the knee and hip on the affected side. The hip is slightly adducted to relax the abdominal muscles in the groin. Gentle squeezing pressure is applied at the base of the hernia with the second hand directing pressure toward the abdominal cavity. Image courtesy of medical illustrator Stacy Cheavens at the University of Missouri School of Medicine.

repairs. (37) They identified 2,030 preterm infants and found an incarceration rate of 8.2% in the late group and recurrent hernia rate of 5.9% in the early group compared with 3.7% in the late cohort. Their findings were in favor of delayed repair with increased risk of recurrence needing reoperation and increased comorbidities in the early repair group. Although there was significant interhospital variation in the proportion of early repairs, this did not change for a given hospital during the study period from 1999 to 2012. (37) A well-researched systematic review and meta-analysis of this issue by Massoud and colleagues reached the same conclusion that repair of inguinal hernia in preterm infants before discharge is associated with increased recurrence without increasing the risk of incarceration in the delayed group. (38) Because the bulk of these reports and meta-analysis was based on retrospective data, it is unclear what factors were involved in patient selection for the early group. Data that included 8,037 infants from 1998 to 2012 were analyzed by Gulack et al and published in 2017. (39) The proportion of infants undergoing early repair increased from 20% in 1998 to 45% in 2012. Concurrent fundoplication or gastrostomy as well as lower socioeconomic status were associated with early repair. (39) Because the reasons for patient selection for early repair are not clear from retrospective studies, prospective studies are needed to address this issue.

ANESTHETIC CONSIDERATIONS

To determine the optimal timing of hernia repair, specific surgical technique, and type of anesthesia, communication among the surgical team, anesthesiologists, and neonatologists is essential. Preterm infants with inguinal hernias often have multiple comorbidities influencing the type of anesthesia and also the choice of anesthetic drugs. The initial assessment of the neonate will include degree of prematurity and presence or absence of bronchopulmonary dysplasia, patent ductus arteriosus, anemia, intraventricular hemorrhage, apnea, and seizures.

General Anesthesia

If the hernia is large, complex, and/or bilateral, general anesthesia may be preferred because the duration of neuromuscular block from regional anesthetics usually is less than 90 minutes. In a survey of American pediatric surgeons in 2005, Antonoff et al reported that 79% of surgeons preferred general to regional blocks, which was comparable to results of a similar survey conducted in 1993. (40) Modern inhalational anesthetics can be combined with caudal or regional local anesthetic blocks to achieve postoperative complications similar to regional anesthesia using spinal injection. (41) If the inguinal hernia repair is combined with another procedure such as airway assessment using endoscopy, bronchoscopy, or gastrostomy tube placement, general anesthesia is preferred.

Regional Anesthesia

Greater consideration for regional anesthesia techniques has been prompted by data from animal experiments that show widespread neuronal death, permanent neuronal deletion, and neurocognitive impairment associated with general anesthesia. Retrospective studies have also raised considerable concern for neurocognitive impairment in children after even a single procedure using general anesthesia. DiMaggio et al reviewed Medicaid data from a cohort of children in New York who underwent inguinal hernia repair before age 3 years. (42) They found a 2-fold increased risk of being diagnosed with developmental or behavioral disorder in those children who underwent general anesthesia. (42) Systematic reviews and meta-analyses of retrospective studies have strongly suggested a significant correlation between neurodevelopment outcomes and operative procedures in early childhood. Three prospective studies were initiated, and interim reports so far have not shown any consistent pattern to suggest neurodevelopmental delay to single and short (defined as <1 hour) exposure to anesthesia. (43) It is also challenging to separate out neurocognitive

changes from anesthesia versus the surgery itself. Assuming that local anesthetic in the spinal canal does not affect cognition, Williams et al studied 265 neonates who underwent procedures under spinal anesthesia and matched controls who did not have any operative procedures. There was no correlation with poor academic achievement. (44)

Following the Food and Drug Administration guidelines published in December 2016 (45) to avoid unnecessary surgery and anesthetic procedures in the perinatal period, 2 questions have been raised. First, can inguinal hernia repair in infants be safely postponed to beyond 56 weeks' postmenstrual age without excessive risk of incarceration, bowel loss, and other complications? Secondly, can regional techniques be used to avoid general anesthesia for inguinal hernias? Risks of delaying surgery include repeated episodes of irreducibility of the hernia, which may compromise the blood flow through the testicular vessels leading to later ipsilateral atrophy. Frank strangulation may ensue with bowel ischemia necessitating surgical intervention when comorbid conditions have not been optimized. Analysis of emergent surgical interventions has shown prolonged hospital stay and greater likelihood of serious complications as well as cost. (46)

Regional techniques such as spinal and caudal epidural injections have been successfully used for inguinal hernia repair. (47) The technique of spinal and caudal anesthesia has a steep learning curve, especially for spinal block. In 2014, Lambertz et al reported results from 100 children treated over a 10-year period. (48) The authors found that 69 children had spinal anesthesia without complications. General anesthesia was used for 31 patients and 7 patients in this group had initial attempts at spinal block that failed. (48) Technical failure to access the spinal space and blood-stained aspirate, and the need for supplemental general anesthetic has been reported in up to 24.6% of cases. The safety and efficacy of spinal anesthesia in infants was reported in 2006 by Williams et al. (49) They reported that despite lower rates of significant complications such as hypoxemia, bradycardia, and postoperative apnea, spinal anesthesia remains underutilized in infants. In their prospectively collected database of 1,554 patients in the Vermont Spinal Registry, the success rate for spinal anesthesia was 97.4% (attending success was 98.9% and trainee success was 83.0%). The time required for administering the spinal block was an average of 10 minutes and the complication rate was low, with 1.6% experiencing bradycardia and only 3.7% requiring supplemental oxygen. This registry had patients who underwent different surgical procedures, and the registry was not specifically restricted to preterm infants. Technical difficulties in smaller preterm infants

with comorbid conditions may not have such good results. Another issue in preterm infants is that the more rapid blood flow and faster circulation of smaller volumes of cerebrospinal fluid in small infants results in a shorter duration of spinal anesthesia. There are specific recommendations for use of spinal anesthesia in preterm infants (Table 2). The addition of epinephrine and/or 10% dextrose to make the preparation hyperbaric can prolong the anesthetic duration. Another technique is to add 1 $\mu\text{g}/\text{kg}$ of clonidine, which doubles the duration of the anesthesia. (50)

A recent meta-analysis by Dohms et al reviewed all the current literature to assess the intraoperative and postoperative complications of general versus spinal anesthesia specifically for inguinal hernia repair in preterm infants. (51) In the final group of 512 patients analyzed, postoperative apnea, need for supplemental oxygen, and need for mechanical ventilation all favored spinal anesthesia. (51) The authors also noted that spinal block was time-efficient, simple, and cost-effective. However, because the studies covered reports from 1990 to 2018, they acknowledged that some of the older anesthetic gases that are no longer in use may have biased the outcomes. The largest prospective randomized study was reported by Davidson et al in 2015. (41) Regional anesthesia that included spinal, caudal, and local blocks without any sedation was compared with general anesthesia using modern anesthetic gases including local blockade but without any nitrous oxide gas or opioids. Early apnea within 30 minutes was lower in the regional group but the overall rate was not different in the study period of 12 hours. Apnea rates were 3% for regional anesthesia and 4% for general anesthesia and primarily related to prematurity. (41)

SURGERY FOR INGUINAL HERNIA REPAIR

The open surgical technique used for inguinal hernia repair was first described by Marcy in 1886 and has since been refined. A very small inguinal skin crease incision (usually between 1 and 2 cm long) is made on the affected side. (2)

TABLE 2. Spinal Technique in Preterm Infants

- Spinal space between L4 and L5 is targeted.
- Access in the sitting position is preferred to ensure even distribution of anesthetic on both sides of the spine.
- Attention to the infant's airway in this position is critical.
- Hyperbaric tetracaine (1 mg/kg) with epinephrine (1:200,000) is commonly used.
- Sedation is avoided by providing sugar water via a pacifier.

The cord structures are identified and the peritoneal sac is separated. The sac is then ligated at the internal ring. Groin

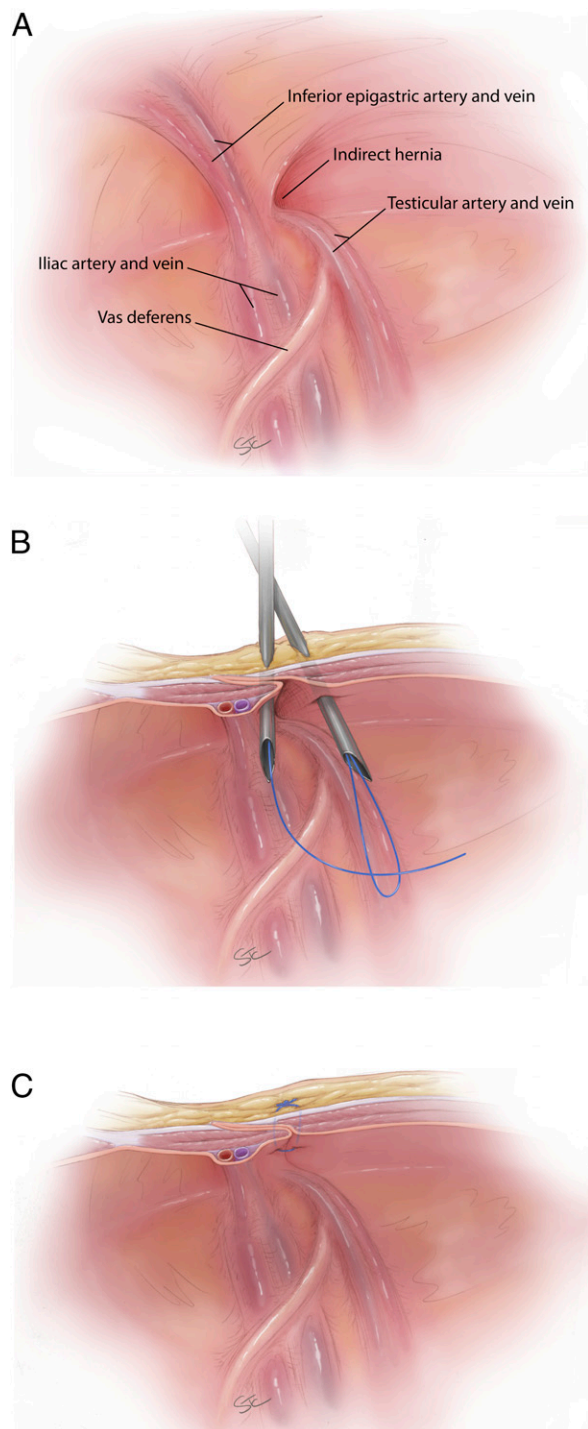


Figure 4. Principle of transabdominal suture closure. A. Anatomic landmarks and hernia orifice is shown. B. The needle is passed with a suture through the abdominal wall, with the laparoscope used to either provide only visualization (subcutaneous endoscopically assisted ligation technique) or assist in safely passing the needle (percutaneous internal ring suture technique). C. The suture is tied closing the internal ring. Image courtesy of medical illustrator Stacy Cheavens at the University of Missouri School of Medicine.

tissue dissection associated with additional scarring may be helpful in preventing postoperative recurrence. (2)

Laparoscopic techniques fall into 2 groups, intraperitoneal and extraperitoneal. Both techniques start with a small scope placed via the umbilicus. In the extraperitoneal technique, the peritoneal opening at the internal ring is closed with 1 or 2 nonabsorbable sutures that are placed with a hollow needle or a curved Riverden needle (percutaneous internal ring suture technique). The sutures are introduced through a 2-mm incision in the groin over the internal ring and the subsequent knot is present under the skin at this site. (52) (Fig 4) If the suture is passed without opening the peritoneum it has been called “subcutaneous endoscopically assisted ligation” (the SEAL procedure). (53)

The intraperitoneal technique uses 2 further instruments that may be placed directly at the level of the umbilicus or through the same umbilical incision (single-incision laparoscopic surgery). The peritoneum is incised to separate the main peritoneal cavity from the inguinal portion and a purse string used to close the peritoneum. Both the laparoscopic techniques and the open procedure rely on the closure of the internal ring with a suture at the same exact site. Advantages of the laparoscopic procedure are the small incision that is made away from the groin and minimal or no handling of the vessels or vas deferens, reducing the chance of injury. The technical feasibility of laparoscopic repair has been repeatedly endorsed by many centers, yet it is estimated that only 14% of pediatric surgeons routinely use this technique in infants. Table 3 lists the advantages and disadvantages of different hernia repair techniques.

COMPLICATIONS OF INGUINAL HERNIA REPAIR

Complications of inguinal hernia repair include hernia recurrence (Table 4), postoperative hydrocele, wound infection, iatrogenic cryptorchidism, testicular atrophy, and injury to the vas deferens. Hernia recurrence is reported to be higher in preterm infants (range, 2%–10%), particularly if the tissue is thinner and if the repair is done early. In contrast, term infants and older children have a recurrence rate less than 1%. Phelps and Agrawal found an 8% recurrence rate in preterm infants with open repair at a median postmenstrual age of 43 weeks’ gestation. (54) Turial et al found that 58 preterm children who underwent laparoscopic repair had a recurrence rate of 3.6%. (55) Pastore and Bartoli described 27 preterm infants who had laparoscopic repair at a median of 49 weeks’ postmenstrual age with no recurrence. (56) This study, however, excluded patients with respiratory distress who underwent repair with spinal

TABLE 3. Advantages and Disadvantages of Different Hernia Repair Techniques

	ADVANTAGES	DISADVANTAGES
Open repair	<ol style="list-style-type: none"> 1. Established procedure with long-term follow-up data and low long-term recurrence 2. Can be done under spinal block 	<ol style="list-style-type: none"> 1. Requires second incision to evaluate contralateral groin 2. Close to diaper area and increased risk of infection 3. Increased handling of the spermatic cord structures with risk of injury to vas deferens/testicular artery
Laparoscopic repair	<ol style="list-style-type: none"> 1. Complete ability to evaluate and repair both sides 2. Better cosmetic repair with smaller incision 3. Further away from groin and less risk of infection 4. Less handling of the spermatic cord structures 5. Can identify direct hernias and other unusual hernias 6. Decreased rate of metachronous hernia 	<ol style="list-style-type: none"> 1. Technically difficult with small working space in abdomen. 2. Requires muscle relaxation and general anesthesia to allow for insufflation of carbon dioxide in abdominal cavity. 3. Recurrence rate is slightly higher.

anesthesia using an open technique. (56) Similar conclusions were reached in a retrospective study by Youn et al from Korea who evaluated 90 preterm infants and found that operating within 7 days of diagnosis led to recurrence in 2 of 5 neonates but when the repair was done before discharge, the recurrence rate was not significantly different than that in term infants. (57)

Wound infection rates are very low for both open and laparoscopic surgery, with the incidence ranging from 0.5% to 2.7% for elective procedures. (58) This increases to 4.5% if emergent surgery for incarceration is needed. (59)(60)

Postoperative hydrocele (incidence, 1%–7%) and iatrogenic cryptorchidism (incidence, 1%–3%) appear to be related to loss of lymphatic channels and scarring in the inguinal canal, which are seen after open surgery and also rarely after laparoscopic repairs. Injury to the vessels and vas deferens are often not reported but are expected to be very rare.

CONTRALATERAL PATENT PROCESSUS VAGINALIS AND METACHRONOUS HERNIA

Saad et al reported data on the incidence of patent processus vaginalis in 1,001 patients with inguinal hernia. (61)

Contralateral patency of the processus vaginalis was seen in 44% of children younger than 1 year, 34% of those in the 1- to 2-year-old group, and 20% of children between 2 and 8 years of age. (61) One recent meta-analysis by Muensterer and Gianicolo noted that the contralateral processus was patent in 38.5%. (62) Their cohort was large, with 19,188 patients younger than 18 years. Based on the known incidence of hernia in children, they calculated that 18 procedures to close the patent processus would be needed to prevent 1 hernia. (62) Maddox and Smith approached it differently. (63) When a pneumoperitoneum was induced and a bulge appeared in the groin, the patent processus was closed and the processus was observed in the remainder of patients. Only 6.8% of patients developed a metachronous hernia (MH) (an MH is a hernia detected on the opposite site at a later time point than the original hernia). In a subgroup analysis, the only variable associated with recurrence was a family history of hernia. (63) Preterm infants differ from term infants in the rate of bilaterality with a higher rate of MHs. Many surgeons have adopted the practice of exploring both sides in male and female infants younger than 2 years and in girls up to 5 years of age. This was devised to account for the high rate of MH that occurs in younger male infants as well as the decreasing risk of patent processus vaginalis in older children. This balanced the risk of a second anesthetic that was often needed within a few months as well as the risk of injury to the vas deferens and testicular vessels. MHs are not only more frequent in preterm infants (12.2% vs 6.3%) but also occur earlier in preterm infants (median 5.2 vs 41.8 months). (57) Laparoscopic advocates have claimed that injury to cord structures is minimized or eliminated by excellent magnification and by approaching from the

TABLE 4. Recurrence Rate of Inguinal Hernia Repair

- Both the laparoscopic and open repair techniques have a higher recurrence rate in preterm children and are similar.
- The recurrence rate in children after a hernia repair is <1% whereas preterm infants have a recurrence rate of 3%–10%.

peritoneal cavity, which requires no handling of these structures during intraoperative dissection; this approach practically eliminates the risk for MH. However, some patent processus cases that are treated will never become hernias, as noted in adults who have a 10% rate of asymptomatic patent processus vaginalis. Burd and Burd performed a neural network analysis of the risks and benefits of operating on asymptomatic versus symptomatic patent processus vaginalis, accounting for risks of anesthesia, injury to the cord structures, and complications of intervention for incarceration. (64) The authors concluded that it is safer to operate only on the symptomatic hernias. However, this study included term infants and older children. Because the risks of a second anesthetic as well as the incidence of MH are higher in preterm infants, it would be reasonable to close any patent processes that are present in this age group.

CONCLUSION

Premature infants have a high incidence of inguinal hernia. They also have a high rate of bilateral hernias. Early repair before 55 weeks' postmenstrual age may be associated with higher recurrence of hernia and respiratory complications. Laparoscopic techniques to repair inguinal hernia in infants are equally efficacious as open operations and can reduce the incidence of MH as well as provide an effective approach for bilateral defects. Spinal anesthetic techniques are underutilized in the treatment of this cohort of patients. Prospective studies are needed for definitive recommendations about the ideal timing of surgical repair.

American Board of Pediatrics Neonatal-Perinatal Content Specification

- Know the etiology, clinical and laboratory features, and management of abdominal masses in the neonate.

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NeoReviews 2020;21:e392

DOI: 10.1542/neo.21-6-e392

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