

# A modified single-port technique for the minimally invasive treatment of pediatric inguinal hernias with high ligation of the vaginal process: the initial experience

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**Abstract** The aim of this study is to evaluate a modified single-port technique for treating pediatric inguinal hernias (PIH) with high ligation of the vaginal process by combining the use of a ureteroscope and a custom-made puncture guide under pneumoperitoneum. The cases of 86 patients with PIH who underwent the procedure in our institution were reviewed. All of the operations were completed uneventfully. The median operative times for unilateral and bilateral lesions were 11 min (range, 8–15 min) and 16 min (range, 12–20 min), respectively. All of the patients were discharged from the hospital on the day of surgery. No massive hemorrhages or infections were reported. The median follow-up was 15 months (range, 12–24 months), during which no recurrences were reported. In conclusion, with the aid of a ureteroscope and a modified custom-made puncture suit, the described single-port technique allowed easier induction of the ligation suture and a shorter operative time than other methods reported previously. However, the determination of long-term efficacy requires additional studies with larger sample sizes and longer follow-up times.

**Keywords** Single port · Minimally invasive operation · Pediatric inguinal hernia · Ureteroscope

## Introduction

Pediatric inguinal hernia (PIH), a common congenital disorder in infants, results from a congenital patent

processus vaginalis (PPV). The principle of the repair for PIH consists of complete ligation of the PPV [6]. For many decades, procedures with this goal had been unchangingly performed using an inguinal incision as part of the traditional cut-down technique [8]. With the advent of minimal access surgery, herniotomy, the gold standard for treatment, has been widely used but recently challenged by laparoscopic high ligation of the vaginal process (LHLVP). There is a justified trend toward the use of LHLVP to manage PIH because of the advantages it offers over the conventional procedure [3, 4, 7, 9].

Early LHLVP techniques required three ports; however, a recent trend aims to reduce the number of ports to meet patient demands for better cosmetic results, less pain, and a reduced risk of surgical injury. Several studies have reported the use of single-port LHLVP [1, 2, 5]. We modified these techniques by using a ureteroscope and a custom-made puncture suit. This technique is advantageous because the use of a ureteroscope for the insertion of the grasping clamp with simultaneous visualization of the operating field makes the surgery quicker and easier. There were 86 patients with PIH treated with this technique in our institution as reported below.

## Patients and methods

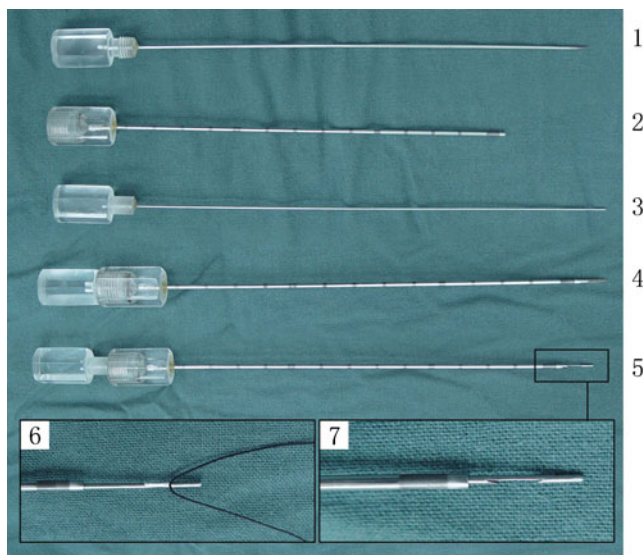
### Clinical data

From June 2006 to September 2009, 105 consecutive patients were diagnosed with PIH based on a reducible scrotal mass and on the results of a scrotal color Doppler ultrasound in our institution. According to the patients' selections, 86 patients (median age, 5.9 years; range, 2.5–13 years) accepted our advice and underwent the minimal

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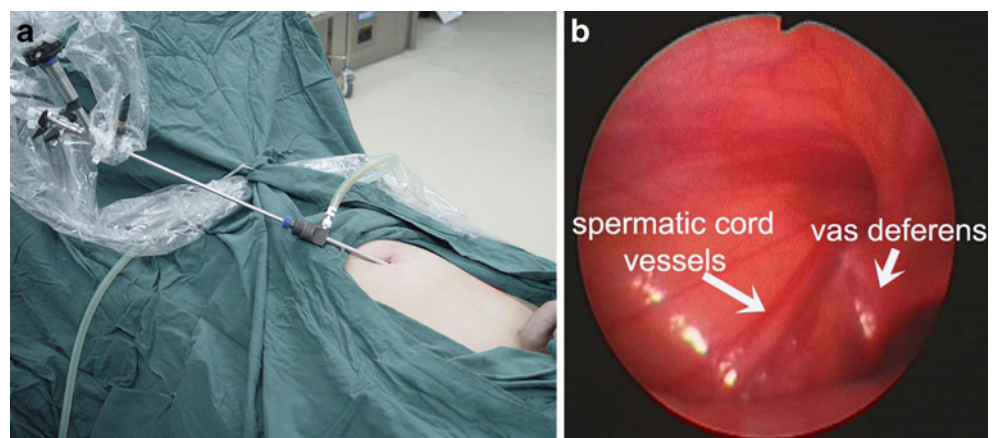


**Fig. 1** Custom-made puncture guide: (1) puncture needle (16 gauge×19 cm), (2) sheath (18 gauge×16 cm), (3) thread-guide needle (14 gauge×23 cm), (4) needle entering the sheath, (5) thread-guide needle entering the sheath, (6) schematic diagram of the in vitro tagging suture thread with the thread-guide needle, (7) magnifying diagram of local regions of the thread-guide needle

invasive procedure; thus, they were included in the study. Among them, 39 patients had lesions on the right side, while 30 patients had lesions on the left side. There were 17 patients with bilateral PIH. The other 19 patients were unwilling to receive the procedure and were not included from the study. All of the surgical procedures were performed by J Pan. Two assistants were needed for each intervention.

Custom guardianship and treatment were performed postoperatively. The patients were discharged from the institution on the day of surgery once their status was found stable. Follow-up occurred at 1 week and 1 month after discharge, and then every 3 months until 24 months from the date of the surgery.

**Fig. 2** A ureteroscope is introduced into the abdomen through a 5-mm trocar after pneumoperitoneum establishment (a). A left vaginal process is found to be patent under ureteroscopy, with clearly identifiable spermatic cord vessels and vas deferens (b)



## 1 Surgical procedures

### Primary equipment

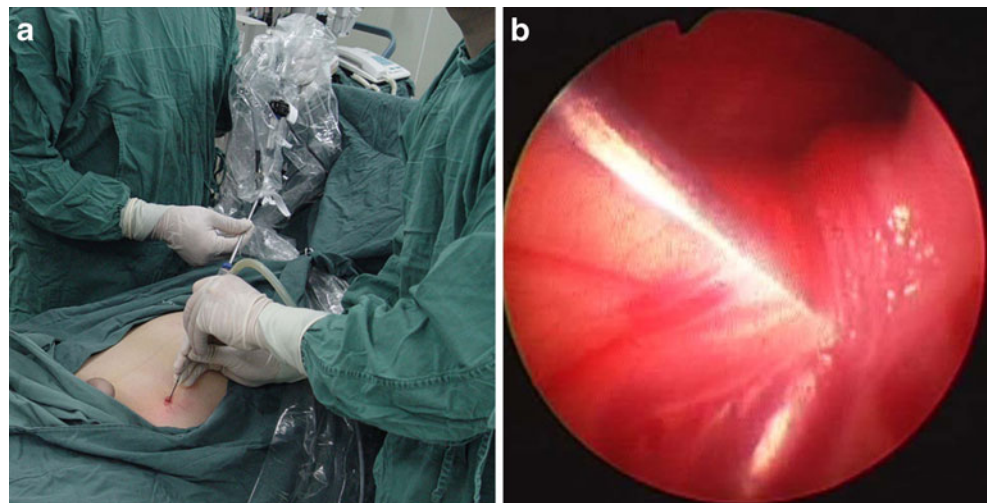
Equipment included a rigid ureteroscope (8.6 F/9.8 F×430 mm, Olympus Corporation, Japan), semi-rigid grasping forceps (5 F×600 mm, Olympus Corporation, Japan), a 5-mm trocar (Stryker Corporation, America), and a custom-made puncture guide (including a puncture needle, thread-guide needle, and sheath) (Fig. 1).

### Surgical procedures

After the induction of general anesthesia, patients were placed in the supine position with both legs open. The TV screen was placed at the patient's feet. The operating surgeon stood on the patient's left side, while both the camera assistant and the second assistant were on the right side. The procedure was performed according to the following steps:

- (1) **Pneumoperitoneum establishment:** A 5-mm incision was made beneath the umbilical area through which the needle was introduced into the peritoneum; pneumoperitoneum was established with CO<sub>2</sub> to a pressure of 8 to 10 mmHg. A 5-mm trocar was inserted as the observation port. The operating bed was adjusted to lower the patient's head (30° from horizontal) and to lower the healthy side (15° laterally). The ureteroscope was introduced to observe the inguinal region structures and to determine the location of the vaginal process (Fig. 2).
- (2) **Puncture:** A 2-mm incision was made in the skin at 2 cm above the inner ring, through which the puncture needle was introduced. The needle penetrated the subcutaneous tissue and muscularis of the abdominal wall, extended into the extra-peritoneal space, separated along the outer half of the internal ring (Fig. 3),

**Fig. 3** The puncture needle travels through the skin and subcutaneous tissue into the abdomen with ureteroscopic guidance (a). It separates tissue along the outer half of the internal ring and crosses the spermatic cord vessels into the abdomen (b)



and then entered the peritoneum across the spermatic cord. The needle was withdrawn, and a 2–0 silk thread was introduced into the peritoneum with the thread-guide needle, which was then clamped by the grasping forceps of the ureteroscope (Fig. 4). Then, the thread-guide needle was withdrawn. The puncture sheath was removed and mounted with the needle to perform another puncture. The needle separated tissue along the inner half of the internal ring, crossed the spermatic cord, and entered the peritoneum through the original passage (Fig. 5). Then, the needle was removed, and the thread-guide needle was placed in the sheath. Under direct visualization, the threads in the abdomen were coiled in two circles around the longitudinal axis of the thread-guide needle, and then the needle was pulled out of the abdomen to guide the thread out of the body (Fig. 6).

- (3) Extracorporeal knotting: Threads were knotted outside of the body to seal the vaginal process. The ureteroscope was removed, and the trocar was removed after

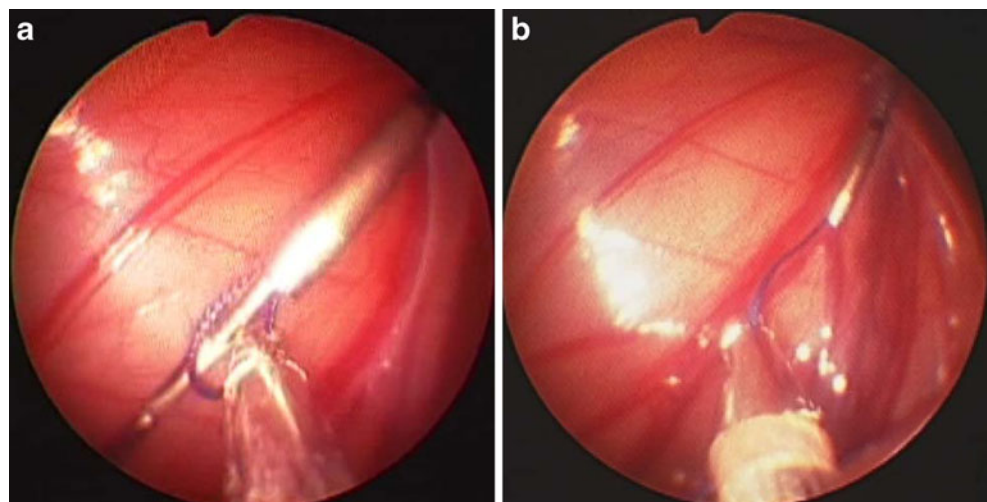
the intraperitoneal CO<sub>2</sub> was vented out. The peritoneum and subcutaneous tissues were sutured layer by layer (Fig. 7). Punctured skin near the umbilicus and the internal ring did not require sutures; the wound was covered with aseptic dressing. Fluid was aspirated by puncture of the avascular region of the scrotum with a 10-ml injector.

The same procedure was performed on the contralateral side in case of bilateral hernias.

## Results

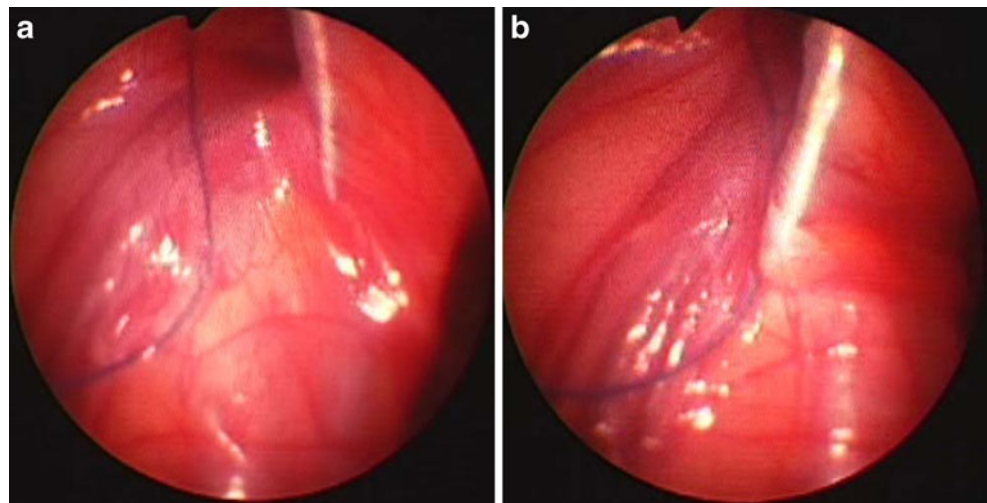
Of the 69 patients diagnosed with unilateral PIH preoperatively, a coexisting contralateral patent vaginal process was found in 19 patients (left,  $n=8$ ; right,  $n=11$ ), and this vaginal process was simultaneously ligated. All operations were completed uneventfully; no injuries of spermatic cord vessels or vas deferens were reported. The median

**Fig. 4** Removal of the thread-guide needle (b) after the foreign body forceps clamps the thread (a)





**Fig. 5** The needle separates the tissue along the inner half of the internal ring (a), crosses the spermatic cord, and enters the abdomen through the previous thread passage (b)



operation times for unilateral and bilateral lesions were 11 min (range, 8–15 min) and 16 min (range, 12–20 min), respectively. Patients were discharged on the same day. No massive hemorrhages, hematomas, or infections were reported.

All of the patients were followed up. The median time of follow-up was 15 months (range, 12–24 months), during which there was no recurrence, no testis atrophy, and no bowel obstruction reported. The perioperative data of the patients are summarized in Table 1.

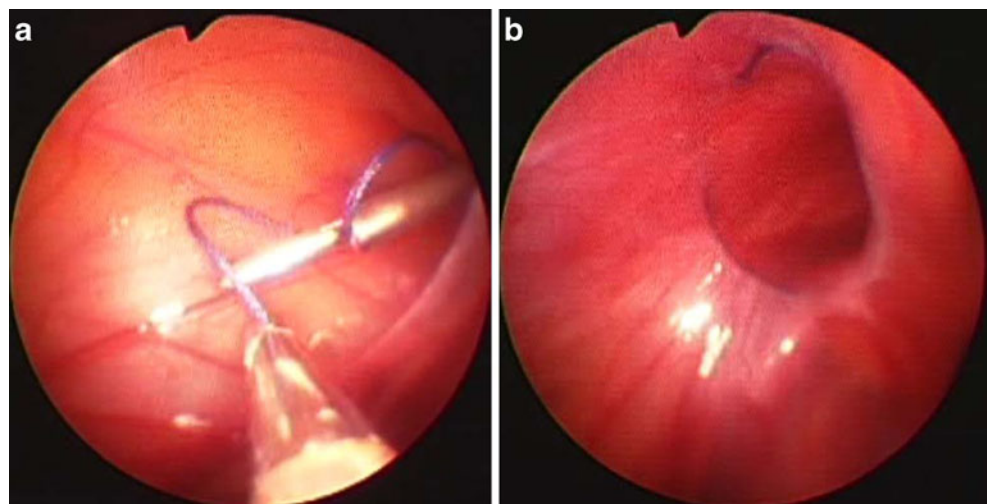
## Discussion

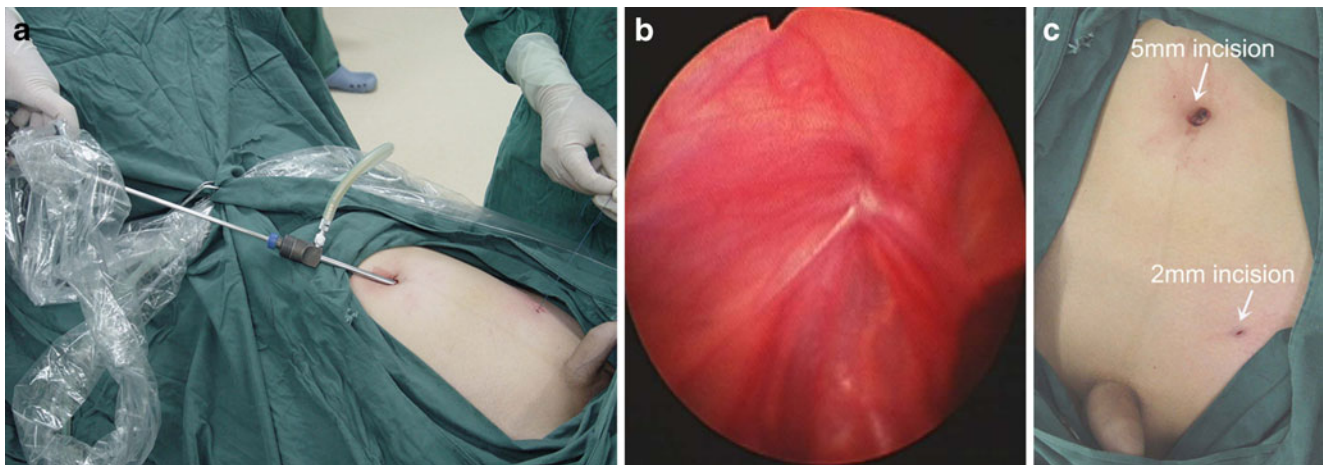
Although considerable debates currently exist about whether the laparoscopic approach to PIH should take the place of the conventional open procedure as the “gold standard”, there is no doubt that LHLVP has advantages over the open procedure: (1) the visual field is clear, so contralateral lesions can be visualized and managed; (2) the operation is

performed under magnified direct vision, which can prevent injury to the vas deferens vessels and the spermatic cord; (3) the operation is performed in the abdomen, which allows a real “high ligation” of the vaginal process; and (4) the surgical incision is minimal and inguinal canal dissection is not needed, which avoids the probable injury of iliohypogastric and ilioinguinal nerves. LHLVP is widely used in the management of PIH with certain efficacy nowadays [7, 9].

Early LHLVP techniques utilized a three-port technique. To reduce the extent of injury and to improve the cosmetic appearance of the surgical incisions, some studies have reported the single-port subcutaneous endoscopic-assisted ligation [2] and the percutaneous internal ring suturing techniques [5]. In both methods, part of the peritoneum should be circumvented to avoid injury to the vas deferens vessels and spermatic cord, which may result in incomplete closure of the vaginal process and postoperative recurrence. In 2009, Yu-Tang Chang et al. [1] reported the treatment of PIH using a single-port laparoscopic-assisted technique with a custom-made hook puncture needle. The puncture

**Fig. 6** After coiling the thread around the needle (a), the thread-guide needle is removed from the body (b)





**Fig. 7** Tightening the thread out of the body (a). The internal ring is closed completely (b). The puncture site with a 2-mm incision does not require sutures. The peritoneum and subcutaneous tissue under the puncture site beneath the umbilicus are sutured, but the skin does not require sutures (c)

needle was used to separate the peritoneum surrounding the vas deferens vessels and spermatic cord. The hernial sac was then completely ligated to avoid recurrence. We previously used a similar puncture needle to treat PIH, but we found two major problems: (1) puncture and thread hooking were performed with the same needle, which inevitably resulted in tissue damage, and (2) hooking the soft thread to the needle without the assistance of other equipment is difficult. Therefore, the custom-made puncture guide included a puncture needle used for puncture and tissue separation and a blunt-head thread guide needle specifically used for thread hooking. Of the two grooves on the head of the thread guide needle (Fig. 1, [7]), the proximal end was used to introduce the thread into the abdomen (Fig. 1; [6]), and the distal end was used to withdraw the thread from the body (Fig. 6a). The blunt

head design can minimize tissue injury during thread hooking. A patent of invention has been applied for in China for the custom-made puncture guide. At present, we need to spend time replicating a new one before each operation. Further cooperation with the biomedical engineer may be investigated and cost–benefit analysis should be performed in the future.

Although the single-port technique can decrease injury, the use of a laparoscope is limiting because there is no operating port; therefore, the procedure is more difficult due to the lack of assistance from additional equipment. Ureteroscopes are primarily used for ureter examination and lithotripsy; they utilize equipment that can clamp stones and foreign bodies or place a ureteral catheter. The ureteroscope can be used for either observation or performance with the assistance of grasping forceps. The use of a ureteroscope can solve the problem of lack of an operating port associated with the use of a laparoscope without increasing the number of ports. In our experience, using the grasping forceps of the ureteroscope to fix and knot silk thread markedly reduces the difficulty of the procedure, thereby reducing the operative time. As compared with the result of Yu-Tang Chang et al. [1], the operation times were 11 min in our report vs 25.1 min for unilateral and 16 min vs 41.5 min for bilateral.

The present study is the first to use a ureteroscope to treat PIH. The ability to introduce grasping forceps from the operating port of the ureteroscope solved the problems associated with the lack of operating equipment that is a problem with single-port laparoscopy. Using this technique, the skin at the incision site did not require sutures, and the incision was hidden, which satisfied the cosmetic appearance needs of patients. Surgical injury was minimal, and postoperative recovery was rapid. No severe complications or short-term recurrences were observed, and the efficacy was good. For that reason, we recommend the wider

**Table 1** Perioperative data

Preoperative data	
Median age, year (range)	5.9 (2.5–13)
Right side PIH ( <i>n</i> )	39
Left side PIH ( <i>n</i> )	30
Bilateral PIH ( <i>n</i> )	17
Intraoperative data	
Number of contralateral PVP found in the operations for unilateral PIH preoperatively ( <i>n</i> )	8 (left); 11 (right)
Median operative time, min (side, range)	11 (unilateral, 8–15) 16 (bilateral, 12–20)
Postoperative data	
Median follow-up time, months(range)	15 (12–24)
Recurrence rate during follow-up	0%
Testis atrophy rate	0%
Bowel obstruction rate	0%

PIH pediatric inguinal hernias, PVP patent vaginal process

clinical use of this technique. However, the determination of long-term efficacy requires additional studies with larger sample sizes and longer follow-up times.

**Conflicts of interest** All authors declare that there are no financial disclosures and no conflict of interest.

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