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LAPAROSCOPIC VERSUS OPEN INGUINAL HERNIOTOMY IN CHILDREN: IS THERE A CLINICAL ADVANTAGE? A RETROSPECTIVE COHORT STUDY

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Abstract

Background: Inguinal herniotomy is one of the most common operations performed in childhood, but it remains unclear whether laparoscopic repair offers a clinical advantage over open repair, particularly in resource-limited public hospitals. We compared outcomes after laparoscopic and open herniotomy in children.

Methods: We conducted a retrospective cohort study in the Pediatric Surgery Department of Lady Reading Hospital – Medical Teaching Institution, Peshawar, from March 2023 to March 2024. We included children aged 14 years or younger who underwent elective repair of a reducible inguinal hernia (n = 160): 72 underwent laparoscopic repair (60 subcutaneous endoscopically assisted ligation [SEAL] needle-assisted repairs and 12 three-port intracorporeal repairs for large hernias), and 88 underwent open repair. The primary outcome was operative time. Secondary outcomes included hospital stay, pain, rescue analgesia, complications, recurrence, metachronous contralateral hernia (MCIH), recovery, and cosmesis. We used Welch's t-test, the Mann–Whitney U test, and Fisher's exact test, together with adjusted regression and Holm correction.

Results: Bilateral hernias were more frequent in the laparoscopic group (17 (23.6%) vs 9 (10.2%)). Operative time was shorter with laparoscopy (25.9 ± 7.3 vs 29.4 ± 9.4 min; difference −3.5 min, 95% CI −6.1 to −0.9), with differences of −3.2 min for unilateral hernias (−5.6 to −0.8) and −15.0 min for bilateral hernias (−22.6 to −7.4). Laparoscopy was associated with lower pain, fewer rescue doses, shorter hospital stay, earlier return to activity, and higher cosmesis scores (all Holm-adjusted $p < 0.05$). Complications occurred in 5 (6.9%) versus 12 (13.6%) cases (RR 0.51 (95% CI 0.19–1.38); $p = 0.204$); recurrence occurred in 2 (2.8%) versus 1 (1.1%) ($p = 0.589$), and MCIH in 0 of 55 versus 3 of 79

unilateral cases (p = 0.269). A contralateral patent processus was closed in 14 unilateral laparoscopic cases (25.5%), and two procedures were converted to open repair.
Conclusions: Laparoscopic herniotomy, predominantly using the SEAL technique, was associated with shorter operative time, particularly for bilateral hernias, as well as less early pain and faster recovery, with no evidence of an increased complication rate. Short follow-up and few events limit conclusions about recurrence and MCIH. Our findings support further evaluation of a tailored approach, including laparoscopic repair for bilateral hernias in girls.
Keywords: inguinal hernia; pediatric surgery; laparoscopy; herniotomy; percutaneous internal ring suturing; metachronous hernia; Pakistan,

Introduction

Inguinal hernia repair is the most common operation performed in childhood [1]. The reported incidence of pediatric inguinal hernia is approximately 0.8% to 4.4% [2]. Because an unrepaired hernia may become incarcerated—a complication reported in roughly 3% to 16% of affected children [3]—surgical repair is recommended once the diagnosis is established. Open high ligation of the hernia sac (herniotomy) has long been considered the standard operation because of its high success and low complication rates [2].

Over the past two decades, laparoscopic repair has become more widely used. It enables inspection of the contralateral internal ring and simultaneous closure of a contralateral patent processus vaginalis (CPPV) [3,4], while avoiding dissection of the cord structures in the inguinal canal [2]. Several techniques are used. Extracorporeal needle-assisted techniques, including subcutaneous endoscopically assisted ligation (SEAL) and percutaneous internal ring suturing (PIRS), use a single umbilical port and a needle to pass a suture around the ring [5–7]. Multiport techniques close the ring with intracorporeal suturing and knot tying [3,6]. Trial subgroup analyses suggest that extracorporeal closure may be associated with shorter unilateral operations and fewer complications than intracorporeal closure [2,3]. Potential concerns include recurrence, injury to the testicular vessels or intra-abdominal structures [2], and testicular ascent [8]. Anaesthetic exposure in young children is another consideration; current evidence indicates that brief, single exposures are not associated with long-term neurodevelopmental impairment [9,10].

The available evidence has not resolved whether one approach is superior. A meta-analysis of eight randomised trials (733 children) found no significant differences in complications, recurrence, or MCIH, although operative time for bilateral repair was shorter with laparoscopy [3]. A subsequent systematic review of 13 trials (1207 children) reported shorter operative time for bilateral hernias, fewer complications, and less MCIH after laparoscopy, with similar recurrence rates [2]. The European Pediatric Surgeons' Association guideline found no clear superiority of either approach and recommended tailoring the choice to local facilities, resources, and expertise [1]. Other systematic reviews and the International Pediatric Endosurgery Group guideline have also examined this question [11,12].

Most comparative evidence comes from high-income centres. Data from low- and middle-income settings are also emerging, including a randomised trial from Nigeria [13], a comparative series reported in the Pakistani literature [14], and other comparative cohorts [15–18]. Whether the reported advantages extend to a busy public-sector teaching hospital in Khyber Pakhtunkhwa remains uncertain.

We therefore compared laparoscopic and open inguinal herniotomy in children treated at our institution. We hypothesised that laparoscopy would reduce operative time, particularly for bilateral hernias.

Secondary aims were to compare early recovery, complications, recurrence, and contralateral hernia development.

Methods

Study design and setting

This retrospective cohort study was conducted in the Department of Pediatric Surgery at Lady Reading Hospital – Medical Teaching Institution (LRH-MTI), a tertiary-care public teaching hospital in Peshawar, Pakistan. Children who underwent surgery between 1 March 2023 and 31 March 2024 were identified from the theatre register. Follow-up information was obtained from outpatient records through 30 April 2024. The study is reported in accordance with the STROBE guideline for cohort studies.

Participants

We included consecutive children aged 14 years or younger who underwent elective repair of a reducible unilateral or bilateral indirect inguinal hernia. We excluded children with incarcerated or obstructed hernias requiring emergency surgery, recurrent hernias, isolated hydrocele, a concomitant procedure (for example, orchidopexy), or incomplete records.

The surgical approach was not randomised. It was determined by parental choice after counselling, the availability of laparoscopic equipment and theatre time, and the operating surgeon. No departmental protocol mandated either technique.

Surgical techniques and perioperative care

All procedures were performed or directly supervised by consultant pediatric surgeons under general anaesthesia. Analgesia consisted of regular paracetamol, with rescue doses given on request. Children were discharged as day cases once they met standard criteria: tolerating oral feeds, having pain controlled with oral analgesia, and voiding.

Open herniotomy. A skin-crease incision was made over the external inguinal ring, and the external oblique aponeurosis was opened. The hernia sac was separated from the cord structures, transfixed, and ligated at the internal ring. The layers were then closed with absorbable sutures.

Laparoscopic SEAL (needle-assisted) repair. This was the default laparoscopic technique. A 5-mm umbilical port was placed using open entry, and pneumoperitoneum was established at 8–10 mmHg. A 30° telescope was used to inspect both internal rings. A 2–3 mm stab incision was made over the internal ring. A hernia needle carrying a non-absorbable suture was passed through the extraperitoneal plane around the medial and then the lateral half of the ring, taking care to avoid the vas deferens and testicular vessels in boys and the round ligament and adnexa in girls. The suture was retrieved, the knot was tied extracorporeally and buried subcutaneously, and complete ring closure was confirmed. In girls, any prolapsed ovary or tube was reduced under direct vision before closure. A patent contralateral processus vaginalis was closed during the same session.

Three-port intracorporeal repair. This technique was reserved for large hernias, defined by the operating surgeon as a wide internal ring, an inguinoscrotal or labial sac, or a sliding component for which secure extracorporeal closure was considered unlikely. A 5-mm umbilical camera port and two 3-mm working ports were placed in the iliac fossae. The ring was closed circumferentially with a non-absorbable purse-string or Z-suture using intracorporeal knot tying. When the sac was very large, the peritoneum

was incised and closed at the ring. Conversion to open repair was recorded. Technique selection was therefore non-randomised.

Outcomes

The primary outcome was operative time, measured from skin incision to wound closure and analysed overall and by clinical laterality at presentation. Secondary outcomes were hospital stay (hours from recovery to discharge); pain at 6 hours (0–10 scale, using the FLACC scale in younger children and a self-report faces scale in older children); number of rescue analgesic doses in the first 24 hours; time to normal activity (days, parent-reported); complications within 30 days (wound infection, scrotal or inguinal swelling or haematoma, hydrocele, testicular ascent, or bleeding); recurrence (reappearance of a hernia on the repaired side, confirmed by the surgeon); MCIH (a clinically evident contralateral hernia after unilateral repair); CPPV detection in laparoscopic cases; and parental satisfaction with the scar on a five-point scale (1 = very dissatisfied, 5 = very satisfied) at the last visit.

Data collection

Two investigators extracted data from operative notes, anaesthesia charts, nursing records, and clinic notes using a standardised proforma. Discrepancies were resolved by consensus. Patient identifiers were removed before analysis.

Sample size

All eligible consecutive patients were included; therefore, no formal sample size calculation was performed. With 55 laparoscopic and 79 open unilateral cases and a pooled standard deviation of 7.0 min, the study had 80% power (two-sided $\alpha = 0.05$) to detect a 3.5-min difference in unilateral operative time (standardised difference 0.50).

Statistical analysis

Analyses followed the intended approach: laparoscopic cases converted to open repair were analysed in the laparoscopic group. Continuous variables are summarised as mean ± standard deviation or median (interquartile range), based on Shapiro–Wilk tests and visual inspection. Operative time was compared using Welch's t-test, with the Mann–Whitney U test as a sensitivity analysis. Skewed or ordinal outcomes (hospital stay, pain, rescue doses, time to normal activity, and cosmesis) were compared using the Mann–Whitney U test and summarised with the rank-biserial correlation. Categorical variables were compared using the chi-squared test or Fisher's exact test. Risk ratios (RRs) were calculated with Katz confidence intervals. Baseline imbalance was assessed using standardised mean differences (SMDs).

The primary outcome was adjusted using multivariable linear regression that included surgical approach, clinical laterality, age, and sex, with an approach-by-laterality interaction, as bilateral repair was expected to benefit most from laparoscopy. The probability of any complication was modelled using logistic regression, with approach, age, laterality, and sex as covariates. Pain at 6 hours, log-transformed hospital stay, and rescue doses (Poisson regression) were adjusted for the same covariates. Because complications were few, the logistic model was considered exploratory.

Secondary outcomes were considered exploratory, and Holm adjustment was applied across six secondary comparisons. A per-protocol sensitivity analysis excluded converted cases. Outcomes by laparoscopic technique and in girls were examined descriptively because these subgroups were small and technique was selected by indication. Recurrence and MCIH are reported as crude proportions because there were too few events for time-to-event analysis. A two-sided $p < 0.05$ was considered significant. Analyses were performed in Python 3.12 (SciPy 1.18.1, statsmodels 0.15.0).

Ethical considerations

Ethical approval was not applicable. The requirement for informed consent was waived for this retrospective record review. The study followed the principles of the Declaration of Helsinki.

Results

Participants

Of the 214 children who underwent inguinal herniotomy during the study period, 54 were excluded: 19 had incarcerated hernias or required emergency repair, 12 had incomplete records, 9 had isolated hydrocele, 8 underwent a concomitant procedure, and 6 had recurrent hernias. The remaining 160 children were included in the analysis: 72 (45.0%) in the laparoscopic group and 88 (55.0%) in the open group (Figure 1). Laparoscopy was used more frequently as the study period progressed (median month of surgery 8.4 (5.9–11.4) vs 5.9 (2.6–9.2); $p < 0.001$).

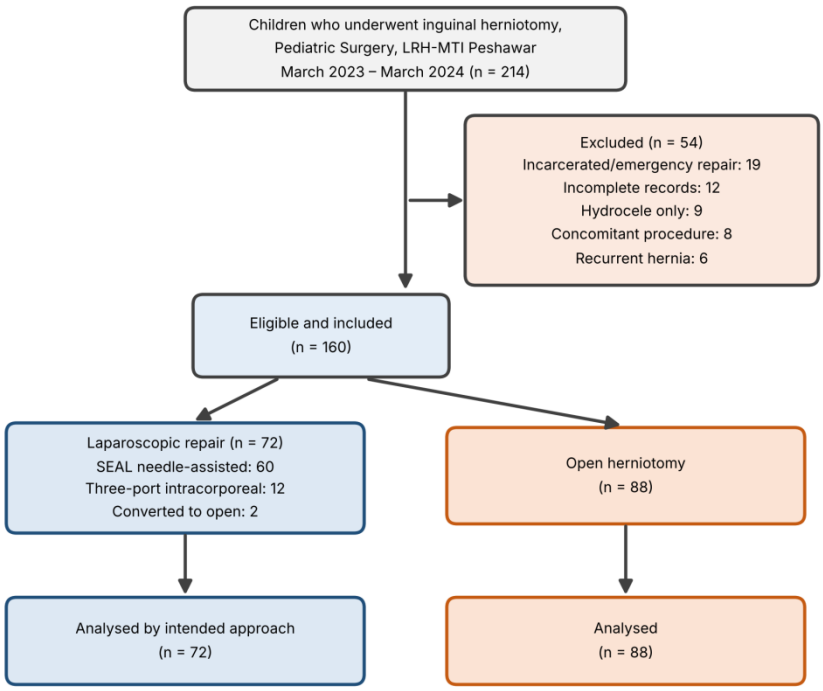


Figure 1. Flow of participants (STROBE). LRH-MTI, Lady Reading Hospital – Medical Teaching Institution.

Baseline characteristics

Mean age was 4.4 ± 3.4 years in the laparoscopic group and 3.4 ± 3.0 years in the open group. Girls accounted for 19 (26.4%) and 14 (15.9%) children, respectively (Table 1). Bilateral hernias were more frequent in the laparoscopic group (17 (23.6%) vs 9 (10.2%); $p = 0.022$; SMD 0.36). Children in the laparoscopic group were slightly older and heavier, although these differences were not statistically significant. History of prematurity and ASA status were similar between groups.

Table 1. Baseline characteristics of the study cohort.

Characteristic	Laparoscopic (n = 72)	Open (n = 88)	p	SMD
Age, years (mean ± SD)	4.4 ± 3.4	3.4 ± 3.0	0.075	0.29
Age, years (median, IQR)	3.6 (1.4–6.9)	2.5 (1.2–4.8)		
Weight, kg (mean ± SD)	11.8 ± 6.1	10.1 ± 5.7	0.072	0.29
Female sex, n (%)	19 (26.4%)	14 (15.9%)	0.103	0.26
History of prematurity, n (%)	6 (8.3%)	9 (10.2%)	0.683	-0.07
ASA physical status II, n (%)	7 (9.7%)	8 (9.1%)	0.892	0.02
Clinical laterality, n (%)				
Right unilateral	34 (47.2%)	49 (55.7%)		
Left unilateral	21 (29.2%)	30 (34.1%)		
Bilateral	17 (23.6%)	9 (10.2%)	0.022	0.36
Month of surgery, median (IQR) †	8.4 (5.9–11.4)	5.9 (2.6–9.2)	<0.001	

Values are mean ± SD, median (IQR) or n (%). p values from Welch's t-test, chi-squared test or Mann–Whitney U test. SMD, standardised mean difference. † Months elapsed since 1 May 2023. The p value for laterality compares bilateral versus unilateral hernias.

Operative outcomes

Operative time was shorter with laparoscopy overall (25.9 ± 7.3 vs 29.4 ± 9.4 min; mean difference −3.5 min, 95% CI −6.1 to −0.9; p = 0.009; Mann–Whitney p = 0.019) (Table 2, Figure 2). For clinically unilateral hernias, the difference was −3.2 min (−5.6 to −0.8; p = 0.008; Hedges' g −0.46); for bilateral hernias, it was −15.0 min (−22.6 to −7.4; p < 0.001). The effect of approach differed by laterality (approach-by-laterality interaction, p < 0.001). After adjustment for age and sex, the difference was −3.4 min (−5.9 to −0.9) for unilateral hernias and −15.1 min (−21.0 to −9.3) for bilateral hernias (Table 5). The per-protocol analysis, which excluded converted cases, showed a similar difference for unilateral hernias (−3.7 min, −6.0 to −1.3).

Two laparoscopic procedures (2.8%) were converted to open repair: one because of a sliding hernia and the other because secure ring closure was not possible using the needle technique. Among the 55 clinically unilateral laparoscopic cases, a CPPV was identified in 14 (25.5%) and closed during the same session.

Laparoscopic technique. SEAL was used in 60 cases (83.3%) and three-port intracorporeal repair in 12 (16.7%). Children who underwent three-port repair were older and heavier (age 7.0 ± 3.6 vs 3.8 ± 3.1 years; weight 16.6 ± 6.0 vs 10.9 ± 5.7 kg), consistent with selection for larger hernias. Compared with open repair, SEAL shortened unilateral operations by 4.5 min (−7.0 to −2.0) and bilateral operations by 17.0 min (−24.5 to −9.5), whereas unilateral three-port repair took longer than open repair (3.2 (0.1 to 6.4) min) (Table 2). The three bilateral three-port cases (mean 40.7 min) were too few for testing. Both conversions, all 5 laparoscopic complications, and both recurrences occurred in the SEAL group; none occurred among the 12 three-port cases. These numbers are too small for comparison.

Table 2. Operative time by approach, clinical laterality and laparoscopic technique.

Group	n	Laparosco	n	Open, min	Mean difference	p

		pic, min			(95% CI)	
Overall	72	25.9 ± 7.3	88	29.4 ± 9.4	−3.5 (−6.1 to −0.9)	0.009
Unilateral hernia	55	24.2 ± 6.6	79	27.5 ± 7.2	−3.2 (−5.6 to −0.8)	0.008
Bilateral hernia	17	31.4 ± 6.9	9	46.3 ± 9.3	−15.0 (−22.6 to −7.4)	<0.001
Unilateral: SEAL vs open	46	23.0 ± 6.4	79	27.5 ± 7.2	−4.5 (−7.0 to −2.0)	<0.001
Unilateral: three-port vs open	9	30.7 ± 3.7	79	27.5 ± 7.2	3.2 (0.1 to 6.4)	0.046
Bilateral: SEAL vs open	14	29.4 ± 5.7	9	46.3 ± 9.3	−17.0 (−24.5 to −9.5)	<0.001
Bilateral: three-port vs open	3	40.7 ± 2.9	9	46.3 ± 9.3	—	—

Operative time is mean ± SD in minutes; mean difference is laparoscopic minus open (Welch's t-test). Laterality refers to clinical presentation. Technique rows compare each laparoscopic technique with the open group; the three-port bilateral group (n = 3) was not tested. SEAL, subcutaneous endoscopically assisted ligation.

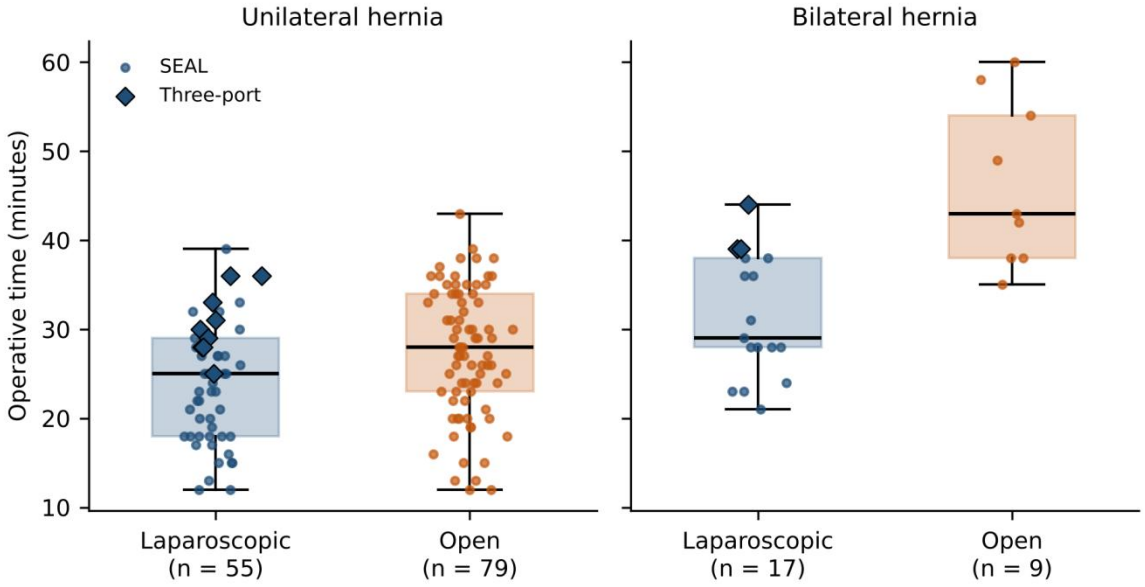


Figure 2. Operative time by approach, stratified by clinical laterality. Boxes show the median and interquartile range; points are individual patients. Diamonds mark three-port intracorporeal repairs; circles in the laparoscopic group are SEAL repairs.

Postoperative outcomes

Children in the laparoscopic group had a shorter hospital stay (median 6 h (IQR 5–8) vs 8 h (6–10); p < 0.001) and lower pain scores at 6 hours (median 2 vs 3). They also required fewer rescue analgesic doses during the first day (median 1 vs 2) (Table 3, Figure 3). Return to normal activity occurred one day earlier (median 2 vs 3 days), and parents gave higher scar satisfaction ratings (median 5 vs 4). All these differences remained significant after Holm adjustment (adjusted p ≤ 0.004). Although statistically robust, the absolute differences were modest, amounting to about one point on the 0–10 pain scale, for example. After adjustment for age, sex, and laterality, laparoscopy was associated with a 1.0-point reduction in the 6-hour pain score (95% CI −1.4 to −0.6), a geometric mean hospital stay ratio of 0.81 (0.71–0.92), and an incidence rate ratio for rescue doses of 0.68 (0.52–0.89) (Table 5).

Table 3. Secondary postoperative outcomes.

Outcome	Laparoscopic (n = 72)	Open (n = 88)	Effect size ‡	p	Holm p
Length of hospital stay, h	6 (5–8)	8 (6–10)	−0.35	<0.001	<0.001
Pain score at 6 h (0–10)	2 (1–3)	3 (2–4)	−0.44	<0.001	<0.001
Rescue analgesic doses in first 24 h	1 (0–2)	2 (1–3)	−0.29	0.001	0.004
Time to normal activity, days	2 (1–3)	3 (2–4)	−0.41	<0.001	<0.001
Parental cosmesis satisfaction (1–5)	5 (4–5)	4 (4–5)	0.29	<0.001	0.002
Any postoperative complication, n (%)	5 (6.9%)	12 (13.6%)	RR 0.51 (0.19–1.38)	0.204	0.204

Values are median (IQR) or n (%). ‡ Rank-biserial correlation for continuous and ordinal outcomes (negative values indicate lower values with laparoscopy; for cosmesis a positive value indicates higher satisfaction) and risk ratio (95% CI) for complications. p values from the Mann–Whitney U test (Fisher's exact test for complications). Holm adjustment across six secondary comparisons.

Complications, recurrence and contralateral hernia

Complications occurred in 5 (6.9%) laparoscopic cases and 12 (13.6%) open cases (RR 0.51 (95% CI 0.19–1.38); risk difference −6.7 percentage points, −16.0 to 2.6; p = 0.204) (Table 4, Figure 3). Although the point estimate favoured laparoscopy, the confidence interval is compatible with both a substantial reduction and a modest increase in risk. After adjustment, the odds ratio was 0.59 (95% CI 0.19–1.84; p = 0.362). Younger age was associated with higher odds of a complication (odds ratio 0.79 per year, 0.63–1.00; p = 0.047) (Table 5). These models are imprecise because there were only 17 events. Most complications were minor and resolved with conservative care. The exception was one superficial wound infection in the open group, which required drainage under local anaesthesia.

Median follow-up was 6.0 (3.1–9.2) months overall. It was shorter in the laparoscopic group than in the open group (5.5 (2.5–8.0) vs 7.3 (3.9–11.2) months; p = 0.005), reflecting the later adoption of laparoscopy. In total, 121 children (75.6%) were followed for at least 3 months and 82 (51.3%) for at

least 6 months; 8 had only an early visit. Recurrence occurred in 2 laparoscopic patients (2.8%) and 1 open patient (1.1%; p = 0.589), at 2.1 and 4.0 months in the laparoscopic group and at 3.2 months in the open group. All recurrent hernias were re-repaired using the open approach. MCIH developed in none of the 55 clinically unilateral laparoscopic cases and in 3 of 79 open cases (3.8%; p = 0.269), at 3.5, 4.2, and 5.4 months.

Table 4. Complications, recurrence and contralateral hernia outcomes.

Outcome	Laparoscopic (n = 72)	Open (n = 88)	p
Surgical-site (wound) infection	1 (1.4%)	4 (4.5%)	0.380
Scrotal/inguinal swelling or haematoma	2 (2.8%)	6 (6.8%)	0.297
Postoperative hydrocele	1 (1.4%)	2 (2.3%)	1.000
Iatrogenic testicular ascent	0 (0.0%)	1 (1.1%)	1.000
Minor needle-site bleeding	1 (1.4%)	0 (0.0%)	0.450
Patients with any complication	5 (6.9%)	12 (13.6%)	0.204
Recurrence	2 (2.8%)	1 (1.1%)	0.589
MCIH in clinically unilateral cases (n = 55 vs 79)	0 (0.0%)	3 (3.8%)	0.269
CPPV detected and closed (unilateral laparoscopic, n = 55)	14 (25.5%)	Not assessed	—
Conversion to open repair	2 (2.8%)	—	—

Values are n (%). Individual complication rows count events; some patients had more than one. p values from Fisher's exact test. MCIH, metachronous contralateral inguinal hernia; CPPV, contralateral patent processus vaginalis.

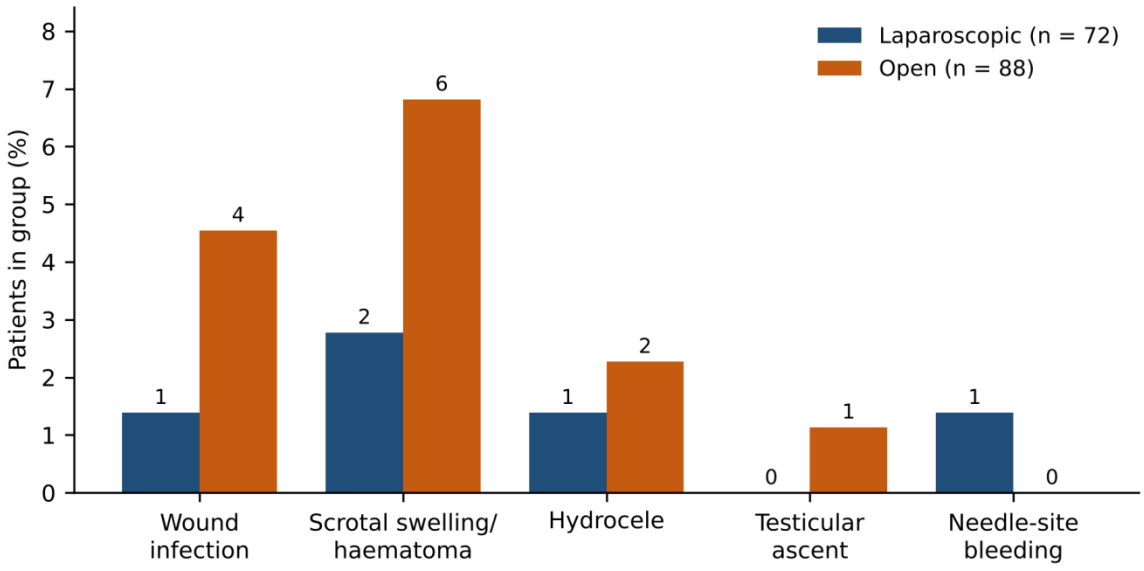


Figure 3. Postoperative complications by type, as a percentage of patients in each group. Numbers above bars are event counts.

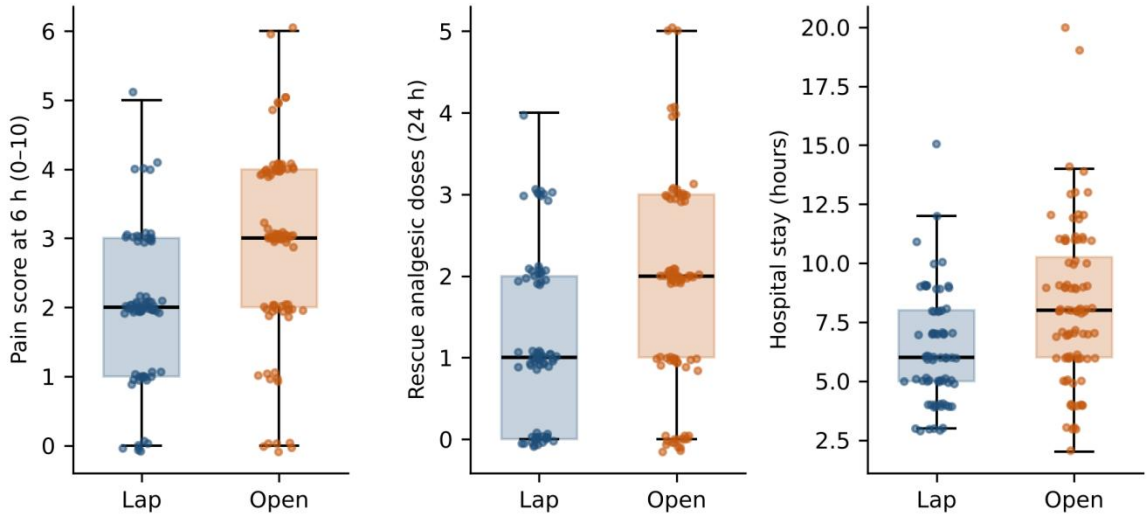


Figure 4. Early recovery outcomes by approach: pain score at 6 hours, rescue analgesic doses in the first 24 hours and hospital stay. Boxes show the median and interquartile range; points are individual patients (slightly jittered).

Table 5. Multivariable analyses of operative time and early outcomes.

Outcome and model	Term	Estimate (95% CI)	p
Operative time, min (linear regression, with interaction)	Laparoscopic vs open, unilateral	−3.4 (−5.9 to −0.9)	0.007
	Laparoscopic vs open, bilateral	−15.1 (−21.0 to −9.3)	<0.001
	Bilateral vs unilateral (open group)	19.1 (14.2 to 24.0)	<0.001
	Approach × laterality interaction	−11.7	<0.001
	Age, per year	0.24 (−0.11 to 0.60)	0.173
	Female vs male	−0.5 (−3.3 to 2.3)	0.703
Any complication (logistic regression; 17 events)	Laparoscopic vs open	OR 0.59 (0.19–1.84)	0.362
	Age, per year	OR 0.79 (0.63–1.00)	0.047
	Bilateral vs unilateral	OR 0.71 (0.14–3.45)	0.667
	Female vs male	OR 0.83 (0.21–3.19)	0.783
Pain at 6 h, points (linear regression)	Laparoscopic vs open	−1.0 (−1.4 to −0.6)	<0.001

Hospital stay (log-linear regression)	Laparoscopic vs open, ratio of geometric means	0.81 (0.71–0.92)	<0.001
Rescue analgesic doses (Poisson regression)	Laparoscopic vs open, incidence rate ratio	0.68 (0.52–0.89)	0.005

Operative-time model adjusted for age and sex. Models for pain, hospital stay and rescue doses adjusted for age, sex and laterality. The complication model was exploratory (events per covariate < 5). OR, odds ratio.

Girls and bilateral hernia

Girls accounted for 19 (26.4%) of the laparoscopic group and 14 (15.9%) of the open group; 6 and 2 of them, respectively, had bilateral hernias (Table 6). Among the 6 girls who underwent laparoscopic repair of bilateral hernias, mean operative time was 29.8 min, compared with 40.5 min among the 2 who underwent open repair. These numbers are too small to support inference. A CPPV was identified in 5 of 13 girls with clinically unilateral hernias (38.5%) and 9 of 42 boys (21.4%), and was closed during the same session. No girl required conversion, and no ovarian or tubal injury was recorded. Complications occurred in 2 (10.5%) laparoscopic and 1 (7.1%) open cases among girls. One laparoscopic girl had a recurrence after SEAL repair; no MCIH occurred in either group.

Table 6. Exploratory outcomes in girls (descriptive; no formal testing).

Variable	Laparoscopic	Open
Girls, n	19	14
Bilateral hernia, n	6	2
Operative time, bilateral, min (mean ± SD)	29.8 ± 9.5	40.5 ± 3.5
Operative time, bilateral, min (range)	21–44	38–43
Unilateral hernia, n	13	12
Operative time, unilateral, min (mean ± SD)	23.5 ± 6.0	28.4 ± 8.1
Laparoscopic technique: SEAL / three-port, n	17 / 2	—
CPPV found at laparoscopy, unilateral cases	5 (38.5%)	Not assessed
Any complication, n (%)	2 (10.5%)	1 (7.1%)
Recurrence, n (%)	1 (5.3%)	0 (0.0%)
MCIH after unilateral repair, n (%)	0 (0.0%)	0 (0.0%)
Conversion to open, n (%)	0 (0.0%)	—

Values are n, n (%) or mean ± SD. CPPV, contralateral patent processus vaginalis; MCIH, metachronous contralateral inguinal hernia; SEAL, subcutaneous endoscopically assisted ligation.

Discussion

Principal findings

In this retrospective cohort of 160 children, laparoscopic herniotomy was associated with shorter operative time than open herniotomy, by approximately 3 minutes for unilateral hernias and 15 minutes for bilateral hernias. It was also associated with lower early pain, fewer rescue analgesic doses, shorter hospital stay, earlier return to normal activity, and greater parental satisfaction with the scar. We found no signal of increased complications or early recurrence, and no MCIH after laparoscopy. However, the

confidence intervals for complications were wide, and follow-up was short and unequal. The study therefore cannot establish that laparoscopy is safer or that recurrence rates are equivalent.

Comparison with previous studies

The larger operative-time advantage we observed for bilateral hernias is consistent with pooled estimates showing that bilateral operations are approximately 7 to 8 minutes shorter with laparoscopy [2,3], and with the European guideline's conclusion that laparoscopic repair reduces operative time for bilateral hernias [1]. The rationale is straightforward: the second side can be closed through the same port, without a second incision or dissection. Our observed difference of 15 minutes was greater than the pooled estimates, possibly because of the extracorporeal needle technique, the small number of bilateral cases (17 vs 9), and the wide confidence interval. For unilateral hernias, pooled analyses found no overall difference, although subgroups using extracorporeal suturing had shorter operative times (approximately 5 to 7 minutes); this difference was no longer significant in one sensitivity analysis [2,3]. Our unilateral difference of approximately 3 minutes falls within that range. Operative time also depends on experience: learning-curve data for percutaneous internal ring suturing show that times change as surgeons gain experience [5]. Operative time for percutaneous versus open repair has been directly compared in unilateral hernias [19], and studies in young infants have favoured the laparoscopic technique [16].

Differences in pain, recovery, and cosmesis were statistically robust but modest. Previous meta-analyses considered the evidence on pain and cosmesis insufficient because trials used different scales and protocols [3], making direct comparisons difficult. Biological differences between the approaches, including inflammatory stress responses, have also been studied [20]. Retrospective pain scores recorded by nurses, parental expectations of minimally invasive surgery, and the lack of blinding could have exaggerated these differences, particularly in parent-reported scar ratings.

Complication rates were numerically lower after laparoscopy (6.9% vs 13.6%), but the difference was not statistically significant. Pooled estimates are inconsistent: one synthesis found no significant difference (odds ratio 0.50, 95% CI 0.14–1.79) [3], while another reported fewer complications after laparoscopy (odds ratio 0.32) [2]. Both reported larger effects in subgroups using extracorporeal suturing (odds ratios 0.15 to 0.16) [2,3], the technique used in most of our laparoscopic cases. Wound infection and testicular ascent are among the most frequently discussed complications. Although risk factors for testicular ascent after laparoscopic percutaneous closure have been identified [8], our event counts—one wound infection and no ascent after laparoscopy—are too small to support a meaningful comparison.

Our findings do not allow conclusions about recurrence. Meta-analyses have found no significant difference between approaches [2,3], but recurrences can occur over several years; one review reported that approximately half appear within 6 months [2]. Median follow-up in our cohort was 6.0 months and was shorter in the laparoscopic group, reducing the opportunity to detect later events in that group. Regarding MCIH, a series of 296 children published in a Pakistani journal reported rates of 12.8% after open repair and 1.4% after laparoscopic percutaneous extraperitoneal closure [14]. One meta-analysis also found a substantially lower rate when a laparoscopically identified CPPV was closed [3]. Our results (0 of 55 vs 3 of 79) are consistent with this direction of effect, but are imprecise. We identified a CPPV in 25.5% of unilateral laparoscopic cases, within the 7.7% to 30.0% range reported across trials [2]; some systematic reviews have reported higher prevalence [4]. Because a patent processus does not always progress to a hernia, routinely closing it may result in overtreatment, and the number of CPPVs

that must be closed to prevent one hernia is not small [4]. The association between CPPV and subsequent hernia has been examined prospectively [21], and closure may offer particular advantages in girls [22]. Decisions should therefore be individualised.

Choice of laparoscopic technique

Most laparoscopic repairs in our cohort used the needle-assisted SEAL technique, which showed the clearest operative-time advantage. The three-port intracorporeal technique was reserved for large hernias and took longer than open repair in unilateral cases. These comparisons are confounded by indication and should not be interpreted as a ranking of techniques: children selected for three-port repair were older, heavier, and had wider rings. The findings are consistent with pooled data suggesting that extracorporeal closure is associated with shorter unilateral operations and fewer complications than intracorporeal closure [2,3]. Trials and cohorts have also compared single-port percutaneous repair with three-port mini-laparoscopic repair [6] and described single-site intraperitoneal closure [7], underscoring the variation in technique. The rationale for a three-port approach is technical: intracorporeal suturing allows controlled circumferential closure of a wide ring and handling of a large or sliding sac under direct vision, which may be more difficult to achieve reliably with a needle-passed suture. Both recurrences in our series followed SEAL repair. Two events are insufficient to support an inference, but they underscore the need for careful technique selection when the ring is wide and for auditing recurrence by ring size. Proficiency also changes over time [5], complicating comparisons between techniques adopted at different stages.

Bilateral hernias in girls: suggested practice points

Girls warrant separate consideration. Pooled reductions in complications after laparoscopy were driven largely by male-specific events such as testicular ascent and scrotal swelling [2], which do not apply to girls. The rationale for laparoscopy in girls therefore rests mainly on operative exposure, the ability to assess both sides, and operative time. Ovarian and tubal injuries have been reported as operative complications in trials [3], and a prolapsed or sliding adnexal component may occur in girls. Bilateral open repair requires two groin incisions, whereas laparoscopy permits inspection of both rings through one port, consistent with the European guideline's statement that laparoscopic repair may be beneficial for bilateral hernias [1]. In our cohort, a CPPV was found in 38.5% of girls with a unilateral hernia. Potential benefits of closing a contralateral processus in girls have been described [22], although not every patent processus progresses to a hernia [4]. The subgroup of girls was small, including only 6 laparoscopic bilateral repairs; the following points are therefore hypothesis-generating and based on our experience and the literature, rather than formal guideline recommendations:

- Consider laparoscopic repair for bilateral inguinal hernias in girls when a surgeon with paediatric laparoscopic expertise and the required equipment are available, given the larger operative-time advantage reported for bilateral disease [2,3].
- Inspect both internal rings systematically at the outset, identify any ovary, tube, or sliding component, and reduce adnexal structures under direct vision before placing a suture.
- Use SEAL for standard-sized rings, taking care to lift the peritoneum to avoid entrapping the round ligament or adnexa, and confirm complete closure on each side.
- Use three-port intracorporeal closure, with the sac managed under direct vision, for wide rings, sliding hernias, or large sacs; convert early if secure closure cannot be achieved.

- If a contralateral CPPV is found during unilateral repair in a girl, discuss closure with the parents as a shared decision, considering its prevalence and the uncertain proportion that would progress to a clinical hernia [4,22].
- Audit outcomes, including recurrence and ovarian or tubal events, with follow-up of at least one to two years, because recurrence may present later [2].

Implications for practice

For a public-sector hospital with limited laparoscopic capacity, our findings support a pragmatic approach consistent with current guidance, which recommends tailoring technique to local facilities and expertise [1]. Laparoscopy may be most useful for bilateral hernias, particularly in girls, and for clinically uncertain hernias, where operative-time advantages and inspection of the contralateral side may be valuable. For uncomplicated unilateral hernias, the benefits appear modest, and open herniotomy remains a safe option. Although shorter operations mean shorter anaesthetic exposure, any advantage of bilateral laparoscopic repair in this respect is likely to be marginal. Available evidence suggests that brief, single anaesthetic exposures are not associated with long-term neurodevelopmental harm [9,10], so this consideration should not determine the choice of approach. Costs of consumables and theatre time were not captured and should be included in future studies.

Strengths and limitations

Strengths of this study include consecutive enrolment, prespecified outcome definitions, stratified and adjusted analyses, a sensitivity analysis, and transparent reporting of baseline imbalance and multiplicity. Several limitations should also be considered. First, the retrospective, non-randomised design leaves the study vulnerable to confounding by indication. Approach was influenced by laterality, parental choice, and equipment availability, and residual confounding may remain. Second, laparoscopy was adopted progressively, so period effects are intertwined with the surgeons' learning curve. Third, follow-up was short and unequal, and few recurrences or MCIH events occurred, limiting conclusions about long-term outcomes. Fourth, the number of bilateral cases was small and complications were rare, resulting in imprecise estimates; the multivariable models should therefore be considered exploratory. Fifth, pain was assessed using different tools according to age, and parent-reported outcomes were not blinded. Sixth, this was a single-centre experience, predominantly involving SEAL repair; the three-port subgroup (12 cases) and the girls with bilateral hernias (8 cases) were too small for inference, and technique was selected by indication. Finally, secondary outcomes were exploratory despite Holm adjustment.

Conclusions

In this single-centre cohort, laparoscopic herniotomy was associated with shorter operative time, particularly for bilateral hernias, and modest improvements in early pain and recovery, with no evidence of an increased complication rate. A clinical benefit in terms of recurrence or prevention of contralateral hernia could not be established because follow-up was short and events were few. Adequately powered prospective studies with at least two years of follow-up and cost data are needed. In the meantime, the choice of technique should reflect laterality, hernia size, family preference, and surgical expertise. Our exploratory findings support further evaluation of laparoscopic repair for bilateral hernias in girls, with SEAL for standard rings and three-port intracorporeal closure for large hernias.

Declarations

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Author contributions: Fayaz ur Rahman: conceptualisation, study design, data curation, and drafting of the manuscript; Naseem Khan and Zahir Shah: data curation and critical revision of the manuscript; Nazir Hussain: formal analysis and interpretation of the data; Fazli Rashid: supervision and critical revision of the manuscript. All authors reviewed and approved the final manuscript.

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