

Modified 2-port laparoscopic herniorrhaphy with Kirschner wire in children

A retrospective review

Zhiqing Cao, MD^{a,b}, Jiangyi Chen, MD^a, Zhixiong Li, MD^a, Guoxin Li, MD^{a,*}

Abstract

Background: Pediatric inguinal hernia is one of the most common diseases in children, and laparoscopy is the main surgical method. This study aims to evaluate the efficacy of a new modified 2-port laparoscopic herniorrhaphy with Kirschner wire (TLHK) for inguinal hernia in children.

Methods: A total of 5304 children with inguinal hernia hospitalized at the Jiangmen Center Hospital from June 2003 to May 2016 were enrolled in this retrospective study. Four thousand one hundred thirty-five children underwent TLHK that comprised the observation group, while 1169 received single incision laparoscopy (SIL) as the control group (CG). A propensity score matched cohort study was conducted between these groups. We included all patients who were diagnosed as inguinal hernia and matched comparators with a proportion of 1:1. The propensity score was calculated using logistic regression with forward stepwise selection in 4 variables. The patients' operative details, intra- and postoperative complications, and postoperative hospital stay were analyzed. The follow-up lasted from 1 month to 2 years.

Results: Among 5304 potential patients, the propensity score identified 270 (135 TLHK cases and 135 comparators) patients. The age, sex, body mass index, and the hernia type and location did not differ between CG and TLHK. TLHK group had a shorter operative time (unilateral: 17.4 ± 3.35 minutes vs 20.7 ± 3.71 minutes; bilateral: 20.4 ± 5.17 minutes vs 25.2 ± 5.43 minutes), less complications (2.10% vs 2.65%), lower recurrence rate (0% vs 4.44%), and similar hospital stay (2.3 ± 1.1 vs 2.1 ± 1.3) as compared with CG. No iliac vessel injury, spermatic cord vessels injury, vas deferens injury, or iatrogenic cryptorchidism occurred in either of the groups.

Conclusion: TLHK is a safe and feasible treatment for inguinal hernia in children due to less invasion and less recurrence rate than SIL.

Abbreviations: BMI = body mass index, CG = control group, CL = conventional laparoscopic hernia repair, HS = hospital stay, IH = inguinal hernia, OT = operative time, SIL = single incision laparoscopy, TLHK = 2-port laparoscopic herniorrhaphy with Kirschner wire, TP = two ports.

Keywords: bone wires, herniorrhaphy, laparoscopy

1. Introduction

An inguinal hernia (IH) is one of the most common diseases in pediatrics with approximately 1% to 4% incidences.^[1] With the development in technology, several medical centers adopted laparoscopic hernia repair in children as the best option for herniorrhaphy, replacing the open procedure due to minimal invasiveness and better cosmetic effect.^[2–7] Three types of

laparoscopic approaches are available for hernia repair, 3 ports (conventional laparoscopic hernia repair, CL), 2 ports (TP), and single incision (SIL). CL commonly requires 3 working ports ranging from 3 to 5 mm, and each increasing port might be associated with increasing morbidity and pain.^[8] SIL uses only one incision in the umbilical and has an invisible scar after the operation; however, the difficult ergonomics of the single incision instruments necessitates that the operation is performed by an experienced surgeon. Moreover, complete sealing of the large internal rings using only one instrument is challenging, thereby causing a high rate of recurrence. Some reports indicate the increase in port-site herniation following SIL, which impedes its wide applicability.^[9–12] TP follows the trend of minimizing the invasiveness without encompassing the challenges of SIL. Basu et al^[13] studied 40 patients with a 6-month follow-up and reported that TP had advantages of comparable operative times to CL, few postoperative complications, and no recurrences. Thus, presently, TP is becoming a widespread technique for herniorrhaphy.

The pathogenesis of inguinal hernia is the failure of procedures such as vaginalis closure as the treatment principle states the high ligation of hernia sac.^[14] Nowadays, there are 2 approaches to close the internal ring of hernia: intraperitoneal suturing and extraperitoneal suturing.^[15] The intraperitoneal suturing uses a small circular needle to close the internal ring,^[9] while the

Editor: Qinhong Zhang.

No competing financial interests exist.

^a Department of General Surgery, Nanfang Hospital, Southern Medical University, Guangzhou, ^b Department of Pediatric Surgery, Huangshi Maternity and Children's Health Hospital of Edong Healthcare Group, Huangshi, Hubei, P.R. China.

* Correspondence: Guoxin Li, 1838# Guangzhou Avenue North, Guangzhou, Guangdong Province, P.R. China (e-mail: gzliguoxin@163.com).

Copyright © 2018 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

Medicine (2018) 97:42(e12790)

Received: 5 January 2018 / Accepted: 13 September 2018

<http://dx.doi.org/10.1097/MD.00000000000012790>

extra-abdominal suturing uses hernia needle to perform the operation percutaneously.^[16] Although the superiority of the approaches is yet controversial, a majority of the junior surgeons prefer to close the internal ring extraperitoneally due to convenience and safety.^[17] According to previous reports, Reverdin needle, Endoclose needle, or tap needle were utilized frequently to suture the inner ring defect; however, they were extremely sharp and were required to puncture the abdomen 2 times, which might traumatize the peritoneal organs such as the spermatic cord, vas deferens, vessels, or intestines.^[18–20] On the other hand, the double-hook needle was too thick for children,^[21] and also, they were expensive in China. Therefore, our center reformed the Kirschner wire, which was widely used in orthopedics as self-made hernia needle; it was 1.2 mm in width and had a modified tip (puncture a tiny hole at the tip, Fig. 1A). Consecutively, we modified the TLHK, since 2003, in children. The present retrospective study aimed to evaluate the technical feasibility, safety, and outcomes of this approach versus SIL.

2. Patients and methods

2.1. Study design

This study was approved by the Ethics Committee of the Jiangmen Center Hospital, Guangdong, China. The retrospective study was conducted at the Pediatric Surgery Department from June 2003 to May 2016. The patients' characteristics including age, sex, body mass index (BMI), operative time (OT), intra- and postoperative complications, and postoperative hospital stay (HS) were assimilated from the medical history and telephonic follow-up.

The inclusion criteria were as follows: age <14 years; $17.6 \leq \text{BMI} \leq 25.2$; the inguinal hernia was diagnosed by ultrasound or other clinical examinations. The exclusion criteria included: age >14 years; $\text{BMI} < 17.6$ or $\text{BMI} > 25.2$; direct hernia; other diseases in addition to hernia that may affect the operation, such as hydrocele and cryptorchidism.

It was expected that participating center would treat over 400 eligible patients per year of inguinal hernia. Based on our previous investigation, the recruitment of patients for enrollment into study was expected to be 80% of the eligible patients seen.

The sample size for this study was determined using the G*Power program (Faul, Erdfelder, Lang, & Buchner, 2007), in which we used chi-squared tests—goodness-of-fit tests: contingency tables with effect size of 0.305, α err prob of 0.05, power 80%, and resulted in 104 per group. After adding the 10% drop rate, the study required 115 patients. Therefore, considering the both groups, this study required 230 patients at least.

TLHK was offered as a first-line treatment for all patients over the study duration. Patients whose hernia ring defect diameter was <1 cm, no other accompanied diseases, and their parents permitted SIL, formed the control group (CG). Every patient and parent have free will to choose the operation method for the inguinal hernia. All patients signed informed consent and acquired the advantages and limitations of these procedures.

2.2. Surgical technique

For TLHK, the surgeon stood on the left side of the patient with inguinal hernia, and the camera assistant stood on the right side. The patient was placed in a supine position, the buttock was bolstered up and tilted 15° with feet-down position and general endotracheal anesthesia was administered for muscle relaxation. Pneumoperitoneum was established by introducing a 3 or 5 mm trocar through a transverse incision at the infraumbilical position, and the abdomen was insufflated to 6 to 12 mmHg with a gas flow rate of 1 to 4 L/min based on the patient's age. The 30° lens was introduced through the first trocar to allow a direct in-line view of the internal ring and hernia on both sides. Then, a second 3 mm trocar was placed at the intersection of the left or right lateral of rectus abdominis and umbilical level, and a 2 mm grasper is advanced through this port for manipulating the peritoneum at the internal ring and the hernia. The modified Kirschner wire with a single 2 to 0 non-absorbable suture was introduced vertically through the eyelet at the surface projection of the internal ring to the preperitoneal space (Fig. 1B); the ilioinguinal nerve, as well as the penetration of the peritoneum, was avoided. With the help of 2 mm grasper traction on the peritoneum, the interior to medial incision along the border of the hernia sac was fashioned, and the Kirschner wire easily traversed the vas deferens and spermatic cord vessels simultaneously (Fig. 2A). The peritoneum was pierced medially by the wire

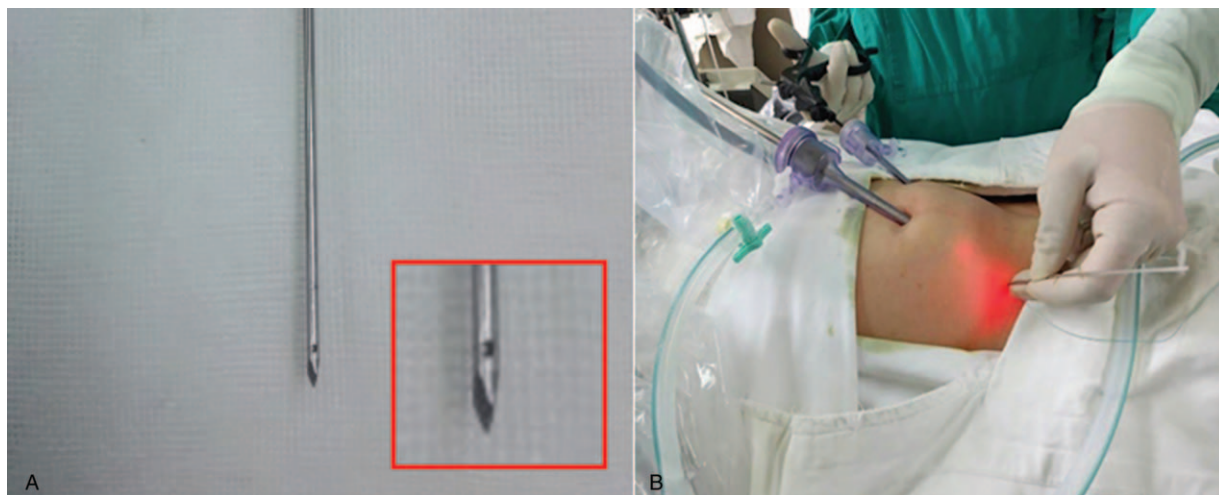


Figure 1. Overview of TLHK. A: The modified Kirschner wire with a tiny hole at the tip. B: 5 mm trocar was inserted through umbilical to settle laparoscopy. 3 mm forceps were placed at the intersection of the left lateral of rectus abdominis and umbilical level. TLHK=2-port laparoscopic herniorrhaphy with Kirschner wire.

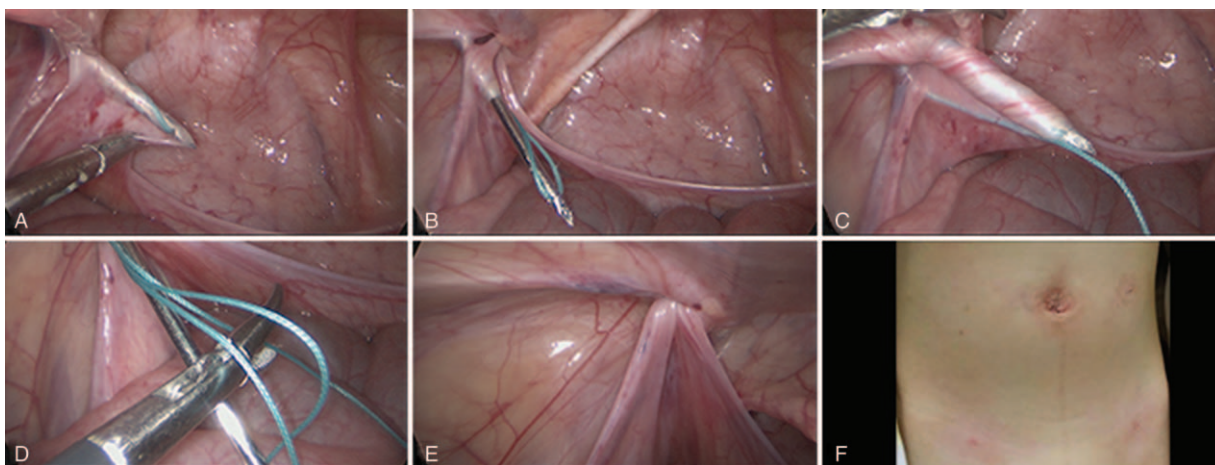


Figure 2. The laparoscopic procedure of TLHK. A: The Kirschner wire traversed the vas deferens and spermatic cord vessels simultaneously with the help of 2 mm forceps. B: The Kirschner wire pierced the peritoneum with a double strand non-absorbable suture. C: Place the single strand thread beneath the inner-half part of the internal ring by Kirschner wire. D: Put the single strand thread into the loop at the end of the Kirschner wire by the assistance of 2 mm grasper. E: Closure of the internal ring of inguinal hernia. F: The post operation appearance of TLHK. TLHK=2-port laparoscopic herniorrhaphy with Kirschner wire.

(Fig. 2B), and the ligature end was left intraperitoneally with the other end outside the abdomen (Fig. 2C). Then, the wire was withdrawn to the extraperitoneal that directly underneath the puncture site, try not to draw out the wire out of body. Subsequently, the wire was sneaking along the lateral side of the internal ring passed the spermatic cord vessels piercing the peritoneum where the ligature was left previously. The end of the ligature was placed through the loops at the tip of the Kirschner wire using a 2 mm grasper (Fig. 2D), following which, the ligature end was pulled out by withdrawing the wire, and the hernia sac was high ligated extraperitoneally by tying the ligature tightly (a minimum of 5 knots; Fig. 2E); the knots were buried subcutaneously. If a hernia was present contralaterally, it was repaired simultaneously. Finally, all the instruments were removed, the abdomen desufflated (Fig. 2F), and the adhesive paper strips were used to cover the incisions.

For the SIL, the following procedure was performed using a modified version of the method developed by Takehara et al.^[22] Through a 5 mm vertical transumbilical incision, a 5 mm 30° lens was placed. A 3 mm port for a 2 mm grasping forceps was inserted in the middle of the lower abdomen and through the same umbilical incision with a different entrance. Briefly, the modified Kirschner wire with a single 2 to 0 non-absorbable suture was inserted vertically at the surface projection of the internal ring to the preperitoneal space. The Kirschner wire was used with the aid of the forceps, and the hernia sac was closed extraperitoneally utilizing circuit suturing without any peritoneal gap. The detail procedures of the Kirschner wire were similar to that of TLHK, avoiding the crashing between the forceps and the lens.

All operations were performed by the senior attending physicians under the directions of the Department of Pediatric Surgery department; a senior resident operated the camera.

2.3. Follow-up

All patients were discharged when they gained consciousness from general anesthesia and did not experience any pain around the wound. Adequate rest and no exhausting activities were

advised to the patients. They were followed up in the outpatient clinic after 2 weeks, 1 month, 3 months, 6 months, 1 year, and 2 years. The parents were advised to contact the department of pediatric surgery with respect to any concerns arising in the immediate postoperative period.

2.4. Data collection and statistical analysis

First, we calculated the propensity score for having inguinal hernia using stepwise forward selection with a significance level for removal from the model of 0.1 and for entry of 0.05. Then, we matched cases to the closest comparators at a proportion of 1:1 based on the propensity score while allowing for replacement. After matching, patients' baseline characteristics, such as sex, age, BMI, and so on among the selected cases and comparators were compared. OT, intra-, and postoperative complications (including vas deferens injury, iliac vessel injury, peritoneal tear, omentum majus out, wound infection, intestinal adhesion, thread residue reaction, thread residue palpable, orchiatrophy, iatrogenic cryptorchidism), recurrence rate, and postoperative hospital stay were collected from all selected children via their medical history and telephonic follow-up. The time of needle passage through vas deferens and spermatic cord vessels was also recorded for assessing the difficulty of the operation. The collective data were organized, tabulated, and statistically analyzed using the Statistical Package for Social Science (SPSS) (SPSS Inc; IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). The quantitative data were presented as mean \pm standard deviation ($\bar{x} \pm SD$), and analyzed between groups by Student *t* test for 2 groups. The qualitative data, frequency, and percent distribution were compared between the groups using chi-square test, and Fisher exact test would be employed if any of the expected values in the groups were under 5. *P* < .05 was considered statistically significant.

3. Results

A total of 5304 children underwent hernia repair successfully; 4135 received TLHK, 1169 underwent SIL. Any significant

Table 1
Demographic data for the 2 groups.

	TLHK (N=135)	CG (N=135)	χ^2	P-value	Total (N=270)
Age, y (SD)	2.7 (1.32)	2.8 (1.24)	0.642	.552	2.7 (1.28)
BMI (SD)	19.3 (3.2)	19.8 (3.4)	1.244	.214	19.5 (3.3)
Sex					
Male (%)	81 (60.0)	85 (63.0)	0.141	.708	166 (61.5)
Female (%)	54 (40.0)	50 (37.0)			104 (38.5)
Presentation					
Unilateral (%)	102 (75.2)	99 (73.6)	0.078	.780	201 (74.4)
Bilateral (%)	33 (24.8)	36 (26.4)			69 (25.6)
Incarceration (%)	17 (12.6)	14 (10.4)	0.146	.703	31 (11.5)

BMI = body mass index, CG = control group, SD = standard deviation, TLHK = modified 2-port laparoscopic herniorrhaphy with Kirschner wire.

difference was not observed with respect to age ($P = .552$), sex ($P = .708$), BMI ($P = .214$), or hernia presentation ($P = .780$) between the TLHK groups and CG (Table 1).

In TLHK, the mean OT was 17.4 ± 3.35 minutes for a unilateral hernia and 20.4 ± 5.17 minutes for bilateral hernias, which was defined from the beginning of cleaning the operative field to closing the incision and was found to be significantly shorter than CG ($P < .001$). During the operation, the duration that the tip of Kirschner wire passed the sperm duct was 8.2 ± 1.27 seconds in TLHK, which was significantly shorter than that in CG (11.3 ± 1.45 seconds, $P < .001$), similar to the time that the needle passed the spermatic cord vessels (11.3 ± 4.65 seconds vs 25.7 ± 4.83 seconds, $P < .001$) (Table 2).

For the intraoperative complications, vas deferens and iliac vessel injuries were avoided in both procedures. The peritoneal tear did not occur in TLHK group, which was significantly less than that in CG ($P = .012$). Omentum majus out occurred in 1 patient because of the 5 mm trocar port placed on the abdomen. Later all the patients were provided "8" sutures at the trocar port and no more happened, besides, the incidence rate was not significant in CG. The thread residue reaction occurred in 3 cases, and all of them were cured after resection of the thread residue. Four children could feel the thread residue beneath the abdominal skin since most of them were thin; thus, a boosting nutrition was advised. There were no hernia recurrences noted in boys within 2 years postoperatively, the recurrence rate of TLHK was significant less than CG ($P = .039$). The recurrent case had large hernia sac and internal ring; all of them underwent a reoperation, following which, no recurrences were observed. The mean hospital stay was 2.3 ± 0.42 days after the operation in the TLHK groups, which was similar with CG ($P = .174$) (Table 3). Based on the follow-up of >6 months, the early cosmetic results in the TLHK and CG were excellent.

4. Discussion

This retrospective study described our initial experience of inguinal hernia repair using TLHK in children. Through extensive clinical data survey (reached total 5304 cases in 13 years period) and follow-up, TLHK technique was ascribed advantages such as shorter operative time, quicker intraperitoneal procedure, less recurrence, and satisfactory cosmetic outcomes as compared with SIL herniorrhaphy.

Although the conventional approach for an inguinal hernia is open repair, this technique has several limitations: the dissection of the cord structures is difficult, and the repair of the hernia sac is challenging.^[2,3] Moreover, the inspection of the contents of hernia sac after reduction is extremely difficult, especially in infants, even for the most experienced pediatric surgeon. In addition, open repair of incarcerated inguinal hernia is associated with severe complications.^[24] The laparoscopic high ligation of inguinal hernia did not require the dissection of the cord structures as from the high-resolution lens; the surgeons could visualize the spermatic cord and the sac contents simultaneously. In this study, 660 incarcerated hernia underwent laparoscopic herniorrhaphy, and none of them exhibited serious complications intra- and postoperatively. Owing to these advantages, we adopted the laparoscopic approach as the first-line operation for hernia repair.

The OT is a crucial factor associated with the postoperative complications,^[25] and a shortened OT could provide better outcomes in patients; however, it faces some obstacles including the difficulties when the hernia needle passes the vas deferens and vessels during the operation. Many surgeons and researchers modified the operation, such as dissection of the vas deferens and vessels by injection saline through a modified hernia needle.^[26] Chan and Tam^[27] injected the saline percutaneously for dissecting vas deferens and vessels; subsequently, the pouch

Table 2
Distribution of studied groups according to time spent in operation.

	TLHK (N=135)	CG (N=135)	t	P-value
OT (unilateral)/min, (SD)	17.4 (3.35)	20.7 (3.71)	7.903	<.001***
OT (bilateral)/min, (SD)	20.4 (5.17)	25.2 (5.43)	7.439	<.001***
Needle passes the sperm duct/s, (SD)	8.2 (1.27)	11.3 (1.45)	18.686	<.001***
Needle passes the spermatic cord vessels/s, (SD)	11.3 (4.65)	25.7 (4.83)	24.955	<.001***

CG = control group, OT = operative time, SD = standard deviation, TLHK = modified 2-port laparoscopic herniorrhaphy with Kirschner wire.

*Significant.

*** $P < .001$.

Table 3**The intra- and postoperative complication of TLHK and control groups.**

	TLHK (N = 135)	CG (N = 135)	χ^2/t	P value	Total (N = 270)
Vas deferens injury, (%)	0 (0)	0 (0)	—	1	0 (0)
Iliac vessel injury, (%)	0 (0)	0 (0)	—	1	0 (0)
Peritoneal tear, (%)	0 (0)	8 (5.92)	6.312	.012*	8 (2.96)
Omentum majus out, (%)	1 (0.74)	0 (0)	<0.001	1	1 (0.37)
Wound infection, (%)	0 (0)	0 (0)	—	1	0 (0)
Recurrence, (%)	0 (0)	6 (4.44)	4.216	.039*	6 (4.44)
Intestinal adhesion, (%)	2 (1.48)	3 (2.22)	<0.001	.999	5 (1.85)
Thread residue reaction, (%)	3 (2.22)	1 (0.74)	0.254	.614	17 (12.59)
Thread residue palpable, (%)	4 (2.96)	2 (1.48)	0.170	.680	6 (4.44)
Orchiatrophy, (%)	0 (0)	0 (0)	—	1	0 (0)
Iatrogenic cryptorchidism, (%)	0 (0)	0 (0)	—	1	0 (0)
Visible scars, (%)	4 (2.96)	1 (0.74)	0.815	.367	5 (1.85)
Hospital stay (postoperation)/d, (SD)	2.3 (1.1)	2.1 (1.3)	1.365	.174	2.2 (1.2)

CG=control group, SD=standard deviation, TLHK=modified 2-port laparoscopic herniorrhaphy with Kirschner wire.

* Significant.

suturing of the internal ring is carried out laparoscopically. The above 2 methods could easily avoid injuring the vas deferens and spermatic cord vessels; however, the extraperitoneal gap created by injecting the saline was invisible. In some rare cases, the duct and vessels adhered to the peritoneum could not be isolated completely; these were at risk when the hernia needle passed the vas deferens and vessels. Thus, we utilized 2 ports that avoided the crash between the forceps and the laparoscopy, thereby reducing the difficulty of the procedures. Moreover, the conventional hernia needle was substituted by the modified Kirschner wire owing to its appropriate sharpness at the tip that would allow easy passage through the vas deferens and vessels extraperitoneally in 10 seconds without injecting saline (Fig. 2A). It is specifically advantageous in infants with loose peritoneum or vast hernia, wherein the peritoneum is flattened, clearly revealing the underneath duct and vessels. With the help of flexible forceps, the Kirschner wire is not sufficiently sharp to injure the intestines, nerves, and the surrounding vessels, thereby rendering the repair of hernia as safe. Nowadays, minimally invasive surgery is developed for cosmetic aesthetics and rapid recovery.^[28] Thus, is SIL superior to 2 ports laparoscopy? In this study, we revealed that the OT, the time that Kirschner wire passed vas deferens and spermatic cord vessels in 2-port laparoscopy were significantly shorter than the single incision for the same skilled surgeon; however, the single incision laparoscopy needs an exceptionally skilled surgeon. Furthermore, the needle tip was invisible while passage through the vas deferens and vessels extraperitoneally, thereby increasing the risk of injury. The single incision laparoscopy needs sufficient operating room inner the abdomen; thus, the high pressure of pneumoperitoneum might affect the respiratory system.^[29,30] For an enhanced cosmetic look of the 2-port laparoscopy, the infra-umbilical incision and 3 mm scars near the umbilical were made nearly invisible with the help of topical skin adhesive to avoid suturing.

The postoperative wound infection is also associated with open surgery.^[31,32] In our study, none of the patients who underwent laparoscopic hernia repair experienced surgical site infection. This phenomenon might be attributed to the short length of the wound in TLHK and SIL, as well as, the short operative time of the laparoscopic procedure.

The conventional laparoscopic hernia sac high ligation using percutaneous needle leaves palpable thread residue, especially in thin patients. This might be partially due to the following reasons:

when we pierced the same skin incision for internal orifice ligation, the routes of the needle reaching the peritoneum were different. Thus, several subcutaneous adipose tissues and muscles tied in the knot rendered it loose, consequently leading to the opening of the internal ring resulting in recurrence. During the preliminary stages of laparoscopic herniorrhaphy, 2 or 3 recurrences occurred annually. Later, we adopted the method of withdrawing the Kirschner wire to the peritoneum and then sneaking extraperitoneally, suturing the rest half of internal ring, which guaranteed the uniqueness of the route from the skin to the peritoneum. Therefore, no subcutaneous tissue and muscles were tied in the knots, and the knots could hide deeper underneath the skin; hardly palpable, and sufficiently tight to avoid recurrence. In this study, the recurrence rate of TLHK was zero, which is less than SIL.

In the case of some recurrence patients with a huge internal orifice, researchers speculated that these were accompanied by loose transversalis fascia and thin obliquus externus abdominis. Thus, several surgeons prefer a “8” shape suturing after pouch suturing in order to strengthen the transversalis fascia.^[2] In our experience of huge hernia, the transversalis fascia was observed after suturing the internal ring. If the fascia is still loose, an “8” shape suture was performed as an additional procedure, which was rather feasible in the TLHK procedure.

Previously, ordinary silk thread was used for ligation in the early stage of laparoscopic herniorrhaphy, which led to the thread residue reaction occasionally, resulting in recurrence.^[33] In our study, 2 boys who received TLHK developed the thread residue reaction on the grown skin 1-month postoperation, which subsequently led to recurrence. Both underwent a reoperation using TLHK; the internal ring was found open. Then, a 2 to 0 non-absorbable braided thread of Polyester (coated) was utilized for ligation, and the thread residue reaction did not recur.

The initial application of the laparoscopic inguinal hernia ligation in 28 girls was reported by El-Gohary in 1997.^[34] Since then, a growing number of laparoscopic inguinal hernia repair techniques have been described, Montupet and Esposito^[33] reported 129 cases of tri-port laparoscopic herniorrhaphy with interrupted sutures in 2000. The study selected girls initially and gradually performed on boys. In an analogous approach, our center firstly carried out the laparoscopic hernia sac high ligation in 2003; the maximum patients were girls owing to the speculation about vas deferens and iliac vessels trauma. Initially, in TLHK, it was difficult to pass the vas deferens and spermatic

cord vessels, thus, we skipped stitching in order to avoid injury. However, after 1 to 2 years, we could complete the purse-string suturing of internal ring extraperitoneally. Since 2016, we employed the 3 mm lens for the laparoscopy, which minimizes the umbilical incision. Furthermore, we carried out the 2-port strategy through single umbilical incision laparoscopy, simultaneously, resulting in satisfactory cosmetic outcome postoperation; however, due to the lack of a sufficient number of cases, it is not discussed in the present article.

Importantly, in the present study, 3 main drawbacks have been identified. Firstly, the huge differences in the patient numbers among the 2 groups might compromise the statistical power. Secondly, the data collected from only 1 institution is insufficient for a persuasive significant power. Thirdly, no other kinds of hernia needle were used as controls to prove the advanced TLHK.

In conclusion, TLHK is a safe and minimally invasive procedure that was approved by the extensive case survey. It could overcome the difficulty of hernia needle passage over the vas deferens and spermatic cord vessels. Moreover, no thread residue palpable at the skin of internal ring was observed, and no vas deferens and spermatic cord were injured. According to our experiences, TLHK should be taken into consideration as an alternative technique.

Author contributions

Conceptualization: Zhiqing Cao, Guoxin Li.

Data curation: Zhixiong Li.

Formal analysis: Jiangyi Chen, Zhixiong Li.

Investigation: Zhiqing Cao, Zhixiong Li.

Methodology: Zhiqing Cao, Guoxin Li.

Resources: Jiangyi Chen, Zhixiong Li.

Supervision: Guoxin Li.

Writing – original draft: Zhiqing Cao.

Writing – review & editing: Guoxin Li.

References

- Mollen KP, Kane TD. Inguinal hernia: what we have learned from laparoscopic evaluation of the contralateral side. *Curr Opin Pediatr* 2007;19:344–8.
- Yildiz A, Celebi S, Akin M, et al. Laparoscopic herniorrhaphy: a better approach for recurrent hernia in boys? *Pediatr Surg Int* 2012;28:449–53.
- Gorsler CM, Schier F. Laparoscopic herniorrhaphy in children. *Surg Endosc* 2003;17:571–3.
- Schier F. Laparoscopic inguinal hernia repair—a prospective personal series of 542 children. *J Pediatr Surg* 2006;41:1081–4.
- Schier F. Laparoscopic surgery of inguinal hernias in children—initial experience. *J Pediatr Surg* 2000;35:1331–5.
- Shah R, Arlikar J, Dhende N. Incise, dissect, excise and suture technique of laparoscopic repair of paediatric male inguinal hernia. *J Minim Access Surg* 2013;9:72–5.
- Yang C, Zhang H, Pu J, et al. Laparoscopic vs open herniorrhaphy in the management of pediatric inguinal hernia: a systemic review and meta-analysis. *J Pediatr Surg* 2011;46:1824–34.
- Takata MC, Duh QY. Laparoscopic inguinal hernia repair. *Surg Clin North Am* 2008;88:157–78. x.
- Zhou X, Song D, Miao Q, et al. Transumbilical endoscopic surgery for completely enclosing inguinal hernias in children. *J Pediatr Surg* 2011;46:2417–20.
- Lopez-Cano M, Pereira JA, Mojal S, et al. An ergonomic study of single-port versus multi-port laparoscopic mesh insertion for ventral hernia repair. *Eur Surg Res* 2012;49:107–12.
- Agaba EA, Rainville H, Ikedilo O, et al. Incidence of port-site incisional hernia after single-incision laparoscopic surgery. *JSLs* 2014;18:204–10.
- Yang GP, Tung KL. A comparative study of single incision versus conventional laparoscopic inguinal hernia repair. *Hernia* 2015;19:401–5.
- Basu S, Chandran S, Somers SS, et al. Cost-effective laparoscopic TEP inguinal hernia repair: the Portsmouth technique. *Hernia* 2005;9:363–7.
- 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.
- 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.
- Li B, Nie X, Xie H, et al. Modified single-port laparoscopic herniorrhaphy for pediatric inguinal hernias: based on 1,107 cases in China. *Surg Endosc* 2012;26:3663–8.
- Lukong CS. Surgical techniques of laparoscopic inguinal hernia repair in childhood: a critical appraisal. *J Surg Tech Case Rep* 2012;4:1–5.
- Peng Y, Li C, Han Z, et al. Modified single-port vs two-port laparoscopic herniorrhaphy for children with concealed deferent duct: a retrospective study from a single institution. *Hernia* 2017;21:435–41.
- Shalaby R, Shams AM, Mohamed S, et al. Two-trocar needlescopic approach to incarcerated inguinal hernia in children. *J Pediatr Surg* 2007;42:1259–62.
- Shalaby R, Ibrahim R, Shahin M, et al. Laparoscopic hernia repair versus open herniotomy in children: a controlled randomized study. *Minim Invasive Surg* 2012;2012:484135.
- Li S, Liu L, Li M. Single-port laparoscopic percutaneous extraperitoneal closure using an innovative apparatus for pediatric inguinal hernia. *J Laparoendosc Adv Surg Tech A* 2014;24:188–93.
- 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.
- Kim S, Hui T. Laparoscopically assisted repair of inguinal hernia through a micro-incision and extra-peritoneal division and ligation of the hernia sac. *Pediatr Surg Int* 2013;29:331–4.
- Chen LE, Zakhshary M, Foglia RP, et al. Impact of wait time on outcome for inguinal hernia repair in infants. *Pediatr Surg Int* 2009;25:223–7.
- Catanzarite T, Saha S, Pilecki MA, et al. Longer operative time during benign laparoscopic and robotic hysterectomy is associated with increased 30-day perioperative complications. *J Minim Invasive Gynecol* 2015;22:1049–58.
- Chang YT, Lee JY, Tsai CJ, et al. Preliminary experience of one-trocar laparoscopic herniorrhaphy in infants and children. *J Laparoendosc Adv Surg Tech A* 2011;21:277–82.
- Chan KL, Tam PKH. A safe laparoscopic technique for the repair of inguinal hernias in boys. *J Am Coll Surg* 2003;196:987–9.
- Saha N, Biswas I, Rahman MA, et al. Surgical outcome of laparoscopic and open surgery of pediatric inguinal hernia. *Mymensingh Med J* 2013;22:232–6.
- Wirth S, Biesemann A, Spaeth J, et al. Pneumoperitoneum deteriorates intratidal respiratory system mechanics: an observational study in lung-healthy patients. *Surg Endosc* 2017;31:753–60.
- Neira VM, Kovesi T, Guerra L, et al. The impact of pneumoperitoneum and Trendelenburg positioning on respiratory system mechanics during laparoscopic pelvic surgery in children: a prospective observational study. *Can J Anaesth* 2015;62:798–806.
- Olsen MA, Nickel KB, Wallace AE, et al. Stratification of surgical site infection by operative factors and comparison of infection rates after hernia repair. *Infect Control Hosp Epidemiol* 2015;36:329–35.
- Ecker BL, Kuo LE, Simmons KD, et al. Laparoscopic versus open ventral hernia repair: longitudinal outcomes and cost analysis using statewide claims data. *Surg Endosc* 2016;30:906–15.
- Montupet P, Esposito C. Fifteen years experience in laparoscopic inguinal hernia repair in pediatric patients. Results and considerations on a debated procedure. *Surg Endosc* 2011;25:450–3.
- El-Gohary MA. Laparoscopic ligation of inguinal hernia in girls. *Pediatr Endosurg Innov Tech* 1997;1:185–8.