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REVIEW ARTICLE

Inguinal hernias in children: Update on management guidelines

Mariana Morgado [1] and Andrew JA Holland [1,2,3]

[1]Department of Paediatric Surgery, The Children's Hospital at Westmead, [2]The Burns Unit, The Children's Hospital at Westmead Burns Research Institute and [3]Douglas Cohen Department of Paediatric Surgery, The Children's Hospital at Westmead Clinical School, The Faculty of Medicine and Health, The University of Sydney, Sydney, New South Wales, Australia

Inguinal hernia repair is one of the most performed procedures in children, but aspects of care remain controversial. The aim of this review was to provide a critical appraisal of recently published guidelines on the management of inguinal hernias in children, by the American Academy of Pediatrics (2023) and the European Pediatric Surgeons' Association Evidence and Guideline Committee (2022). This was achieved by delineating areas of controversy and reviewing the most relevant recent literature on these topics. Currently available moderate-to-low quality evidence recommends postponing hernia repair in premature infants until after discharge, to reduce the risk of respiratory difficulties and recurrence. Laparoscopic repair provides similar outcomes to open but may shorten operative time in bilateral cases. No clear recommendation can be made for contralateral exploration, therefore should be evaluated case by case. In preterm infants, consideration of regional anaesthesia may reduce post-operative apnoea and pain, with no difference in neurodevelopment outcomes.

Key words: neonatal surgery; neonatology; surgery.

Inguinal hernia (IH) repair is one of the most performed surgical procedures in children. IH incidence is 8–50 per 1000 term live births, raising to 20% in premature or very low birthweight (VLBW) infants.[1,2] Risk of incarceration in children is 4%, increasing to 8% in infants.[3,4] In Australia the incidence of annual male herniotomies has fluctuated between 2669 and 3323 and in females between 670 and 738.[5]

Key points

1 In preterm infants, postponing hernia repair until after discharge from neonatal intensive care unit may be beneficial in preventing respiratory difficulties and hernia recurrence, without increase in incarceration and reoperation.
2 Based on the currently available evidence, both laparoscopic and open repair have comparable outcomes in terms of complications and recurrence. Laparoscopic inguinal hernia repair might be advantageous in children with bilateral inguinal hernia.
3 There is no evidence to suggest that a single short general anaesthesia will cause adverse neurodevelopmental outcomes but regional anaesthesia may be considered in preterm infants given an association with decrease post-operative apnoea and pain.

Correspondence: Professor Andrew JA Holland, Department of Paediatric Surgery, The Children's Hospital at Westmead, Sydney, NSW 2145, Australia. Fax: 1300315668; email: andrew.holland@health.nsw.gov.au

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Infant IH are invariably indirect, with protrusion of intra-abdominal contents through a patent processus vaginalis (PPV); most commonly bowel (91%) in males and ovaries (89.5%) in females.[6] From 2 years, in both genders, omentum becomes most common.[6] The right testis descends later, which may explain why right IH are more frequent than left (ratio 7:2).[7] Some evidence suggests that the smooth muscle cells which propel the descent of the testis may fail to undergo apoptosis, leading to failure of PPV obliteration,[8] potentially explaining why >90% occur in males.[9]

Direct hernias are rare in children, involving herniation of intra-abdominal content through a weakness in the posterior wall of the inguinal canal, known as Hesselbach's triangle. VLBW infants with giant inguinoscrotal hernias may be at risk of developing secondary direct hernias, because a wide neck at the internal ring stretches and weakens the posterior wall of the canal.[10]

Even though IH is a common pathology, there remain many management controversies. The aim of this paper is to provide a critical appraisal of the American Academy of Pediatrics (AAP) guidelines[11] published in 2023, in comparison to the guidelines published by the European Pediatric Surgeons' Association (EUPSA) Evidence and Guideline Committee in 2022.[12]

Methods

Formal assessment of the guideline quality was made with the AGREE II checklist,[13] a tool to improve reporting of clinical practice guidelines, applied by both authors.

This was a narrative review of both guidelines and new relevant literature published in the last 10 years. Relevant literature

was identified using key words and medical subject headings (MeSH) terms in the PubMed and Cochrane databases. The search was completed on 6 April 2024 and the MeSH terms employed were 'Inguinal Hernia, 'Infant' and 'Infant, Newborn'.

Exclusion criteria: articles including adolescents, adults or animals; articles not in English and case studies. This was followed by a selection by the authors of the articles that provided more relevant content given the questions raised. This was a non-systematic approach, therefore susceptible to selection bias.

We delineated four research questions, prioritising topics covered in both guidelines:

1 What is the optimal timing for repair of hernias in premature patients?
2 What is the best surgical approach to hernia repair?
3 Should we explore the contralateral side?
4 What is the best anaesthesia for newborn hernias?

Results

Guideline appraisal using AGREE II tool

The application of the AGREE II tool[13] allowed a global appraisal of the guidelines. The EUPSA guidelines[12] demonstrated clear scope, rigorous methodology and clarity of presentation, scoring 6/7 points. The AAP guidelines[11] also demonstrated a clear scope, addressed well applicability and editorial independence but lacked in methodology and in clarity of presentation, scoring 4/7 points. Overall, the EUPSA guidelines are based on a well-designed systematic review (SR) and meta-analysis conducted by a large committee of specialists and the AAP guidelines are based on the critical appraisal of the current literature by a committee of four specialists. Results by questionnaire domain are provided in Table 1.

What is the optimal timing for repair of hernias in premature patients?

Timing of IH repair in premature patients remains controversial. In a survey by EUPSA (2023), with 180 responses from 50 countries, 56%–60% favoured repair prior to neonatal intensive care unit (NICU) discharge[14] and in a similar survey by the AAP (2005), 63% would perform the repair prior to discharge.[15] The decision rests on the balance between the technical challenges, post-operative apnoea, recurrence and incarceration.

Some literature supports early repair. Lautz *et al.*, based on inpatient database review, demonstrated 16% incarceration in 49 000 preterm infants when the repair was performed during hospitalisation, increasing to 28% if delayed within the first year.[16] Delaying repair after 40 weeks increased incarceration by twofold.[16] A meta-analysis by Choo *et al.*[17] also showed a lower risk of incarceration (odds ratio (OR) 0.43) if repaired before discharge, but higher risk of post-operative respiratory complications (OR 4.36).

In favour of a delayed repair, a meta-analysis by Masoudian *et al.*[18] demonstrated significant increase in the risk of respiratory difficulty (OR 3.59) and recurrence (OR 4.12) in repairs before NICU discharge, with no difference regarding incarceration, surgical complications and reoperation. A retrospective cohort study by Choo *et al.*[19] also demonstrated a surprisingly low risk of incarceration after discharge of 0% in 219 premature infants versus 1% in the early treatment group.

Both the EUPSA[12] and AAP[11] guidelines, based on moderate-quality evidence, recommend postponing repair until after NICU discharge, given it may reduce respiratory complications and recurrence, without increased incarceration or reoperation. The EUPSA Committee's meta-analysis of retrospective cohort studies (level 2b), showed no difference in incarceration (18.1% vs. 11.3% before and after discharge) and reoperation, but both recurrence (OR 3.52) and respiratory complications (OR 4.90) were more common with surgery prior to discharge.[12] A 2024 multicentre randomised controlled trial (RCT) assessed adverse event rates associated with timing of repair, also concluding that late repair resulted in fewer infants having at least one serious adverse event (risk difference –7.9%).[20]

A relevant subgroup are females with prolapsed ovary in the IH, with an incidence as high as 38.3%.[21] Based on the findings by Boley *et al.*[22] that showed a twisted/infarcted ovary at the time of surgery in 27% of the girls with a prolapsed ovarian, emergency surgery was recommended if non-operative reduction was unsuccessful. Data since has been highly variable. A retrospective review by Kurobe *et al.*[21] found 0% of ovarian torsion in 208 VLBW infants during NICU hospitalisation, recommending delaying surgery to prior to discharge (37–52 weeks corrected), given decreased anaesthetic risk without increased torsion. Ohkura *et al.* support this, with 4.8% strangulation in herniated ovary, but all cases after the newborn period.[6] Dreuning *et al.* published retrospective analysis with 1084 patients, reporting 21.7% herniation and 6% strangulation, with a median diagnosis-to-surgery interval of 11.5 days, but no clear conclusions could be drawn.[23]

The EUPSA Committee[12] concluded that, although repair within a few days may reduce the risk of torsion and strangulation, based on the currently available low-quality evidence (level 4), no recommendation could be made regarding the timing of repair for asymptomatic irreducible ovarian IH. This topic was not included in the AAP guidelines.

A current trial entitled 'Timing of Inguinal Hernia Repair in Premature Infants' (#NCT01678638) that completed enrolling in 2023 may help to determine the optimal timing for these patients.[24]

Table 1 AGREE II checklist results (numbers presented are the median of results)

Agree II tool domains	EUPSA Evidence and Guideline Committee (2022)	American Academy of Pediatrics (AAP) guidelines (2023)
1. Scope and Purpose	7	6
2. Stakeholder Involvement	6	6
3. Rigour of Development	6	2
4. Clarity of Presentation	7	5
5. Applicability	5	6
6. Editorial Independence	4	7
Overall assessment	6	4

What is the best surgical approach to hernia repair?

Historically, the standard approach in paediatrics was open ligation of the hernia sac, which was challenged by the raising availability of laparoscopy, increasing the discussion on the benefits of each approach. In 2024's EUPSA survey, 54% favoured open and 11% laparoscopic for premature and VLBW.[14]

The EUPSA Committee's meta-analysis (eight RCT) found no differences between both techniques in complications (including injury to spermatic cord/ovary, testicular atrophy, hydrocele, wound infection and bleeding), recurrence, length of stay, time to recovery and development of a metachronous contralateral inguinal hernia (MCIH).[12] The only advantage reported for laparoscopy was a significantly shorter operative time in patients with bilateral hernia repair (weighted mean difference (WMD) −7.19).[12] Dreuning *et al*. in 2019 published a similar meta-analysis (eight RCT) that reached equivalent results.[25]

A SR by Zhao *et al*. (13 RCTs) found more conflicting results. Both techniques were comparable in unilateral operative time, time to recovery, length of stay, recurrence and hydrocele, but overall, laparoscopic repair had shorter operative time for bilateral repair (WMD −8.23), lower complications (OR 0.32), lower wound infection (OR 0.14) and decreased MCIH (OR 0.09).[26] A retrospective review of 1697 patients by Chong *et al*. also found a decrease incidence of MCIH after laparoscopic approach.[27]

Another common argument in favour of laparoscopy is cosmesis. A RCT by Shalaby *et al*. supports this view, with an 'ugly' scar reported in 4% for open and 0% for laparoscopy.[28] Surprisingly, the meta-analysis by Dreuning (three RCTs) reported better cosmetic results after open hernia repair, even when comparing with intra and extracorporeal subgroups.[25] Also found no difference in wound cosmetic problems (hypertrophic or unsightly scar, granuloma).[25] Although there is large conceptual heterogeneity among the included RCTs, it challenges the assumption that cosmesis is a laparoscopic advantage.

EUPSA guidelines[12] state that, based on the currently available evidence (level 1b), there is no definite superiority of either technique. In bilateral IH repair, laparoscopy might reduce operative time. The AAP guidelines conclude that ample evidence suggests laparoscopic approach is at least as effective as open.[11]

Focusing on different laparoscopic techniques, there is considerable variation but they can be grouped into transperitoneal (close the internal ring with an intracorporeal suture) and extraperitoneal (suture closing the internal ring in the preperitoneal space). A SR by Shalaby *et al*.[29] comparing both approaches showed no differences in post-operative hydrocele and recurrence rate, with a shorter operative time for bilateral extraperitoneal repair. Injury to spermatic vessels was not reported. Dreuning *et al*.'s meta-analysis showed less complications and reduced unilateral operation time with extraperitoneal, and shorten length of stay with intraperitoneal.[25]

The EUPSA meta-analysis[12] included three retrospective cohort studies[30–32] and found no differences in recurrence, vessel injury and post-operative hydrocele. Extraperitoneal approach demonstrated shorter surgery in both unilateral and bilateral repair. Based on current evidence, there is no superiority for either technique in regards to recurrence and complications but the extraperitoneal approach is believed to reduce operation time. The AAP guidelines[11] state that there is some evidence in favour of extraperitoneal approach.

Should we explore the contralateral side?

In 2024 EUPSA survey, contralateral side evaluation was never performed by 40% of respondents and 29% only performed it during laparoscopic repair.[14] Nataraja and Mahomed[33] SR reported a 5.76% risk of developing a MCIH after a unilateral repair, more common before 6 months (12.4%) or in initial left-sided hernia (12.1%).

In theory, a contralateral exploration could avoid a future surgery, although the presence of a PPV does not mean it will develop into a clinically significant hernia. The definition of PPV is highly variable, its natural history remains unknown and the rate of contralateral PPV that will develop into a hernia is also variable, reportedly from 1.2%[34] to 13%.[35] Contralateral exploration can expose the patient to unnecessary complications but, on the other hand, the US Food and Drug Administration has warned of the potentially harmful impact of repeated anaesthesia on the child's brain.[36]

In EUPSA's meta-analysis (23 retrospective studies),[12] 5726 of 9603 children had a contralateral exploration and in 63.5% a PPV was identified. Of those with unilateral exploration, only 8.4% developed a MCIH. Routine contralateral exploration had a complication rate of 1.97%,[12] including testicular atrophy, hydrocele, hematoma, wound infection, apnoea and recurrence. No study compared complications of contralateral exploration to complications of unilateral repair followed by MCIH repair. Six studies showed that contralateral exploration increases total anaesthesia by 15–20 min[12] although, if a MCIH develops this time might be longer.

A SR by Kokorowski *et al*. identified a contralateral PPV in 30% during laparoscopy but only 7.3% developed a hernia, with a number needed to treat (NNT) of 3, reinforcing that a PPV is a poor indicator of a future MCIH.[37] Another SR (2019) found an even higher NNT of 18.[38] Conversely, Chong *et al*.[27] comparing open and laparoscopic repair, concluded that the use of laparoscopy to assess the contralateral side reduced significantly the rate of MCIH (3.8% vs. 0.8%).

EUPSA guidelines state that since there is no high-level evidence comparing both approaches and there is extensive heterogeneity among current evidence, no clear recommendation can be made.[12] AAP guidelines conclude that, in the absence of better-quality data, it remains unclear whether incidentally identified PPV should be repaired and recommends a pre-operative, family-centred discussion of risks and benefits of both approaches.[11]

What is the best anaesthesia for newborn hernias?

Preterm infants undergoing general anaesthesia (GA) are susceptible to post-operative apnoeic episodes (in 5%).[14] Episodes of apnoea with bradycardia can decrease both diastolic and systolic flow velocity, leading to potential deleterious hypoxic–ischemic brain effects.[39]

Coté *et al*. combined eight prospective studies, concluding that the risk of apnoea was inversely related to gestational and post-conceptual age, and directly related to anaemia.[40] Among nonanemic infants without recovery apnoea, the risk of post-operative apnoea did not decrease below 1% until the post-conceptional age of 56 weeks with a gestational age of 32 weeks or post-conceptional age of 54 weeks with gestational age of 35 weeks.[40] A 2019 meta-analysis linked early repair in premature with increasing respiratory complications.[18]

The EUPSA meta-analysis concluded that there was a similar risk of apnoea and bradycardia between central regional and GA.[12] Moderate-quality evidence indicates that regional anaesthesia may reduce the risk of post-operative apnoea (OR 0.46) within the first hour and pain (OR 0.44).[12] Regional anaesthesia had a tendency towards less intervention for apnoea but not statistically significant. Jones *et al*.'s Cochrane SR corroborates that choosing spinal over GA may reduce post-operative apnoea by 47%, with a NNT of 4.[41]

Regarding the potential association between GA and neurodevelopmental deficits in children, no human studies have corroborated this theory.[11,42] Grabowski *et al*.'s SR reports conflicting evidence of an association between exposure to anaesthesia in early childhood and adverse long-term neurodevelopmental outcomes.[42] Although reasonable to avoid multiple exposures or prolonged anaesthesia, there is no evidence that exposure to a single 'brief' GA poses any significant risk to neurodevelopment, academic performance or autism spectrum disorder.[42]

The only study included in the EUPSA meta-analysis[12] reporting neurodevelopmental outcomes was the GAS (General Anaesthesia compared to Spinal anaesthesia) trial, a RCT that demonstrated no difference in outcomes between regional and GA, at 2 years follow-up.[43]

The AAP guidelines, mention similar results from the Paediatric Anaesthesia Neurodevelopment Assessment study[44] that assessed neuropsychological functions and behaviour using a sibling-matched cohort and found no differences in IQ scores.

Table 2 Recommendations from the EUPSA Committee guidelines and the AAP guidelines

Question	EUPSA Guidelines (2022)	American Academy Guideline (2023)
1. What is the optimal timing for repair of hernias in premature patients?	Moderate-quality evidence (level-2 evidence; grade B): postponing IR repair until after discharge may be beneficial in preventing respiratory difficulties and hernia recurrence.	In preterm infants, repair can be safely considered after discharge from the neonatal intensive care unit.
2. What is the best surgical approach to hernia repair?	Recommendation (level-1 evidence; grade B): there is no definite superiority of either the laparoscopic or open treatment strategy, in complications, recurrence and MCIH. Laparoscopy might be advantageous in bilateral IH in reduced operation time.	Ample evidence suggests that laparoscopic approach is at least as effective, if not better than, traditional open ligation.
	Recommendation (level-2 evidence; grade B): there is no definite superiority for either the laparoscopic extraperitoneal or transperitoneal approach, in complications and recurrence. The extraperitoneal approach may result in reduced operation time.	Within minimally invasive approaches, there is some evidence to favour the extraperitoneal approach.
3. Should we explore the contralateral side?	Recommendation (level-2 and 3 evidence): absence of high level evidence comparing contralateral to unilateral repair and extensive heterogeneity among currently available evidence, therefore no clear recommendation can be made.	A pre-operative, family-centred discussion encompassing the low but present risk of developing a contralateral hernia, the very low but potentially harmful risk of incarcerated hernia, and the potential need for another surgical procedure can guide operative management, because different families may have a variety of perspectives on risk and benefit.
4. What is the best anaesthesia for newborn hernias?	Recommendation (level-1 evidence; grade B): central regional anaesthesia instead of general anaesthesia may be considered in preterm infants requiring IH repair, since it is associated with some decrease in the occurrence of post-operative apnoea and post-operative pain.	There is no conclusive evidence to suggest that exposure to a single relatively short duration of anaesthetic has adverse effects on neurodevelopmental outcomes in otherwise healthy children.
		Institutional policies should be developed outlining the need and duration of observation after anaesthesia in former preterm infants.

The EUPSA guidelines recommend considering central regional anaesthesia in preterm infants requiring IH repair, given decreased post-operative apnoea and pain.[12] The AAP guidelines recommend developing institutional policies outlining the need and duration of post-operative observation in former preterm infants.[11]

Conclusion

Although IH in children are common, there are still many controversies. Guideline recommendations are summarised in Table 2.

Based on the moderate-quality evidence, both guidelines recommend postponing IH repair until after discharge from NICU, given potential benefits in preventing respiratory difficulty and recurrence without increase in incarceration risk.

Both guidelines consider laparoscopic and open surgery outcomes comparable, but laparoscopic repair may have utility in bilateral hernias. The EUPSA guidelines found moderate-quality evidence of no superiority between laparoscopic techniques. However, both guidelines suggest that the extraperitoneal approach may reduce operative time.

Regarding contralateral exploration, the EUPSA guidelines state that in the absence of good quality evidence, no recommendation should be made. Conversely, AAP guidelines recommend a family-centred discussion prior to surgery.

The EUPSA guidelines recommend considering regional anaesthesia in preterm infants to reduce post-operative apnoea and pain. AAP state no evidence of adverse neurodevelopmental outcomes with short anaesthesia and recommend the development of institutional policies.

Available evidence was of variable quality and this manuscript is not a SR. Therefore, there are limitations, including the possibility of selection bias of our literature and interpretation. These recommendations may not apply to every clinical setting so local population and resources may dictate institutional protocols. High-quality evidence studies are still needed to answer the many controversies of paediatric IH management.

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