Laparoscopic extraperitoneal technique versus open inguinal herniotomy in children: historical controlled intervention study

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ABSTRACT

Objective To compare surgical outcomes of percutaneous extraperitoneal simple purse string method of laparoscopic hernia (LH) repair with a traditional open inguinal hernia (OH) repair in children with indirect inguinal hernia in a single center.

Methods This study is a historical-controlled intervention study of two groups of patients: patients in the controlled group had OH repair performed from January 2016 to December 2017, and patients in the study group had LH repair from January 2018 to December 2019 at a single institution. Outcomes of the OH and LH groups, in terms of operative time, recurrence, complications, incidence of metachronous contralateral inguinal hernia (MCIH) and contralateral patent processus vaginalis (CPPV) were analyzed.

Results Three hundred and five patients were enrolled in the study. Among them, 95 cases underwent laparoscopic percutaneous extraperitoneal closure herniomy (LH group), and 210 cases underwent conventional open inguinal herniomy (OH group). In terms of operative time, only unilateral herniomy in females of the OH group was significantly less than that of the LH group (15.7±7.1 min vs 20.5±7.4 min, p=0.004). No significant difference in overall complication was observed between the two groups of patients. The incidence of CPPV in the LH group was 15.7% (15/95), and MCIH in OH group was 10.9% (23/210).

Conclusions Laparoscopic herniomy may prevent the need for a second operation of metachronous contralateral hernia. Both open and laparoscopic techniques are equivalent in pro and cons.

INTRODUCTION

Indirect inguinal hernia (IIH) is one of the most common surgical problems in infants and children. The incidence of right-sided hernia is more than two to three times that of left-sided hernia.1-3 Bilateral IIH can present with synchronous or metachronous contralateral inguinal hernia (MCIH). Incidence of MCIH ranges from 5% to 20%. In the past, many studies found that the risk factors for MCIH were preterm, gender (female) and initial left-sided IIH.4 Many pediatric surgeons performed exploration of the asymptomatic side in the high-risk group to avoid a second anesthesia and to reduce cost and chance of incarceration.3-9 However, negative exploration sometimes occurred, which was the potential risk of an unnecessary operation.

In 1990, laparoscopy was first used for diagnosis of contralateral IIH, and laparoscopic repair was introduced later with regard to intracorporeal repair in 1993 first described by Montupet and Esposito, as noted by Schier.10 11 The laparoscopic approach has been rapidly gaining popularity owing to its safety and efficacy. In addition, it also defines contralateral patent processus vaginalis (CPPV), which shows an open internal ring with an outpouching of peritoneum that
bulges into the inguinal canal on the asymptomatic side and allows repair of CPPV in the same operation. Many techniques of intracorporeal and extracorporeal repair have been developed. The extracorporeal techniques all involve the placement of a suture circumferentially around the internal ring and tying the knot using percutaneous technique, which is feasible with minimal dissection, with less complication and better cosmetic result compared with the traditional open approach.12–21

The aims of the current study were to compare surgical outcomes of percutaneous extraperitoneal simple purse string method of laparoscopic hernia (LH) repair with a traditional open inguinal hernia (OH) repair in children in a single center and to determine if doing LH repair in children is worthwhile.

METHODS
Study design
A historical-controlled intervention study was carried out in children aged less than 12 years who had gotten hernia repair operation from 1 January 2016 to 31 December 2019 in a single unit. Exclusion criteria included IH with undescended testis, irreducible incarcerated IH and strangulated IH. The patients were divided into two groups: (1) a historical-controlled group of patients who had an OH repair performed from 1 January 2016 to 31 December 2017, and (2) a prospective group of patients who had been undergoing laparoscopic extraperitoneal hernia repair from 1 January 2018 to 31 December 2019. Informed parental consent was obtained from the prospective groups.

Surgical procedure
All patients underwent standardized general anesthetic induction and maintenance. Some of the OH group had been inserted a laryngeal mask airway and/or had adjunct ilioinguinal nerve block. The anesthetic technique depended on an anesthesiologist. In the LH group, only the records of patients with ipsilateral pathology were reviewed to determine if MCIH occurred after 2 years postoperatively (they returned to have MCIH repairs at our hospital). All parents were advised to contact the department of pediatric surgery if there were any complications.

Follow-up and data collection
All patients were followed up postoperatively 1 week, 1 year at the outpatient clinic and 2 years by phone. In the OH group, the records of patients with ipsilateral pathology were reviewed to determine if MCIH occurred after 2 years postoperatively (they returned to have MCIH repairs at our hospital). All parents were advised to contact the department of pediatric surgery if there were any complications.

The medical records of all patients were analyzed by sex, age, initial side, presence of CPPV, presence of MCIH, operation time, recurrence and complications among the groups.

The measured outcomes were operative time, complications (such as wound infection, testicular atrophy and postoperative hydrocele), recurrence and incidence of MCIH in the OH group and CPPV in the LH group.

Sample size
The sample size of this study was calculated based on factors associated with significant outcomes (operative time) from previous studies22–24 using alpha=0.05 (two-sided test) and a power of 0.80, and the difference between two proportions. The study by Endo et al22 found that operative time of bilateral repair was shorter in the laparoscopic group (35.8±11.6 vs 46.7±17.7 min, p<0.001), which provided the number of approximate sample sizes in each group as 40.

Statistical analysis
Categorical data were reported as count and percent and were analyzed with Fischer’s exact probability test. Continuous data were reported as mean and SD or as median and IQR and were analyzed with the Student t-test or the Mann-Whitney U test as appropriate.

The propensity score was generated as the probability of being assigned to laparoscopic or open herniotomy. It was calculated in the form of logit as a function of three factors (age, sex and bilaterality). The calculated propensity was then used by the inverse probability treatment
weighting in the regression equation to identify the difference in operative time between the two treatment groups. A value of $p \leq 0.05$ was considered statistically significant.

**RESULTS**

**Patient characteristics**

Four hundred twenty-six patients were assessed for eligibility and were separated into two groups. In the OH group, 224 cases had hernia repair from 1 January 2016 to 31 December 2017, of which three were excluded based on the exclusion criteria and 11 received laparoscopic surgery. In the LH group, 202 cases had hernia repair operations during 1 January 2018 to 31 December 2019, of which 105 cases received open herniotomy, and 2 cases were excluded by exclusion criteria. A total of 305 patients (210 cases in the OH group and 95 cases in the LH group) were then further analyzed. All patients in the LH group had successful laparoscopic surgery without conversion. In both groups, the median age at the time of initial operation was 3 years, and male gender was twice more than female gender. Distribution of right to left to bilateral hernia at time of initial presentation was 6:5:1 in the OH group and 4:3:1 in the LH group. Mean follow-up time was 33.1±5.7 months in the OH group and 23.7±0.7 months in the LH group, respectively. General characteristics were shown in table 1.

**Operative time**

Because of the referent group was the historical control, the propensity score weighting was done to reduce bias between groups. The result after the propensity score weighting methods showed that the mean of operative time in LH group was significantly longer than that in OH group in all cases ($p=0.013$). In the special group, the operative time of unilateral herniotomy in male and female patients was significantly longer in LH group than that in OH group (27.9±9.6 vs 24.5±11.5 min, $p=0.045$ and 20.5±7.4 vs 15.7±7.1 min, $p=0.004$, respectively). Although the mean operative time for bilateral hernia repair in male patients in LH group was quite less than that in OH group in practical terms, the difference was not statistically significantly (40.6±12.7 vs 43.3±7.9 min, $p=0.608$). The other group differences were also not significantly different.

**Postoperative complications and recurrence**

The OH group had complication rate of 1.9% (4/210) and 0% for recurrence, while those were 2.1% (2/95) and 1% (1/95), respectively, in the LH group ($p=0.681$ and $p=0.311$, respectively). Four cases in the OH group had complications, which were major complications as injury to spermatic element for one case and minor complication as mark swelling from seroma for 3 cases. Wound infection was not found in the OH group. For the LH group, two cases had complications—umbilical wound infection and development of postoperative hydrocele with spontaneous resolution. Recurrence was found in only one case in the LH group, while major complication as injury to the spermatic element was not found. Testicular atrophy was not found at all in both groups. However, there was no significant difference of overall complication and recurrence between the two groups.

**Metachronous IH**

The incidence of MCIH in OH group was 10.9% (25/210), with 82.6% of MCIH occurring within 2 years after the initial side was diagnosed. A review of patient

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**Table 1** Characteristics of data

| Characteristics          | Laparoscopic group (n=95) | Open group (n=210) | P value |
|--------------------------|---------------------------|--------------------|---------|
| Age (years), median (IQR)| 3 (1–5)                   | 3 (1–5)            | 0.856   |
| Male gender, n (%)       | 62 (65.3)                 | 146 (69.5)         | 0.507   |
| Side, n (%)              |                           |                    | 0.444   |
| Right                    | 46 (48.4)                 | 104 (49.5)         |         |
| Left                     | 37 (38.9)                 | 89 (42.4)          |         |
| Bilateral                | 12 (12.6)                 | 17 (8.1)           |         |
| Complications, n (%)     | 2 (2.1)                   | 4 (1.9)            | 0.681   |
| Recurrence, n (%)        | 1 (1.0)                   | 0 (0)              | 0.311   |
| Operative time* (min), mean±SD | 26.6±10.5               | 23.1±11.8          | 0.013   |
| Unilateral herniotomy in male patient | 27.9±9.6                 | 24.5±11.5          | 0.045   |
| Bilateral herniotomy in male patient | 40.6±12.7               | 43.3±7.9           | 0.608   |
| Unilateral herniotomy in female patient | 20.5±7.4                | 15.7±7.1           | 0.004   |
| Bilateral herniotomy in female patient | 25.0±5.7                 | 26.0±6.6           | 0.796   |
| Follow-up time (min), mean±SD | 23.7±0.7                 | 33.1±5.7           | <0.001  |

*Operative time between laparoscopic group and open group after using the inverse probability treatment weighting of propensity score (propensity score created from the probability to choose the method of hernia repair with three parameters: age, sex and bilaterality).
records of MCIH developments 2 years after primary operation found that only female patients were returned to have MCIH repairs. The most likely predictors of developing MCIH were initial presentation with left sided IIH (p=0.007) and female gender (p=0.028). The characteristics of patients in the OH group who had MCIH are shown in Table 2.

Contra lateral pathology

The incidence of CPPV in the LH group was 15.7% (15/95). The incidence of CPPV in patients who had initial presentation with left-sided IIH were found to be significantly higher than those who had right-sided presentation, (25.6% vs 10.9%, p=0.022). The characteristics of the patients in the LH group who had CPPV were shown in Table 3.

DISCUSSION

The standard surgical treatment of IIH in infants and children is to divide and ligate the hernia sac at the internal inguinal ring without narrowing the ring. Open herniotomy has been the standard treatment for decades because it is credited with being easy to perform and as having a high success rate and low rate of complication. However, there has been much debate over the benefits of laparoscopic versus OH repair. Reported advantages of LH repair included excellent visual exposure, minimal dissection, less complications, comparable recurrence rate, and better cosmetic result compared with the traditional open approach. In addition, LH repair also allows CPPV to be defined and repaired in the same operation,25–27 explaining why there was no MCIH in the LH group.

LH repair in children is known to require longer operative time than OH. Many reports showed that it ranged from 20 min to 74 min.10–21 23–25 Regardless, the operative time depends on technique, number of sides, sex and experience. In our study, we used extracorporeal suture ligation with hydrodissection technique, which was mentioned as less time-consuming.15–21 25 However, we found that open surgery took less time than laparoscopic surgery, especially in unilateral herniotomy in both genders. This may be because the surgeon is more proficient in the open technique.

In practice, laparoscopic repair in boys with bilateral disease took a bit shorter operative time than OH, but the difference was not statistically significant. The learning curve of the surgeon might improve the technique and skill and eventually the surgeon could perform laparoscopic herniotomy significantly faster and would have a lower complication rate.

As for recurrence, the previous systemic reviewed studies23 24 reported no significant difference was observed between two techniques, whereas the rates of other complications, such as wound infection, hydrocele and testicular atrophy, were significantly higher in the OH group. In our study, recurrence was found in only one case in the LH group and occurred within 7 months postoperatively. Cause of recurrence was knot disruption. Major complication as injury to spermatic elements occurred only in the OH group, and long-term testicular atrophy was not found. There was no significant difference in overall complication rate between the two groups in our study. However, the accuracy of the result was limited by short follow-up time.

The incidence of contralateral inguinal hernia in chil dren after unilateral repair ranges from 5.8% to 11.6%.6–9 The biggest advantage of LH is to define and repair contralateral pathology while potentially preventing the need for a second operation that minimizes the
chance of incarceration of metachronous contralateral hernia. Before the era of LH repair, surgical management of contralateral groin remained controversial, and there were many studies about prediction of contralateral inguinal hernia in children. Contralateral exploration was a method to diagnose the presence of CPPV, but this technique may lead to spermatic cord injury, testicular atrophy and wound infection. Contralateral laparoscopy could accurately diagnose the presence of CPPV. This study shows that incidence of presence of CPPV in the LH group is about 15% and that incidence of MCH in the OH group is about 10%. However, the actual number of patients with MCH development was unclear. The incidence was determined from medical records in only the cases who revisited for having MCH repairs. Regardless, many studies show that the incidence of developing MCH is lower than that of CPPV. The relationship between presence of CPPV and subsequent development of contralateral inguinal hernia remains unknown, assuming that indirect hernias in adults start with asymptomatic peritoneal protrusion. We found the initial presentation with left-sided hernia to be a risk of presence of CPPV and development of MCH. As regards gender, developing contralateral hernia was found to be significantly higher in females. We may interpret that in terms of preventing of developing a contralateral hernia, female patients who present with initial left-sided hernia are likely to benefit from LH more than other groups. But conversely, performing LH repair in unilateral disease in women may take longer operative time. Although the operative time was statistically different, it showed no more than 5 min in time different in every group, which had no clinical meaning.

Strengths of our study are to use extracorporeal techniques, which are uncomplicated but effective, and to apply equipment that is easy to find in basic operating room, which is feasible with minimal dissection with less complication so that patients in the LH group can have a successful laparoscopic operation without conversion. The study also has several limitations. There was some bias in the study design, and the groups were collected at different times and in different manners (retrospective vs prospective). To allow a reasonable comparison, we use the inverse probability treatment weighting of propensity score. The number of MCH developments especially 2 years after the initial operation was reviewed in OH group from the records of patients who returned to have MCH repairs which maybe inexact. The laparoscopic technique was performed by the same surgeon whose accumulated experience may have caused the one-sided result.

In the era of laparoscopic surgery, many operations have evolved from open technique to laparoscopic technique for a number of advantages. For pediatric hernia surgery, many studies reported that there is little difference in clinical outcomes between the two techniques. LH is still not clearly superior to OH. Therefore, the choice of surgical method depends on many factors, such as cost, endoscopic equipment availability of the hospital, and surgeon’s preference and expertise.

In conclusion, LH may prevent the need for a second operation of metachronous contralateral hernia. Both open and laparoscopic techniques are equivalent in pro and cons.

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REFERENCES

1. Schier F, Danzer E, Bondartschuk M. Incidence of contralateral patent processus vaginalis in children with inguinal hernia. J Pediatr Surg 2001;36:1561–3.
2. Bowling K, Hart N, Cox P, et al. Management of paediatric hernia. BMJ 2017;359:j4484.
3. Owings EP, Georgeson KE. A new technique for laparoscopic exploration to find contralateral patent processus vaginalis. Surg Endosc 2000;14:114–6.
4. Khorana J, Reanpang T, Tepmalai K. Risk factors for contralateral metachronous indirect inguinal hernia in children with unilateral inguinal hernia. Journal of the Medical Association of Thailand 2019;102:pp:997–1002 http://www.jmatonline.com/index.php/jmat
5. Schwöbel MG, Schramm H, Gitzelmann CA. The infantile inguinal hernia – a bilateral disease? Pediatr Surg Int 1999;15:115–8.
6. Tackett LD, Breuer CK, Luks FI, et al. Incidence of contralateral inguinal hernia: a prospective analysis. J Pediatr Surg 1999;34:684–8, discussion 87–8.
7. Wenk K, Sick B, Sasse T, et al. Incidence of metachronous contralateral inguinal hernias in children following unilateral repair - A meta-analysis of prospective studies. J Pediatr Surg 2015;50:2147–54.
8. Hoshino M, Sugito K, Kawashima H, et al. Prediction of contralateral inguinal hernias in children: a prospective study of 357 unilateral inguinal hernias. Hernia 2014;18:333–7.
9. Nairaraja RM, Mahomed AA. Systematic review for paediatric metachronous contralateral inguinal hernia: a decreasing concern. Pediatr Surg Int 2011;27:953–61.

Suttiwongsing A, et al. World Jnl Ped Surg 2022;5:e000436. doi:10.1136/wjps-2022-000436
10 Schier F. Laparoscopic herniorrhaphy in girls. J Pediatr Surg 1998;33:1495–7.
11 Montupet P, Esposito C. Laparoscopic treatment of congenital inguinal hernia in children. J Pediatr Surg 1999;34:420–3.
12 Becmeur F, Philippe P, Lemandat-Schultz A, et al. A continuous series of 96 laparoscopic inguinal hernia repairs in children by a new technique. Surg Endosc 2004;18:1738–41.
13 Yip KF, Tam PKH, Li MKW. Laparoscopic flip-flap hernioplasty: an innovative technique for pediatric hernia surgery. Surg Endosc 2004;18:1126–9.
14 Wheeler AA, Matz ST, Schmidt S, et al. Laparoscopic inguinal hernia repair in children with transperitoneal division of the hernia sac and proximal purse string closure of peritoneum: our modified new approach. Eur J Pediatr Surg 2011;21:381–5.
15 Schier F et al. Laparoscopic Herniorrhaphy. In: Bax KMA, Georgeson KE, Rothenberg SS, eds. Endoscopic surgery in infants and children. 1 ed. Berlin, Heidelberg: Springer, 2008: 577–84.
16 Harrison MR, Lee H, Albanese CT, et al. Subcutaneous endoscopically assisted ligation (SEAL) of the internal ring for repair of inguinal hernias in children: a novel technique. J Pediatr Surg 2005;40:1177–80.
17 Takehara H, Yakabe S, Kameoka K. Laparoscopic percutaneous extraperitoneal closure for inguinal hernia in children: clinical outcome of 972 repairs done in 3 pediatric surgical institutions. J Pediatr Surg 2006;41:1999–2003.
18 Oue T, Kubota A, Okuyama H, et al. Laparoscopic percutaneous extraperitoneal closure (LPEC) method for the exploration and treatment of inguinal hernia in girls. Pediatr Surg Int 2005;21:964–8.
19 Patkowski D, Czernik J, Chrzan R, et al. Percutaneous internal ring suturing: a simple minimally invasive technique for inguinal hernia repair in children. J Laparoendosc Adv Surg Tech A 2006;16:513–7.
20 Shalaby RY, Fawzy M, Soliman SM, et al. A new simplified technique for needleless inguinal herniorrhaphy in children. J Pediatr Surg 2006;41:863–7.
21 Bharathi RS, Arora M, Baskaran V. How we "SEAL" internal ring in pediatric inguinal hernias. Surg Laparosc Endosc Percutan Tech 2008;18:192–4.
22 Endo M, Watanabe T, Nakano M, et al. Laparoscopic completely extraperitoneal repair of inguinal hernia in children: a single-institute experience with 1,257 repairs compared with cut-down herniorrhaphy. Surg Endosc 2009;23:1706–12.
23 Esposito C, St Peter SD, Escolino M, et al. Laparoscopic versus open inguinal hernia repair in pediatric patients: a systematic review. J Laparoendosc Adv Surg Tech A 2014;24:811–8.
24 Feng S, Zhao L, Liao Z, et al. Open versus laparoscopic inguinal hernioplasty in children: a systematic review and meta-analysis focusing on postoperative complications. Surg Laparosc Endosc Percutan Tech 2015;25:275–80.
25 Lee Y, Liang J. Experience with 450 cases of micro-laparoscopic hernioplasty in infants and children. Pediatric Endosurgery & Innovative Techniques 2002;6:25–8.
26 Schier F. Laparoscopic surgery of inguinal hernias in children-initial experience. J Pediatr Surg 2000;35:1331–5.
27 Schier F, Montupet P, Esposito C. Laparoscopic inguinal herniorrhaphy in children: a three-center experience with 933 repairs. J Pediatr Surg 2002;37:398–7.
28 Niyogi A, Tahim AS, Sherwood WJ, et al. A comparative study examining open inguinal herniotomy with and without hernioscopy to laparoscopic inguinal hernia repair in a pediatric population. Pediatr Surg Int 2010;26:387–92.
29 Oberg S, Andresen K, Rosenberg J. Etiology of inguinal hernias: a comprehensive review. Front Surg 2017;4:52.
30 Holcomb GW, Miller KA, Chaignaud BE, et al. The parental perspective regarding the contralateral inguinal region in a child with a known unilateral inguinal hernia. J Pediatr Surg 2004;39:480–2.
31 Mittenburg DM, Nuchtern JG, Jaksic T, et al. Laparoscopic evaluation of the pediatric inguinal hernia—a meta-analysis. J Pediatr Surg 1998;33:874–9.
32 van Wessem KJP, Simons MP, Plaisier PW, et al. The etiology of indirect inguinal hernias: congenital and/or acquired? Hernia 2003;7:76–9.
33 Thumbe VK, Evans DS. To repair or not to repair incidental defects found on laparoscopic repair of groin hernia: early results of a randomized control trial. Surg Endosc 2001;15:47–9.