

Review Article

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Inguinal hernia repair in newborns: A systematic literature review

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ABSTRACT

Background: Inguinal hernia (IH) is a prevalent condition in children necessitating surgical repair. However, determining the optimal timing (early or delayed) of inguinal herniotomy in neonates and preterm infants remains debatable. While open herniotomy traditionally serves as the standard inguinal hernia repair (IHR) procedure, laparoscopic repair has gained traction in recent decades. Our study aims to scrutinize both the optimal timing and approach to inguinal hernia repair in neonates and preterm infants.

Methods: We conducted a literature review on surgical repair of IH in neonates and preterm infants published between 1999 and 2024.

Results: Twenty studies met the inclusion criteria for this review. All studies were retrospective, predominantly originating from Europe and the United States. Thirteen out of the 20 studies focused solely on preterm infants. Patient sample sizes ranged from 30 to 8037, totaling 14533 patients. Most studies indicate that delaying inguinal hernia repair in newborns and preterm infants does not increase the risk of incarceration or recurrence. Moreover, postponing repair until after discharge from the NICU correlates with a shorter postoperative hospital stay and notably diminishes the risk of long-term postoperative ventilator dependence, thereby mitigating potential perioperative complications. Hence, this approach seems safe for certain patients whose families can reliably access appropriate surgical care.

Conclusion: Significant disparities exist in the timing of inguinal hernia repair for newborns and preterm infants across various pediatric surgery centers. Current evidence suggests delayed inguinal hernia repair may be a viable option for selected patients. Regarding the optimal approach in this population, laparoscopy appears safe and effective.

INTRODUCTION

Inguinal hernias (IH) are very common in children with an incidence of 0.8-4.4% [1]. This condition occurs in up to 30% of preterm infants [2]. IH is more common in males with a sex ratio of 2/1 to 9/1 [3]. Although inguinal hernia repair (IHR) is one of the most commonly performed procedures in children, it can be challenging in neonates and preterm infants due to the fragility of the hernia sac, small anatomical area, and potentially associated morbidities [4]. Inguinal exploration with clear dissection followed by secure high ligation of the hernial sac has remained the standard procedure; nonetheless, the laparoscopic approach has recently gained popularity and seems feasible and effective even in premature infants weighing 3 kg or less [5].

The optimal timing of inguinal hernia repair in neonates and preterm infants remains controversial. Because of the risk of intestinal strangulation or testicular atrophy due to incarceration, newborns with inguinal hernias admitted to the NICU are often repaired before discharge. Other surgeons advocate delaying repair after discharge, which gives the infant time to grow, potentially reducing technical challenges, intraoperative complications, and the risk of postoperative apnea in preterm infants [6].

The review article analyzed the published literature on IH in neonates and preterm infants, for ideal timing of surgery and the feasibility, safety, and benefits of classical and laparoscopic surgery in these patients.

METHODS

We performed a detailed systematic review of the literature related to the management of IH in neonates and preterm infants regarding the optimal timing of surgical repair by assessing the clinical outcomes of each option (early versus delayed treatment) as well as the ideal approach for surgical repair in this age group (classic versus laparoscopy) by evaluating the risks and benefits of each procedure.

We conducted an electronic search of the literature on IH in neonates and preterm infants using PubMed and Google Scholar. Selected articles were published over 25 years (from 1999 to 2024). Keywords searched were the following: Inguinal Hernia, Newborn, Preterm, Surgery, and Laparoscopy.

We included studies published in English since 1999 that compared clinical outcomes of early and delayed

inguinal hernia repair in both term and preterm neonates. Additionally, we incorporated studies published during the same period that analyzed the risks and benefits of classic and laparoscopic approaches in this pediatric age group. Abstracts, editorials, and case studies were excluded from our analysis. Papers focusing on inguinal hernia in pediatric age groups other than neonates (older than 1 month) were also excluded from our review.

From each study, the information drawn includes details on the authors, the year of publication, the sample size, the methods employed, the gestational age at birth, the gender, the age at which surgery was performed, the nature and features of the surgical process, the timeframe between diagnosis and the surgical intervention, and the outcome of the follow-up. All of this data was carefully recorded and analyzed in each respective study.

Table 1: Characteristics of the populations included in the studies related to the timing of repair and definition of « early » herniotomy

Author	Population	Number	Sex ratio	Median follow-up	Definition of « early » repair
Uemura et al.	premature	40	3.4/1	Not mentioned	Within 2 weeks of diagnosis
Misra et al.	premature	251	4.1/1	6 weeks after surgery	Within 7 days of diagnosis
Vaos et al.	Premature (28-35 post-conceptional age)	41	100% males	20 months after surgery	Within 7 days of diagnosis
Lautz et al.	premature	1463	3.5/1	1 year after surgery	Within 40 weeks post-conception
Lee et al.	premature	172	8/1	2 months after surgery	Before NICU discharge
Sulkowski et al.	Neonates	2030	6.5/1	1 year after surgery	Within 7 days of diagnosis
Pini Prato et al.	Neonates (<5kg)	154	4.5/1	42 months after surgery	Within 30 days of diagnosis
Gulack et al.	Premature (PCA<34 weeks)	8037	4.5/1	Not mentioned	Before NICU discharge
Khan et al.	Premature (PCA<37weeks)	263	3.3/1	19,1 weeks after surgery	Before NICU discharge
Bawazir et al.	Neonates	127	6/1	8 months after surgery	At the time of diagnosis (when the neonate presented to the pediatric surgery clinic with an asymptomatic IH)

IH: Inguinal Hernia; IHR: Inguinal Hernia Repair; NICU: Neonatal Intensive Care Unit; PPV: patent processus vaginalis

QUALITATIVE SYNTHESIS

Out of the 230 published articles, 20 were deemed suitable for inclusion in this review. All included studies were retrospective and originated from Europe and the USA. The patient cohort exclusively comprised neonates (both term and preterm) with inguinal hernia. Thirteen studies specifically focused on premature neonates (gestational age < 37 weeks). The patient sample sizes in the included studies ranged from 30 to 8037, totaling 14533 patients. Most patients were male, with a sex ratio of 3 to 1.

Characteristics of the study population included in these analyses, repair timing, and the definition of "early" herniotomy in each study, are presented in Table 1.

DISCUSSION

Timing of repair

The optimal timing of IHR in neonates is still controversial. Delaying surgical repair in this age group may stem from various factors such as the complexity of the operation, the presence of numerous coexisting medical conditions associated with prematurity, and the potential anesthesia risks [1]. Another reason is the potential risk of developing learning disabilities among children undergoing anesthesia in early childhood [2,3].

However, delayed repair can lead to hernia incarceration in up to 30-40% of patients. Furthermore, the risk of testicular atrophy following hernia incarceration can reach up to 30% [4].

Other studies have shown different results. For example, Lee et al. reported no case of hernia incarceration in 35 newborns discharged from the NICU with IH. They concluded that preterm infants undergoing elective repair have minimal risk of postoperative apnea and that repair before discharge from NICU is associated with a longer hospital stay [5].

Uemura in 1999 and Vaos in 2010 recommended performing early hernia repair in newborns to prevent perioperative morbidity like incarceration, subsequent testicular ischemia, and hernia recurrence. Lautz et al. also reported that premature neonates with IH are twice as likely to be incarcerated if their repair is delayed beyond 40 weeks post-conceptual age [6–8].

Pini Prato et al. demonstrated that while herniotomy in neonates and ex-preterms is technically challenging, the frequency of complications associated with the procedure is comparatively low. Therefore, the authors advise performing herniotomy before discharge for neonates diagnosed during their hospital stay and scheduling the procedure as early as possible (within a month) for those who present to the outpatient clinic [9].

In contrast, Misra et al. advocated early herniotomy in premature infants only for larger hernia causing discomfort to the newborn, or when it is sometimes difficult to determine if the hernia is still reducible. Otherwise, their approach is to wait until the neonates are ready to be discharged from the NICU. The authors also recommend regular inspection and manual reduction of these hernias for early detection of incarceration [10].

A multi-institution study including 8037 newborns and published in 2017 by Gulack et al. reported substantial variation regarding the timing of IHR in premature infants, with more and more infants receiving repair before discharge over time (from 20% in 1998 to 45% in 2012) [11].

Similarly, based on a multi-institutional neonatal cohort, Sulkowski et al. reported major practice differences in IHR timing at children's hospitals, with a proportion of patients receiving delayed repair ranging from 3% to 74% across 25 hospitals. The authors concluded that the treating hospital was a significant factor in determining the timing of IHR. They also stated that delayed repair was linked to an incarceration rate of 9.5%. In contrast, patients treated with early IHR were more likely to undergo repeat hernia surgery within a year. Based on these results, the authors suggest that delayed IHR may be a viable option for selected patients [12].

A consensus statement of the Canadian Association of Paediatric Surgeons published in 2000 suggested that

repairs of IH in preterm infants should be performed as soon as possible, preferably within a week of diagnosis [13].

However, conclusions from all of these studies are limited by their retrospective nature. The optimal timing for repairing inguinal hernias in newborns is still uncertain. The risks of postponing the procedure, such as incarceration and the resulting morbidity of an early repair, must be balanced against the possibility of peri-anesthetic complications and the complex difficulties involved in operating on a neonate [1]. Definitive recommendations cannot be made from these data and require prospective studies.

Peculiarities of the IHR in preterms

Preterms have the highest incidence of IH among the pediatric population (between 10% and 30%) [14]. This incidence increases as gestational age decreases [15, 16].

Despite being one of the most common procedures performed on preterm infants, the optimal timing of IHR remains problematic. While early repair is associated with technical difficulty as well as perioperative risks, a delayed approach can lead to incarceration. On the other hand, the question of the potential long-term neurotoxic effects of general anesthesia and sedation drugs on neonates has been a contentious topic for numerous years. As a result, in response to a recent survey conducted by the American Academy of Pediatrics (AAP), over half (53%) of pediatric surgeons have reported fixing inguinal hernias in premature neonates only when it is convenient [1].

Vaos et al, in their two-institutional-center study including 41 preterms between 28 and 35 weeks of gestational age, compared the results of herniotomy between those who were operated on within 1 week of diagnosis and those who were operated on more than 1 week after diagnosis. The authors reported a higher incidence of incarceration when the repair is delayed (56% vs. 12%). Moreover, recurrence and testicular atrophy were more likely to occur in patients who underwent delayed herniotomy. The study also found that a longer duration between the diagnosis and surgery in the group that underwent late repair resulted in longer periods of hospitalization and surgery. Therefore, the authors concluded that performing a herniotomy within a week of diagnosis was crucial for premature infants since delaying the operation would result in a higher rate of incarceration, which could lead to testicular ischemia and an increased incidence of hernia recurrence [7].

A 2019 study by Bawazir et al, including 118 neonates, 45% of whom underwent early IH repair and 55% late IH repair, showed no significant

difference in the incidence of hernia incarceration but reported higher rates of hernia recurrence and postoperative apnea in the early repair group. The authors concluded that delaying hernia repair may be a reasonable option for some newborns whose families are educated on the potential risks and benefits of surgical intervention [4].

A more recent study published in 2023 including 928 premature neonates revealed that inpatient IHR was associated with increased procedure time and anesthetic duration, wound infection rates, blood transfusions, unplanned intubations, ventilator days, reoperation rate, postoperative hospital length of stay, and unplanned readmissions. Another study published the same year suggested that deferring herniotomy after discharge for premature infants is safe with close monitoring and associated with a chance of spontaneous resolution. In fact, in the delayed group, no infant developed incarcerated IH while awaiting elective operation (median time from diagnosis to operation 44 days) [14, 15].

Based on these data, it is clear that avoiding incarceration is the main reason for choosing early repair in preterms. However, concern about postoperative respiratory complications, such as apnea events and re-intubation, often leads to delaying the surgery. As many as 43% of premature neonates undergoing hernia repair will develop respiratory complications, with lower weight at surgery and a history of respiratory distress syndrome being independent risk factors [8]. Postoperative apnea in premature infants is inversely related to the use of general anesthesia and the postconceptional age, and the incidence was reported to be <5% when the postconceptional age is >60 weeks according to Bawazir et al. [4].

Technical difficulties are also a major concern when operating on extremely small neonates. Both the thin spermatic cord and the fragile hernia sac can be easily damaged in this population, thus surgical precision is required.

Open vs laparoscopy

The open surgical technique used for IHR was first described by Marcy in 1886 and has since undergone multiple refinements. After making a 1-2 cm long inguinal skin incision on the side of the hernia, the cord structures are identified, and the peritoneal sac is first isolated and then ligated at the internal ring [17].

Nagraj et al published in 2006 one of the largest studies on the incidence of complications after inguinal herniotomy in babies weighing 5 kg or less. The authors concluded that open IHR in this population is not only technically challenging but also associated with high risks of recurrence (2.3%),

wound infection (2.3%), and testicular atrophy (2.7%) [18].

During the last decades, interest in laparoscopy for IHR in children has been growing. However, this approach remains debatable in neonates and more particularly in preterm infants with very low birth weight.

The procedure is performed in the supine position under general anesthesia with endotracheal intubation. A three-port transperitoneal approach is utilized. A 5 mm 0° or 30° laparoscope is inserted through the umbilicus. Two additional 3 mm working instruments are placed in the lower right and left quadrants of the abdomen. The pneumoperitoneum pressure is maintained at 6-8mmHg. Some authors use percutaneous needles to infiltrate saline subperitoneally to separate the peritoneum from the spermatic cord. 3/0 or 4/0 Prolene is used to close deep rings internally via the purse-string technique [19-22].

One of the main advantages of laparoscopy is that it contributes to the diagnosis of patent processus vaginalis (PPV) and contralateral hernias, which are found in a considerable number of patients, especially in the youngest age group. Additionally, the laparoscopic approach seems to have lower rates of complications when performed in emergencies compared to the classical approach and appears to reduce iatrogenic injury to the spermatic cord by avoiding dissection of the peritoneal sac [19].

Pastore et al stated that laparoscopic repair offers the benefit of treating bilateral IH during the same surgery or closing a contralateral PPV to prevent future metachronous IH, which is particularly important for newborns and preterm babies, as the risk of metachronous IH is higher in this age group. In their study, a contralateral PPV was found intraoperatively in 12 out of 19 patients who had a preoperative diagnosis of unilateral IH. According to the authors, bilateral closure of PPV in these patients resulted in the absence of metachronous IH at follow-up [20].

In their study, Aneiros Castro et al. stated that there were no recorded instances of metachronous contralateral hernia in their patients following laparoscopic treatment. The authors noted that, while not all patients who tested positive for a PPV would develop a clinical hernia, current levels of evidence do not indicate any increase in morbidity from treating contralateral hernia or PPV diagnosed through laparoscopy. The authors, therefore, recommend that hernias or PPV be repaired, even if they are asymptomatic. In conclusion, the authors found that laparoscopic IHR appears to be a safe and effective treatment for preterm infants [19].

Pini Prato et al, however, advocate the "wait-and-see" approach. Given the risk of testicular atrophy due to surgical manipulation of the cord, they do not suggest routine contralateral exploration of unilateral IH in males, whereas females should be considered separately, as the incidence of surgical complications is extremely low and insignificant in this group [9].

A study by Esposito et al, including 67 infants weighing 3 kg or less who underwent laparoscopic IHR, concluded that this approach is safe and technically easier than open inguinal herniotomy. The authors did not report a single case of testicular atrophy or postoperative infections in their series. These results led us to state another considerable benefit of laparoscopic repair, which is a lower infection rate compared to open IHR, where the scars are inside the diaper area and therefore subject to urine or fecal contamination [21].

From a technical point of view, Esposito et al pointed out that laparoscopic repair could be challenging for the surgeon considering the small space of the abdominal cavity in neonates. Consequently, they recommend performing one or two enemas the day before surgery to empty the bowel leading to creating a larger space for instruments [21]. The authors also shared their tips and tricks regarding the trocar positions and the needle size. They recommend positioning both surgical trocars at the umbilical level at the same level as the telescope to allow for a greater distance between the trocars and the inner inguinal ring. As for needle size, they recommend using a needle with a maximum length of 17-20 mm, as larger needles are difficult to use in preterm infants and carry a higher risk of complications [21].

Another interesting benefit of laparoscopic repair reported by Esposito et al is that by applying laparoscopic traction combined with external manual pressure, it is possible to slightly reduce the hernia content in case of incarceration [21].

A retrospective review carried out by Chan et al, including 79 premature neonates with IH treated by laparoscopy, also concluded that this approach is both possible and safe in premature neonates provided that they weigh at least 2.5 kg and have adequate anesthesia support. The authors suggest that low insufflation pressure (between 6 and 8

mmHg) be used in these patients, as pneumoperitoneum can occasionally exacerbate gaseous exchange issues [22].

The median operative time for laparoscopic repair of unilateral hernia reported by Chan et al in the previous study was 46.5 min, whereas it was 19 min for Turial et al [22,23]. For Pastore et al, the median operative time was 30 min for unilateral hernia and 39 min for bilateral hernia. All authors stated that operative time decreased after improving the learning curve [20,21].

These results reveal that performing laparoscopic IHR on preterm infants and newborns is not only possible but also secure and less technically challenging compared to conventional open herniotomy. Moreover, it is linked with a low risk of both recurrence and testicular atrophy. Nevertheless, it necessitates sufficient laparoscopic surgical expertise and appropriate anesthetic care.

There are two major limitations to this review: 1) the retrospective nature of all the included studies and 2) the heterogeneity among variables. Another potential limitation of our work was the definition of "delayed repair," which differs from one center to another. Definitive recommendations will likely require additional multicenter prospective investigation.

CONCLUSION

Our review revealed that there is considerable controversy regarding the timing of IHR for neonates and preterm infants, as evidenced by marked variation in practice across various hospitals. Current data suggest that delayed IHR may be a viable option in selected patients, but further research is needed. Laparoscopy appears to be safe, and effective and has some procedural advantages over traditional open techniques. Nevertheless, further prospective randomized studies are needed to be able to scientifically compare the two methods.

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