

# Single-port laparoscopic herniorrhaphy using reverse puncture technique without hydrodissection in treatment of pediatric inguinal hernia

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## Research Article

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# Abstract

## Background

In single-port laparoscopic percutaneous extraperitoneal closure, hydrodissection is commonly used. Although hydrodissection makes the operation easier, it can cause shock and twist the vas deferens. The aim of this study was to investigate whether the reverse puncture technique could be used instead of hydrodissection.

## Methods

Between March 2019 and January 2021, 132 children with inguinal hernias underwent single-port laparoscopic percutaneous extraperitoneal closure using the reverse puncture technique. The double-hook core needle with a suture was used to puncture the abdominal cavity along the lateral border of the internal ring under single-port laparoscopic vision. The suture was left in the abdominal cavity. The needle was then passed through the gap between the vas deferens / spermatic vessels and the peritoneum along the medial border of the internal ring to capture the end of the suture. The suture was tied in the extraperitoneal space after it was brought out of the abdominal wall.

## Results

The 132 patients, 106 males and 26 females, had an average age of  $2.71 \pm 2.18$  years. Sixty patients were chosen for bilateral surgery, with 57 of them having contralateral patent processus vaginalis. The average operating time for unilateral and bilateral cases was  $9.9 \pm 2.1$  and  $15.4 \pm 3.3$  minutes, respectively. One patient had a recurrence during the 9 to 24 month follow-up period (0.7%).

## Conclusions

For the treatment of pediatric inguinal hernias, single-port laparoscopic percutaneous extraperitoneal closure utilizing the reverse puncture technique provides a simpler and safer option.

## Background

Inguinal hernia is one of the most frequent diseases in children, accounting for around 15% of pediatric surgical cases [1]. This condition can be treated in a variety of ways in the clinic. With the advancement of minimally invasive surgery, pediatric surgeons are increasingly using single-port laparoscopic percutaneous extraperitoneal closure (SLPEC) to treat inguinal hernia in children. SLPEC is a well-established, minimally invasive, and effective surgical procedure. This approach allows for suturing around the hernia ring at the internal ring level without injuring the neighboring vas deferens and spermatic arteries, as well as extracorporeal ligation, which reduces the utilization of operating equipment [2, 3]. SLPEC using a double-hook core needle for the treatment of pediatric inguinal hernia has been reported in the literature [4].

Regardless of these advantages, SLPEC has a steep learning curve [5]. Regardless of these advantages, SLPEC has a steep learning curve [5]. The technical challenge is to pass a device with a suture through the gap between the vas deferens and the peritoneum. Even a qualified surgeon may struggle to conduct a complex inguinal hernia in which the medial peritoneum of the internal ring develops folds in children with long-standing inguinal hernias.

To address this issue, surgeons frequently employ the hydrodissection technique to separate the vas deferens and spermatic vessels from the retroperitoneum [6]. The hydrodissection approach, on the other hand, might generate shock and distort the vas deferens into an angle. We endeavored to complete the treatment without hydrodissection to decrease the impact of the hydrodissection on the vas deferens. In clinical practice, we discovered that the double-hook core needle without a suture has a smoother appearance and travels more readily through the vas deferens and spermatic vessels than the needle with a suture.

As a result, we anticipated that if the needle was not hindered during the procedure by a suture, the difficulty of completing SLPEC would be lessened. To put this notion to the test, we developed SLPEC utilizing the reverse puncture technique for treating inguinal hernia in children. In theory, SLPEC would be more ideal if the reverse puncture technique could replace the hydrodissection approach.

To provide a clinical reference, this study assessed the operability, safety, and efficacy of the "reverse puncture" approach employing double-hooked core needles.

## **Methods**

We investigated whether SLPEC utilizing the reverse puncture technique was successful and safe for the treatment of juvenile inguinal hernia.

## **Clinical Data**

Between March 2019 and January 2021, we conducted research at Huizhou Second Maternal and Child Healthcare Hospital's Department of Pediatric Surgery. After being diagnosed through symptoms, signs, and ultrasonography, the clinical data of 132 children who underwent SLPEC utilizing the reverse puncture technique were retrospectively examined. Children under the age of three months, those with an incarcerated hernia, and those with other co-morbidities were not allowed to participate. Before surgery, our hospital's Ethics and Safety Committee approved the procedure with the informed consent of the patients' parents, and informed consent to publish clinical data was also obtained. The first author was in charge of all of the patients.

## **Surgical Instrument**

The following items were necessary for this study's process (Fig. 1a-b): a Stors laparoscopic system, a 30° laparoscopic lens with a diameter of 5 mm, a trocar with a diameter of 5 mm, and a double-hook core needle Surgaid Medical Device Co., Ltd., Xiamen, China, furnished the needle. The device was made up of a stainless steel jacket, an inner core, and two hooks on the front end of the core: one for feeding the ligature suture and one for catching the end of the suture. The needle's tip was blunt and had an acute angle, making it easier to dissect the space between the vas deferens / spermatic arteries and the peritoneum.

## Surgical Method

Patients were positioned in the supine posture, with their hips suitably cushioned, while under general anesthesia. The surgeon took a position on the patient's left side, while the assistant took a position on the patient's right side. The screen was put on the patient's foot on the side. The pneumoperitoneum needle was placed into the abdominal cavity through a 5 mm incision in the central umbilical to maintain pneumoperitoneum pressure of 6–8 mmHg. A trocar (5 mm) was placed through the umbilical incision after the pneumoperitoneum needle was removed.

An inspection of the internal inguinal ring opening revealed the existence of a hernia. To close the internal ring, a 2 mm skin incision on the body surface where the internal ring was positioned was initially necessary. A non-absorbable suture was attached to the outside hook of a double-hook core needle apparatus. This needle was then introduced into the extraperitoneal space through the tiny incision.

The traditional hydrodissection procedure for the next surgical operation was to advance the needle with suture along the medial side of the internal ring [4]. By introducing a tiny amount of water into the extraperitoneum through the needle, the vas deferens and peritoneum were separated. The suture was left in the peritoneal cavity after the needle punctured peritoneum. The needle followed the lateral side of the internal ring, separating the spermatic arteries from the peritoneum once more with the hydrodissection technique. The needle was then inserted into the peritoneal cavity, where the suture was grasped and tied.

Instead of using the hydrodissection approach, we applied reverse puncture technology at this point (Figs. 2a-f, 3a-e). In the preperitoneal area, the needle was initially guided along the lateral border of the internal ring. The needle punctured the peritoneum and entered the abdominal cavity when it reached the lateral portion of the spermatic vessels. The suture persisted in the abdominal cavity when it was freed from the needle core. This device was then progressively retracted until its tip landed on the top of the internal ring in the extraperitoneal area. The needle was then softly stroked in the extraperitoneal region, utilizing its tip to progressively pass through the gap between the vas deferens / spermatic vessels and the peritoneum, starting from the medial border of the internal ring. The needle's tip punctured the same spot on the peritoneum to get access to the abdominal cavity. The suture end was captured by the needle's inner hook and secured in the sheath. Through the same subcutaneous path, the needle containing the suture was taken out of the abdomen wall. The knot was knotted extracorporeally to ligate the internal ring after the testicle was brought to the base of the scrotum and the scrotum was gas-free.

The identical method would be used to repair a patent processus vaginalis (PPV) on the contralateral hernial ring. An absorbable suture was used to seal the umbilical wound. The 2 mm needle puncture incision in the abdominal wall did not require sutures.

## Statistical analysis

Data was collected using a pre-designed proforma. The results were analyzed using IBM SPSS Statistics 26 program. Counts and percentages were used to describe categorical variables. The median and standard deviation ( $\bar{x} \pm S$ ) are used to represent continuous variables.

## Results

All 132 pediatric patients were treated by SLPEC using the reverse puncture technique. With a mean age of  $2.71 \pm 2.18$  years (3 months – 9.3 years), there were 106 males and 26 females. There were 129 (97.7%) and 3 (2.3%) cases that were preoperatively diagnosed as unilateral hernias and bilateral hernias, respectively. In 57 (43.2%) cases, contralateral PPV was discovered during surgery. As a result, 60 (45.5%) of the cases were surgically repaired on both sides. The average repair time was  $9.9 \pm 2.1$  minutes for unilateral repair and  $15.4 \pm 3.3$  minutes for bilateral repair (Table 1).

Table 1  
Patient demographics and clinical characteristics

Parameters	Observations
Total patients	<i>N</i> = 132(%)
Mean age <sup>a</sup>	2.71 ± 2.18 years (3 months to 9.3 years)
Sex	
Male	106 (80.4%)
Female	26 (19.6%)
Side of hernia (preoperative)	
Right	78 (59.1%)
Left	51 (38.6%)
Bilateral	3 (2.3%)
Contralateral PPV <sup>b</sup> (intraoperative)	57 (43.2%)
Mean operation time <sup>a</sup>	9.9 ± 2.1 min (unilateral) 15.4 ± 3.3 min (bilateral)
Follow-up	9 ~ 24 months
Complications	1 (0.7%)
Recurrence	1 (0.7%)
a: Data are mean ± SD for mean age and mean operation time.	
b: PPV, patent processus vaginalis.	

Except for one patient who suffered a disruption of the wound in the umbilical 6 hours after surgery due to a loosened thread knot, all patients had no serious complications. The child was taken back to the operating room and his incision was patched up once more. Following surgery, all patients were discharged within 1–2 days. They all bounced back quickly, with no testicular shrinkage, hydrocoele, suture granulomas, or iatrogenic cryptorchidism.

All of the pediatric patients who were recruited were followed up on for 9 to 24 months after surgery via outpatient visits and phone interviews. Only one patient had a recurrence 9 months after surgery, which was treated with reoperative treatment and cured. The rate of recurrence was 0.7 percent.

## Conclusions

Internal ring closure is a common surgical procedure for inguinal hernia in children [7, 8]. Open surgery has steadily been supplanted with laparoscopic surgery as less invasive surgery has become more common in kids. The laparoscopic approach is distinguished by little tissue injury and a quick recovery time. The vas deferens and spermatic vessels are also less at risk with laparoscopic percutaneous extraperitoneal closure, and a contralateral PPV, which is a potential metachronous hernia, is identified [9]. SLPEC has made significant progress in recent years. SLPEC has only one puncture hole in the umbilical, causing less tissue stress and better cosmetic results than laparoscopic percutaneous extraperitoneal closure [10, 11].

SLPEC is currently preferred by the majority of surgeons. However, because to the lack of an intraoperative assist clamp, the technique is complicated. SLPEC has commonly utilized the hydrodissection approach to treat pediatric inguinal hernias. The suture can easily traverse the gap between the vas deferens / spermatic vessels and the peritoneum thanks to the hydrodissection technique. However, during the separation of the retroperitoneum, the hydrodissection technique affects and distorts the vas deferens and spermatic veins.

In view of this, our study explored the use of the reverse puncture technique to implement SLPEC instead of the hydrodissection technique. The suture was initially put into the abdominal cavity from the lateral aspect of the spermatic vessels in the reverse puncture technique. The needle was then rotated and turned with the bevel of the needle back to the operator before crossing the gap between the vas deferens / spermatic vessels and the peritoneum, while keeping the needle bevel close to the peritoneum. The assistant needed to position the lens close to the surgery site at this point so that the surgeon could view the needle and its angle in the retroperitoneal area through the thin, transparent peritoneum. With the needle's "bevel" feature at the tip, the needle was pushed and traversed the space between the vas deferens / spermatic vessels and the peritoneum without the obstruction of suture. Furthermore, in the place where the needle entered the abdominal cavity, the reverse puncture technique differed from the hydrodissection technique. The classic hydrodissection procedure allowed the needle to effortlessly pass the vas deferens and spermatic vessels following water injection, allowing the needle to puncture the abdominal cavity in either the pain triangle or the Doom area, depending on the surgeon's operating tendencies. The reverse puncture technique operation required that the needle without the suture crossed through the vas deferens and spermatic vessels so that the position of the needle punctured into the abdominal cavity could only be in the pain triangle area along the lateral aspect of the spermatic vessels. A space could be produced by gently sliding the needle tip up and down in the extraperitoneal area for complex inguinal hernias with folds or scars in the peritoneum on the medial edge of the internal ring. The operation had to be gentle at this point to prevent injuring the peritoneum or minor extraperitoneal arteries. Continue to slide the needle tip up and down in this space to separate the gap between the vas deferens / spermatic vessels and the peritoneum. It usually takes some patience for the tip of the needle to pass through this gap without being hindered by the suture.

To accomplish the surgical procedure of SLPEC in this investigation, we used a double-hook core needle. The ligature suture may be placed and captured using the outer and inner hooks of the double-hook core

needle, and the needle does not need to be entirely removed from the body to transfer the suture. This procedure guarantees that both ends of the ligature suture are in a single channel and that the ligature is above the internal ring in the extraperitoneal area. Other auxiliary needles, such as the Kirschner wire or tuohy needle, should always be completely removed from the body and re-punctured while transferring the suture, in contrast to the double-hook core needle [12, 13]. It is difficult to ensure that both ends of the suture are in the single channel at this point. Non-single channel knots will inevitably ligate some of the subcutaneous tissue and muscle along with the peritoneum. Too much tissue ligation might cause the knot to relax, increasing the risk of postoperative hernia recurrence [14]. Furthermore, ligating subcutaneous and muscle tissues can result in a superficial knot that does not extend into the extraperitoneal area. The majority of suture granulomas after SLPEC are caused by knots not being buried deeply enough, according to research [15]. The design features of the double-hook core needle considerably lower the risk of recurrence and suture granulomas following SLPEC, which is why we picked it.

Li et al. [4] used a two-hooked cannula device with a hydrodissection approach to operate SLPEC. The average operation time for unilateral hernia was  $9.8 \pm 2.1$  minutes, and  $13.6 \pm 2.2$  minutes for bilateral hernia. The average operation time for unilateral hernia was  $9.9 \pm 2.1$  minutes, while for bilateral hernia was  $15.4 \pm 3.3$  minutes in this study. Our surgery took a little longer than theirs, but the difference wasn't significant. It was difficult for the needle to penetrate the gap between the vas deferens / spermatic vessels and the peritoneum without hydrodissection, but it also avoided the vas deferens / spermatic vessels being damaged by hydrodissection.

SLPEC without hydrodissection is now being used by some pediatric surgeons to treat inguinal hernia in children [12]. Their research used a device with a suture through the vas deferens / spermatic vessels, which differed from our reverse puncture approach. We also attempted to complete SLPEC using the conventional puncture method and without hydrodissection. We discovered the advantages of the reverse puncture procedure after closely comparing these two surgical techniques. Indeed, regardless of the type of puncture technology used, a trained pediatric surgeon may do SLPEC on an ordinary child with an inguinal hernia in a matter of minutes. The reverse puncture approach, on the other hand, provides clear advantages for children with complicated inguinal hernias. Many of these youngsters have a long history of inguinal hernia, and the peritoneum on the medial border of the internal ring has folds or scars.

It's tough for the needle to cross the distance between the vas deferens / spermatic arteries and the peritoneum because of folds and scars, but it's even more difficult when a suture is in the way. The peritoneum or minor extraperitoneal vessels may be injured at this point, resulting in an extended surgery time. Chen et al. [12] operated SLPEC without hydrodissection and the reverse puncture approach. Their average operation time for unilateral hernia was  $12.5 \pm 3.5$  minutes, and  $20.5 \pm 4.5$  minutes for bilateral hernia. Our treatment took less time than that of Chen et al., demonstrating the benefit of the reverse puncture technique. Furthermore, for a pediatric surgeon who is not experienced with SLPEC, the reverse puncture approach may be helpful. To get the needle through the gap between the vas deferens / spermatic vessels and the peritoneum, an inexperienced pediatric surgeon may have to repeat the

procedure several times. Because the non-absorbable suture has a coarser look than the needle, it raises the risk of minor extraperitoneal vascular injury following several punctures. When a tiny vessel is torn, the blood collects in the extraperitoneal region, obstructing the surgical field. SLPEC utilizing the reverse puncture technique is safe and successful in the treatment of juvenile inguinal hernias, according to our findings.

This study did not include children under the age of three months who had inguinal hernias. To begin with, children under the age of three months have a tiny intra-abdominal volume, restricted maneuverability, and the vas deferens / spermatic arteries are frequently hidden by the intra-abdominal bowel. The surgical procedure is extremely dangerous if the vas deferens or spermatic vessels are not clearly seen. Second, young newborns frequently present with an incarcerated hernia that necessitates emergent surgery. The internal ring of an incarcerated hernia is compressed, generating local edema and unclear structures between the vas deferens / spermatic arteries and the peritoneum. Even if the implanted hernia contents are preoperatively integrated back into the abdominal cavity, completing SLPEC with a double-hook core needle alone is also difficult. Additional gripping tools are frequently required intraoperatively to complete the internal ring closure in these patients. We've conducted SLPEC on a number of children aged 1 to 3 months who had inguinal hernias, with the majority of them requiring additional grasping equipment to help the needle pass the gap between the vas deferens / spermatic arteries and the peritoneum. Because girls lack the vas deferens and spermatic arteries, surgery on some individuals could also be performed without the use of special grasping equipment.

In this study, SLPEC without hydrodissection was used in practice, which made the operation more difficult for the pediatric surgeon. The peritoneum had to be jacked up during the crossing of the space between the vas deferens / spermatic vessels and the peritoneum without the aid of hydrodissection drifting away from the peritoneum, allowing the needle tip to cross and penetrate slowly. The operation needed patience and dexterity. The procedure is delayed to some amount due to the difficulties of the operation and the psychological pressure on the operator. The operational time in this study was 9 - 15 minutes for unilateral hernias and 10 - 25 minutes for bilateral hernias in the first 5 instances, and thereafter rapidly decreased. The surgery approach in this study, like other laparoscopic operations in children, was shown to have a learning curve. The process time will be stabilized as the number of cases, operation proficiency, and experience accumulate.

Finally, 132 children with inguinal hernias were treated with SLPEC utilizing the reverse puncture approach, with positive clinical outcomes. In the treatment of inguinal hernia in children, this approach was found to be both safe and effective. SLPEC utilizing the reverse puncture technique did not raise the risk of surgical damage or other auxiliary operations when compared to hydrodissection, and it lowered the difficulty of the surgery when compared to the conventional puncture technique. The reverse puncture technique is conducted in the same way as the other puncture techniques, with the exception of the puncture sequence. After understanding standard SLPEC, the surgeon can be proficient without any more training. Surgeons can also study the surgical procedures of the reverse puncture technique first, even if they have no expertise with SLPEC. This research looks into the feasibility and safety of doing this

operation in day surgery, and we'll continue to collect cases and map out the learning curve for this procedure in a single center in the future.

## Abbreviations

SLPEC, single-port laparoscopic percutaneous extraperitoneal

PPV, patent processus vaginalis

## Declarations

### Ethics approval and consent to participate

All procedures carried out in studies involving human participants were in accordance with the Ethical standards of Huizhou Second Maternal and Child Healthcare Hospital's Ethics and Safety Committee and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The informed consent to participate in the study was obtained from all parents of children participants. The parents of all children participants signed the written informed consent, and they agreed to participate in the study.

### Consent for publication

Not applicable.

### Availability of data and material

The dataset was submitted in additional supporting files.

### Competing interests

HZ, YSX, QW, ZMY declare that they have no financial or non-financial conflict of interest.

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### Authors' contributions

Designed the study: TSX, HZ; data gathering: ZMY; analyzed the data: QW. Data interpretation: HZ, QW. Each author contributed important intellectual content during manuscript drafting or revision and agrees to be personally accountable for the individual's own contributions and to ensure that questions pertaining to the accuracy or integrity of any portion of the work, even one in which the author was not

directly involved, are appropriately investigated and resolved, including with documentation in the literature if appropriate. All authors have read and approved the final manuscript.

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## Figures

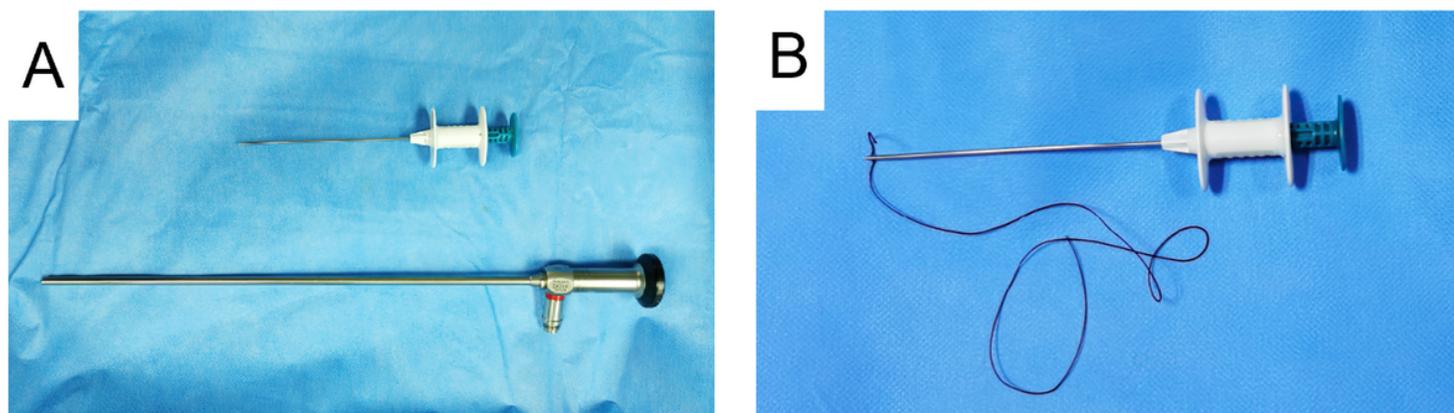
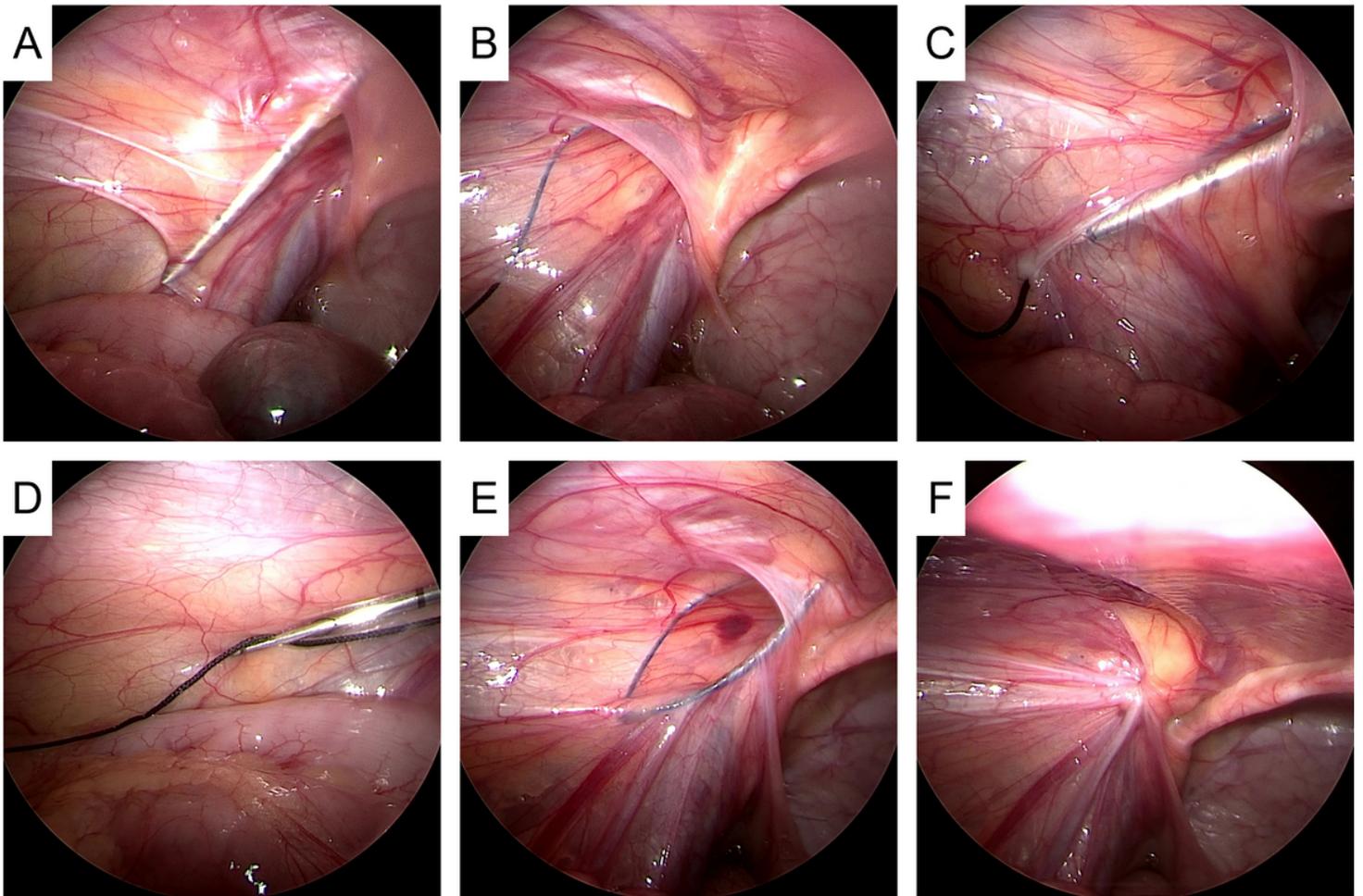


Figure 1

The equipment, materials and procedure of the surgery

a The equipment.

b The appearance of the device when hooked to non-absorbable suture.



**Figure 2**

Operation of single-port laparoscopic percutaneous extraperitoneal internal ring closure using reverse puncture (Left inguinal hernia)

**a** The needle was guided along the lateral border of the internal ring.

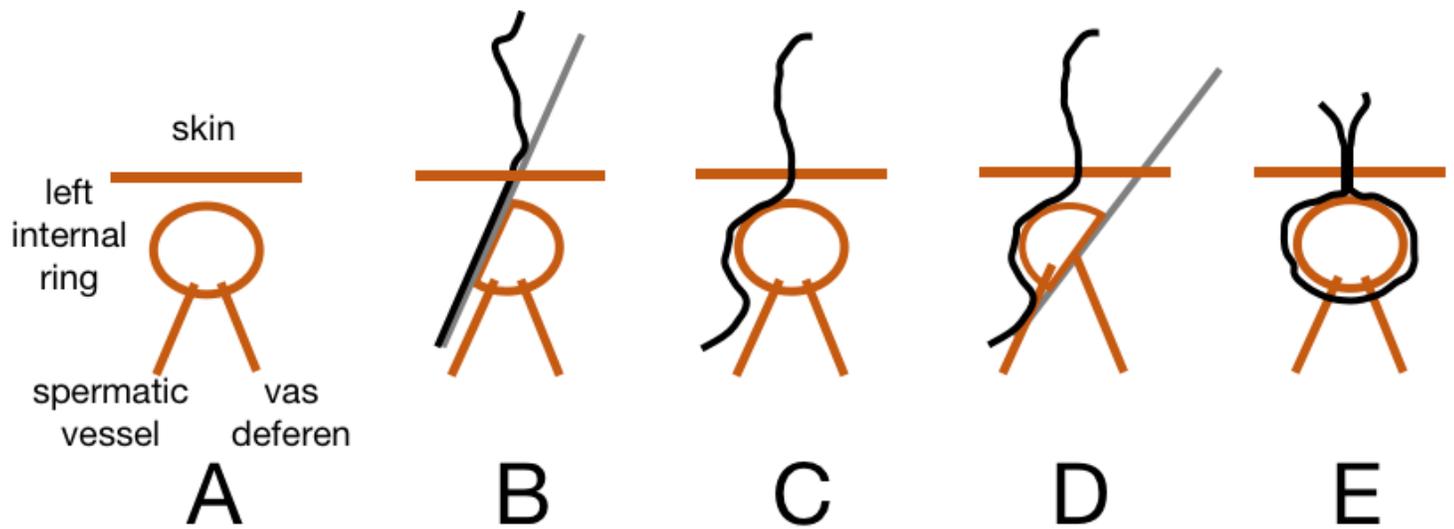
**b** The suture was left in the abdominal cavity.

**c** The tip of the needle passed through the gap between the vas deferens / spermatic vessels and the peritoneum from the medial border of the internal ring.

**d** The suture end was caught.

**e** The suture end was pulled out of the abdominal wall.

**f** The internal ring was closed.



**Figure 3**

Schematic diagram of SLPEC using reverse puncture technique (Left inguinal hernia)

- a** The left internal ring.
- b** The needle with suture was pushed from the lateral side of the left internal ring.
- c** The suture was left in the abdominal cavity.
- d** The suture was captured.
- e** The end of suture was brought out.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [ClinicalData.xlsx](#)