

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

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To cite: Suttiwongsing A, Khorana J, Ruangwongroj P, et al. Laparoscopic extraperitoneal technique versus open inguinal herniotomy in children: historical controlled intervention study. *World Jnl Ped Surgery* 2022;5:e000436. doi:10.1136/wjps-2022-000436

Received 14 April 2022
Accepted 4 July 2022



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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 herniotomy (LH group), and 210 cases underwent conventional open herniotomy (OH group). In terms of operative time, only unilateral herniotomy in females of the OH group was significantly less than that of the LH group (15.7 ± 7.1 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 herniotomy 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

WHAT IS ALREADY KNOWN ON THIS TOPIC?

- ⇒ Many advantages of laparoscopic hernia repair were reported, and the greatest benefit of laparoscopy was to diagnose the presence of contralateral patent processus vaginalis accurately and then conduct repair in the same operation.
- ⇒ Laparoscopic surgery is known to be more costly due to the nature of the limited budget hospital; thus, is it worth doing laparoscopic surgery in pediatric hernia repair?

WHAT THIS STUDY ADDS

- ⇒ The overall results of laparoscopic and conventional open hernia repair technique are equivalent. Both are good either way.
- ⇒ Most metachronous contralateral inguinal hernias occurred in the first 2 years after initial operation.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ These results may help clinicians to provide information on surgical options for pediatric hernia repair and on a proper postoperative follow-up time for herniotomy.

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.⁵⁻⁹ 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 IIH with undescended testis, irreducible incarcerated IIH and strangulated IIH. 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 all patients had received an endotracheal tube. Prophylaxis antibiotic was not given, and postoperative pain was controlled by oral paracetamol.

The OH group was performed by the lowest skin crease incision approximately 1 inch in size, then high ligation of hernia sac using 3/0 silk suture; the distal sac was divided or excised; then the wound was closed in layer using absorbable suture.

The LH group was performed by laparoscopic extraperitoneal hernia repair technique. A 5 mm camera was inserted into the abdomen by open technique via an umbilical port. Pneumoperitoneum was established at 8 mm Hg pressure. A 3 mm Maryland forceps was inserted into the mid-lower abdomen without a trocar for holding the tip of a suture. A stab incision was made above the internal ring. An epidural needle was inserted via the stab incision. First, the needle was medially advanced beneath the peritoneum, in front of the spermatic vessels and vas deferens while injecting 0.9% sodium chloride solution

to separate them from each other. A 3/0 PROLENE was inserted into the peritoneal cavity via the epidural needle. The needle was withdrawn backward and reinserted laterally beneath the peritoneum to encircle the hernia sac. A Prolene loop was inserted via the epidural needle to take the tip of the previously inserted PROLENE out the peritoneal cavity to perform a complete purse-string ring. A knot was made extraperitoneally. Before tightening the knot, the scrotum and inguinal canal were squeezed, then intraperitoneal pressure was released. CPPV was evaluated in all patients, and if it had been patent, it would be repaired at the same time. The umbilical defect was repaired by using 3/0 Vicryl suture, and the skin was closed with Steri-Strip. Open technique operations were done by two pediatric surgeons and residents, whereas all laparoscopic operations were made by a single pediatric surgeon.

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, 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.

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 al.*²² 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

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).

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 IIH

The incidence of MCIH in OH group was 10.9% (23/210), with 82.6% of MCIH occurring within 2 years after the initial side was diagnosed. A review of patient

Table 2 Development of MCIH in open group

Characteristics	Patients	Development of MCIH within 2 year	Development of MCIH total	Incidence of total MCIH (%)	P value
Gender					
Male	146	11	11	7.5	0.028
Female	64	8	12	18.8	
Initial side					
Right	104	6	6	5.8	0.007
Left	89	13	17	19.1	

MCIH, metachronous contralateral inguinal hernia.

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 IHH ($p=0.007$) and female gender ($p=0.028$). The characteristics of patients in the OH group who had MCIH are shown in [table 2](#).

Contralateral 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 IHH 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 IHH 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 studies^{23 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 children 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

Table 3 Presence of contralateral patent of processus vaginalis in laparoscopic group

Characteristics	Patients	Presence of contralateral patent of processus vaginalis	Incidence (%)	P value
Sex				
Male	62	10	16.1	1.000
Female	33	5	15.2	
Initial side				
Right	46	5	10.9	0.022
Left	39	10	25.6	

chance of incarceration of metachronous contralateral hernia.^{4 10-21 23-28}

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.^{1 2 5-9 29} 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 MCIH in the OH group is about 10%. However, the actual number of patients with MCIH development was unclear. The incidence was determined from medical records in only the cases who revisited for having MCIH repairs.

Regardless, many studies show that the incidence of developing MCIH is lower than that of CPPV.^{1 3 30 31} 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.^{32 33}

We found the initial presentation with left-sided hernia to be a risk of presence of CPPV and development of MCIH. 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 difference 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 MCIH developments especially 2 years after the initial operation was reviewed in OH group from the records of patients who returned to have MCIH 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^{23 24 28} 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.

Acknowledgements The authors acknowledge the Clinical Research Center, Chiangrai Prachanukroh Hospital, Thailand, which supported the research conduct and funding. We also acknowledge the pediatric surgery unit, anesthesiology department and all pediatric nursing unit, Chiangrai Prachanukroh Hospital, which supported our patients and protocols.

Contributors AS contributed to conceptualization, methodology, resources, data curation, validation, formal analysis, data curation, software, investigation, writing (review), writing (original draft), project administration and editing and responsible for the overall content as the guarantor. PR contributed to formal analysis. KN contributed to the formal analysis and editing. JK contributed to writing (review), supervision and editing. All authors in the article contributed and approved the submission of the article.

Funding The Clinical Research Center, Chiangrai Prachanukroh Hospital, Thailand, supported the research conduction and funding (grant number of CR.0032.102/Research/008).

Competing interests None declared.

Patient consent for publication Written informed consent forms were taken from the parents of each participating child.

Ethics approval This study involves human participants and was approved by the ethical committee for research in human subjects of Chiangrai Prachanukroh Hospital (approval number: EC CRH 0038/62 In).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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