



Scan to know paper details and author's profile

# Study About the Feasibility of Totally Extraperitoneal Single-Incision Laparoscopic Surgery Via Umbilical Margin Incision Under the Posterior Rectus Abdominis Sheath

*Xiaojun Wang, Ting Fei & Encheng Zhou*

*Ningbo University*

## ABSTRACT

**Purpose:** To evaluate the feasibility of SILS-TEP surgery via umbilical margin incision under the posterior rectus abdominis sheath.

**Methods:** A single 2.5-cm-long curved incision was made along the lower umbilical border. A 4 cm gap under the posterior rectus abdominis sheath was created. The silica gel sealing sleeve of an Iconport single-port device was wedged under the posterior rectus abdominis sheath. The peritoneum was pressed down by the laparoscopic instrument to maintain tension, and the preperitoneal space was broadened towards the lower abdomen. Conventional laparoscopic instruments were used to complete the operation according to the procedure for laparoscopic totally extraperitoneal herniorrhaphy.

**Keywords:** custom-made single-port device; Iconport; single-incision laparoscopic surgery (SILS); totally extraperitoneal herniorrhaphy (TEP).

**Classification:** LCC Code: TK3351

**Language:** English



LJP Copyright ID: 392841

London Journal of Medical and Health Research

Volume 22 | Issue 4 | Compilation 1.0



© 2022. Xiaojun Wang, Ting Fei & Encheng Zhou. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 4.0 Unported License (<http://creativecommons.org/licenses/by-nc/4.0/>), permitting all noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.



# Study About the Feasibility of Totally Extraperitoneal Single-Incision Laparoscopic Surgery Via Umbilical Margin Incision Under the Posterior Rectus Abdominis Sheath

Xiaojun Wang<sup>a</sup>, Ting Fei<sup>o</sup> & Encheng Zhou<sup>p</sup>

## ABSTRACT

**Purpose:** To evaluate the feasibility of SILS-TEP surgery via umbilical margin incision under the posterior rectus abdominis sheath.

**Methods:** A single 2.5-cm-long curved incision was made along the lower umbilical border. A 4 cm gap under the posterior rectus abdominis sheath was created. The silica gel sealing sleeve of an Iconport single-port device was wedged under the posterior rectus abdominis sheath. The peritoneum was pressed down by the laparoscopic instrument to maintain tension, and the preperitoneal space was broadened towards the lower abdomen. Conventional laparoscopic instruments were used to complete the operation according to the procedure for laparoscopic totally extraperitoneal herniorrhaphy.

**Results:** SILS-TEP hernia repair was successfully completed in 102 patients. The mean operative times were 70.5 minutes (range, 40 to 130 minutes) and 52.8 minutes (range, 36 to 90 minutes) for unilateral indirect hernia and unilateral direct femoral hernia, respectively. Four seroma cases were seen during the 1- to 32-month follow-up periods, and all were treated conservatively. No other major complications were observed. The mean postoperative hospital stay duration was 3.3 days.

**Conclusions:** With the assistance of a suitable single-port laparoscopic device, SILS-TEP operation via umbilical margin incision under the posterior rectus abdominis sheath is safe and feasible as well as easy to master and popularize.

**Trial registration:** The study was retrospectively registered with the Chinese Clinical Trial Registry (ChiCTR) ([www.chictr.org.cn](http://www.chictr.org.cn); registration number: ChiCTR1900023056; registration date: May 9, 2019).

**Keywords:** custom-made single-port device; Iconport; single-incision laparoscopic surgery (SILS); totally extraperitoneal herniorrhaphy (TEP).

**Author  $\alpha$   $\sigma$   $\rho$ :** Department of General Surgery, The Affiliated Hospital of the Medical School of Ningbo University, Ningbo 315020, China.

## I. INTRODUCTION

Total external peritoneal (TEP) hernia repair is a common surgical method for indirect inguinal hernia, direct hernia and femoral hernia. Three operation holes are usually needed to complete the operation. The initial preperitoneal space is usually created in front of the posterior sheath of the rectus abdominis muscle on the side where the hernia is located and behind the muscle. The advantage of this method is its ability to reduce the probability of peritoneal damage during the initial stage. However, in the initial stage of TEP surgery, once peritoneal damage occurs, the operation will become difficult to perform, and sometimes TAPP surgery or surgical operation is required because the field of vision in front of the lens will be blocked after gas enters the anterior peritoneal space. In 2008, the first case of totally extraperitoneal single-incision laparoscopic surgery (SILS-TEP) was reported by Filipovic-Cugura J[1-2]. Over the past 10 years, SILS-TEP surgery has been promoted by many

experts[3-16]. In 2022, the author[17] reported their early experience of SILS-TEP via umbilical margin incision under the posterior rectus abdominis sheath. The advantages and disadvantages of this method were further analysed.

## II. MATERIALS AND METHODS

### 2.1 Materials

The principal author used a single-hole device named Iconport (Figs. 1 and 2) to seal the incisions and complete SILS-TEP via umbilical incision under the posterior rectus abdominis sheath. The Iconport single-hole device is composed of an operating panel made of medical polypropylene plastic and an incision protective sleeve made of medical silica gel.

### 2.2 Patients

We retrospectively analysed 102 patients who underwent SILS-TEP between 16 February 2019 and 15 June 2022 at the Affiliated Hospital of the Medical School of Ningbo University. All patients with an inguinal hernia admitted to our institute were considered for SILS-TEP hernioplasty. The exclusion criteria were as follows: (1) an age of <20 years, (2) an acute bowel-incarcerated hernia, (3) a previous history of retroperitoneal surgery, such as for a recurrent hernia after laparoscopic hernioplasty or prostatectomy, or (4) compromised cardiopulmonary function. In these cases, we performed open hernia repair. In this study, we analysed only short-term outcomes. All surgeries were performed after obtaining informed consent from the patients, and the study was approved by our Institutional Review Board.

### 3.3 Surgical technique

After general anaesthesia, the patient was placed in a supine position with the arm opposite the side of the hernia in adduction. In step 1, a skin incision was made. A single 2.5-cm-long curved incision was made along the lower umbilical border (Fig. 3). The subcutaneous tissue was incised to reveal the aponeurotic layer. In step 2, the operating space was created in the preperitoneal space behind the linea alba under

direct vision. Usually, we use two vascular forceps to clamp the linea alba at a place 0.5 cm away from the root of the umbilical hole and lift it up. A small opening is cut horizontally between the two forceps so that the small blood vessel forceps enter the linea alba towards the direction of the symphysis pubis and gently expand the space. The linea alba was cut approximately 0.5-0.8 cm longitudinally, and the dissected aponeurosis tissue was pulled on both sides to create a 4 cm gap under the posterior rectus abdominis sheath, which was actually equivalent to making a "Y"-shaped incision around the root of the umbilical hole in the aponeurosis. In step 3, the silica gel incision seal sleeve of the single-hole device was installed below the aponeurotic layer of the incision (Fig. 4). The superficial tissue of the preperitoneal fascia was cut transversely along the deep surface of the aponeurosis using an electrocoagulation device, and the space in the preperitoneal space was gradually increased (Fig. 5). In step 4, the anterior peritoneal space adjacent to the umbilicus was enlarged. Under CO<sub>2</sub> gas inflation, the preperitoneal space was dissected gradually using conventional straight and rigid types of laparoscopic instruments. If the peritoneum has been damaged during the initial operation, the surgeon can still identify the layers of the preperitoneal tissue because the forceps are pressing down on the peritoneum and the electric coagulation hook can be used to gradually widen the preperitoneal space (Fig. 6). In step 5, the preperitoneal space was expanded to expose the Retzius space. In step 6, the Bogros space was broadened. In step 7, the hernia sac was stripped (Fig. 7). In step 8, the mesh was placed. When we finished creating the preperitoneal space (Fig. 8), the entire myopectineal orifice was visualized, the hernia sac was visualized and freed from the spermatic cord, and a 12\*14 cm polypropylene mesh (ETHICOH ULTRA PRO, Johnson, Norderstedt, Germany) was inserted and deployed to cover the entire myopectineal orifice (Fig. 9). Other meshes with the same function can also be used. No fixation is required for a flat mesh. In step 9, the incision was sutured and covered. The linea alba was closed intermittently with a 2-0 absorbable suture, and the skin was consecutively closed with a 4-0 absorbable suture

by subcuticular methods (Fig. 10). The strips were inserted into the umbilical hole to assist in pressing the incision, and a covering was applied to the incision.

#### IV. DATA COLLECTION

The age, sex, body mass index, American Society of Anaesthesiologists (ASA) score, site of hernia, operative time, bleeding volume, conversion, postoperative hospital stay duration, follow-up duration, complications, and hernia recurrence of the patients were recorded. The pain scores were checked 1 day after surgery by a member of the team using a visual analogue scale (VAS). Some patients were followed up with outpatient visits, while others were followed up with phone calls; for patients who could not be contacted by phone, the last follow-up findings were used in the analysis. The results were expressed as the means  $\pm$  SDs or as numbers (percentages).

#### V. RESULTS

SILS-TEP hernia repair was successfully completed in 102 patients. The patient demographics and hernia characteristics are summarized in Table 1. The overall mean age of the patients was 59.7 years (range, 21 to 81 years), and the mean body mass index was 23.4 kg/m<sup>2</sup> (range, 18.6 to 35.6 kg/m<sup>2</sup>). The operative and postoperative data are summarized in Table 2. The mean operative times were 70.5 minutes (range, 40 to 130 minutes) and 52.8 minutes (range, 36 to 90 minutes) for unilateral indirect hernia and for unilateral direct or femoral hernia, respectively. The mean operative time was 90.5 minutes (range, 60 to 180 minutes) for bilateral hernia. The mean operative pain VAS score on postoperative Day 1 was 1.8 $\pm$ 0.8. Two patients experienced internal spermatic vessel injury, but there was no discomfort during the following 15 months. All of the surgical procedures were completed uneventfully, but peritoneal rupture occurred in 19 cases, and the distal indirect hernia sac was amputated in 6 cases. No other intraoperative complications existed. Four seromas were observed during the 1- to 32-month follow-up periods, and all were treated conservatively. No other major complications,

such as chronic pain, mesh infection, testicular atrophy, umbilical hernia, delirium or urinary retention, were noted during the follow-up period. There was no mortality or recurrence. The mean postoperative hospital stay duration was 3.3 days.

#### VI. DISCUSSION

Due to the fusion of various layers of tissue on the deep surface of the umbilical foramen with the peritoneum, it is generally believed that it is not feasible to directly enter the posterior sheath of the rectus abdominis to create a preperitoneal space near the umbilical foramen to perform TEP surgery [1-16], which easily causes peritoneal damage. In October 2017, based on the previous umbilical incision experience of more than 200 cases of transumbilical single-hole laparoscopic appendectomy[18], the author made a preliminary conclusion that when an incision was made around the root of the umbilical hole, approximately 70-80% of the patients were below the aponeurosis layer, and the tissue composed of preperitoneal fat, preperitoneal fascia and peritoneum was thick and not easily damaged.

Only approximately 20-30% of patients have easily damaged peritoneum. Before 2016, the author's work content did not include the diagnosis and treatment of inguinal hernia. In 2017, the author began to learn laparoscopic hernia repair. Due to the lack of practical experience in membrane anatomy knowledge required by laparoscopic hernia repair at that time, the author did not independently complete any TEP surgery until October 2017. However, the author continued to use a self-developed laparoscopic single-incision sealing device (Product name: Iconport, Chinese patent No. 201110229309.4 US patent No.: US9, 393, 003B2) (Figure 1,2). Since November 2013, he has engaged in single-port laparoscopic surgery mainly using laparoscopic appendectomy and accumulated more experience using this device to complete single-port laparoscopic surgery. The author believes that it is feasible to perform SILS-TEP via umbilical margin incision under the posterior rectus abdominis sheath. First, by keeping the umbilical region away from the groin area and using the abdominal wall around the

navel that lacks any major blood vessels and nerves, beginners can create the preperitoneal space by entering directly into the skin incision at the lower edge of the umbilical foramen and under the posterior rectus abdominis sheath, similar to the operation of superficial mass surgery. For beginners, this method is safer and simpler than previous methods of creating the preperitoneal space. Second, TEP surgery is difficult due to peritoneal damage. However, the initial operation of single-hole TEP surgery through umbilical incision always compresses the peritoneum downwards through an operating instrument to provide tension. In this case, regardless of whether the peritoneum is damaged, the instrument is always pressing the peritoneum under the lens, and the field of vision in front of the lens is basically clear. Therefore, the expansion of the preperitoneal space can be carried out smoothly (Fig. 5 and 6). Third, the anterior peritoneal space under the posterior rectus abdominis sheath can be entered through the incision at the lower umbilical margin, and the operation can be carried out safely by expanding the space to the lower abdomen with the posterior sheath of the rectus abdominis as the anatomical mark. This method is simpler than the original three-hole method for TEP, which requires accurate identification of the anatomical layer of the membrane. Peritoneal damage easily occurs around the umbilical region far from the groin, but small peritoneal damage in the area not covered by hernia repair materials does not affect the quality of surgery. However, small peritoneal damage above the cover area of hernia repair materials has no significant impact on the quality of surgery. When there is a small peritoneal rupture, the surgeon knows to bring the separated layer closer to the superficial abdominal wall to avoid widespread peritoneal rupture. Fourth, the reason for the difficulty of single-port laparoscopic surgery is that the small incision limits the flexibility of the instrument. Any measures that are conducive to improving the flexibility of single-port laparoscopic instruments are of positive significance. The key point to limiting the flexibility of the device is the aponeurotic incision. The aponeurotic incision should be properly cut to 3-4 cm without affecting

the appearance of the incision. The single-port laparoscopic operation under the posterior rectus abdominis sheath is much more flexible than operating the instrument in the anterior space of the posterior rectus sheath. Fifth, the purpose of the initial operation of TEP surgery is mainly to expand the anterior peritoneal space. The single-port laparoscopic surgical instrument enters the surgical field below the lens and presses down on the peritoneum, creating effective tension and facilitating spatial expansion. In this operation, only one instrument is moved, which alleviates the problem of interference between two instruments in the single-hole operation. Dissection of the hernia sac in the groin region requires frequent coordination of two instruments, which may be difficult but can be attempted by alternating among different orifices. Sixth, if the operation is difficult, TEP surgery can be completed by adding holes or TAPP surgery.

The initial umbilical incision is always needed, and the quality of the operation can be guaranteed. In October 2017, the author performed the first SILS-TEP via umbilical margin incision under the posterior rectus abdominis sheath with another doctor's assistant who also had no TEP operation experience. The operation went smoothly, and the recovery was good. Subsequently, all inguinal patients without surgery and anaesthesia contraindications underwent SILS-TEP via umbilical margin incision under the posterior rectus abdominis sheath, thus the clinicians accumulated early operational experience and gained some unfamiliar local anatomical knowledge. First, there was longitudinal adipose tissue on the deep surface of the linea alba in the lower abdomen of all patients, which could reduce the risk of direct peritoneal incision when cutting the linea alba.

Second, the position directly behind the posterior sheath of the bilateral rectus abdominis has loose adhesion between the peritoneum and the posterior sheath, which can generally expose the space smoothly and rarely cause peritoneal damage. Third, the Retzius space can be easily exposed from the umbilical to the symphysis pubis, but the layer may be deep, so it is necessary to approach the anterior abdominal wall at the

level below the half-loop to return to the original ideal level for TEP surgery. Fourth, the posterior sheath of the rectus abdominis in many patients is very thin, similar in appearance to the preperitoneal fascia, and can be easily cut from behind in order to enter the posterior space of the rectus abdominis. Fifth, attention should be given to identifying the upwards extension of the inferior epigastric artery from the umbilical to extend the anterior peritoneal space under the posterior sheath to avoid the difficulty of visual field exposure caused by the separation of blood vessels to the side of the peritoneum. Sixth, in all patients, the outer margin of the bilateral rectus abdominis is equivalent to the position of the semilunar line, and the peritoneal layer is dense and adherent, which easily causes peritoneal damage. When the space between the bilateral semilunar lines is separated first, the peritoneum is relaxed and compressed downwards, which can form a large angle with the abdominal wall, and is conducive to identifying the gap and successfully removing the peritoneum. However, if the anterior peritoneal fat is not exposed without cutting the midabdominal line, the posterior space of the posterior sheath of the contralateral rectus abdominis is only used to peel the peritoneal adhesion at the semilunar line. Because the peritoneum is tense, the acute angle formed between the peritoneum and the abdominal wall is relatively small even if pressed downwards, which is not conducive to identifying layers to peel the peritoneum, and the membrane is easily damaged. Seventh, when the peritoneum is damaged, the force of the instruments pressing the peritoneum will increase, and too much tension will increase the risk of vascular haemorrhage in the subabdominal vascular branch. This kind of haemorrhage can stop bleeding by itself after the tissue is severed and exceeds the position of the blood vessel, and the main blood stem will rarely bleed due to excessive pulling. Eighth, the silicone sleeve of the Iconport single-incision sealing device inserted in the incision relies on its own elastic support to form a seal, which can be installed in a small preperitoneal gap to establish pneumoperitoneum and can avoid the need to create a large space in

pneumoperitoneum. The larger preperitoneal space is more likely to affect the smooth operation by peritoneal damage and incision bleeding.

Ninth, the operation of alternating coordination of instruments in the separation of the hernia sac can be completed by selecting two operation holes close to each other on the Iconport panel. The operation holes on the plastic panel are 15 mm in diameter and 12 mm in spacing. The parallel relationship between the two instruments is conducive to the alternating and dislocation of the instrument heads. When the two instruments deviate from each other, a 20-30 degree operation triangle can be formed to facilitate the smooth implementation of the operation. Tenth, because the instrument is accessed from the umbilical cord away from the groin area, it is easy to flatten the mesh, and if the surgeon wants to extend the mesh beyond the hernia ring, they simply need to cut out a larger mesh. This group of data included the surgical data of three surgeons in the learning period, and the longer operation time than the single-hole TEP operation time reported in the literature was related to the immature technology in early practice. In this study, the mean operation time for unilateral indirect hernia was 70.5 minutes, the mean operation time for unilateral direct hernia or femoral was 52.8 minutes, and the mean operation time for bilateral hernia was 90.5 minutes. The average operation time was directly related to the surgical experience of the surgeon. There was no need to increase the size of the auxiliary operation hole or change to a TAPP operation for other reasons. Two patients experienced internal spermatic vessel injury, but no other intraoperative complications occurred. Three seroma cases were observed during the 1- to 32-month follow-up period, with no other major postoperative complications. There are no obvious shortcomings to this study.

The main problems in SILS-TEP under the posterior sheath approach are as follows: 1. An appropriate incision sealing device is needed to facilitate the smooth establishment of pneumoperitoneum and preferably to maintain peritoneum integrity. Currently, the single

incision sealing device on the market needs to be improved; 2. Most doctors lack intuitive experience on whether the anterior peritoneal space behind the posterior sheath can be successfully created in the area adjacent to the umbilical foramen; 3. It is necessary to be familiar with the single-port laparoscopic operation to successfully complete the operation; 4. Good team cooperation is needed. For example, when the instrument enters the surgical field from the umbilical incision, it is best to withdraw the lens to guide the instrument under the incision; otherwise, it is easy to penetrate the peritoneum into the abdominal cavity or scratch the superficial abdominal wall, which causes bleeding. After continuous efforts, the surgical skills of the author's team are becoming increasingly mature.

In this group of data, the patients admitted by the author were routinely treated with SILS-TEP via umbilical margin incision under the posterior rectus abdominis sheath. Other members of the research group are still in the stage of selecting indications to carry out different types of surgical procedures. The similar surgeries carried out are mainly arc-shaped skin incision at the lower umbilical margin and transverse incision at the aponeurosis approximately 1 cm below the umbilical hole, which indicate that each surgeon has different understandings of the advantages and disadvantages of this surgical procedure. The author believes that the SILS-TEP operation via umbilical margin incision under the posterior rectus abdominis sheath is safe and feasible, and it is suggested that beginners choose the single-incision sealing device with a relatively small chassis. Surgeons might find it better to familiarize themselves with the single-incision sealing device by transumbilical single-hole laparoscopic appendectomy transumbilical single-hole cholecystectomy or transumbilical single-hole TAPP surgery. During the operation, we can determine in the actual environment of the abdominal cavity which operations can be successfully completed and which operations cannot be successfully completed. In addition, when making an umbilical incision, the aponeurotic layer can be cut, and the peritoneal layer cannot be opened in a hurry. It can be

observed whether the preperitoneal space in the direction of the umbilical hole in the lower abdomen can be easily separated, and the size of the posterior sheath and preperitoneal space that can be successfully separated can be estimated when the size of the umbilical skin incision is determined. The larger the posterior sheath anterior peritoneal space that can be created under direct vision, the simpler the initial operation of endoscopic expansion of the anterior peritoneal space. The author suggests mastering the technique of single-hole TAPP first, because as long as the surgeon gets used to the left and right hand alternating operation, they can pull the tissue in different directions to expose the surgical field. Compared with the three-hole TAPP, the single-hole TAPP operation is not more difficult, and the surgical safety of patients learning the SILS-TEP surgery can be ensured by mastering the single-hole TAPP procedure. It has been confirmed that even if the peritoneum is completely damaged at the beginning, the smooth operation of SILS-TEP will not be affected. The learning curve of SILS-TEP surgery via umbilical margin incision under the posterior rectus abdominis sheath has also been solved. Therefore, the author believes that with simple training and selecting an appropriate single-incision sealing device, beginners can master the skills of SILS-TEP surgery via umbilical margin incision under the posterior rectus abdominis sheath, which can become an advantageous strategy to replace three-hole endoscopic hernia surgery.

## VII. CONCLUSIONS

With the assistance of a suitable single-port laparoscopic device, SILS-TEP operation via umbilical margin incision under the posterior rectus abdominis sheath is safe and feasible and easy to master and popularize.

### *List of abbreviations*

SILS-TEP, totally extraperitoneal single-incision laparoscopic surgery.

BMI, body mass index

TEP, totally extraperitoneal; totally extraperitoneal herniorrhaphy VAS, visual analogue scale.

## ACKNOWLEDGEMENTS

The authors would like to thank the leader of the Affiliated Hospital of the Medical School of Ningbo University for supporting this study.

### *Declarations*

### *Funding*

None.

### *Competing interests*

The authors declare that they have no competing interests.

### *Ethics approval*

This study was reviewed by the research ethics committee of the Affiliated Hospital of Medical School of Ningbo University. Reference Number: 2019 KY0402.

### *Consent to participate*

Written informed consent was obtained from all participants in this study.

### *Consent for publication*

All information in this study was approved for publication by all participants.

### *Availability of data and material*

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### *Code availability*

Not applicable.

### *Authors' contributions*

The author (Xiaojun Wang) is the inventor of the custom-made single port device named Iconport. All operations in this study were performed by all three authors. All authors participated in the study. All authors read and approved the final manuscript.

*Running head:* SILS-TEP by custom-made single-port device.

*Authorship declaration:* Xiaojun Wang is the inventor of the Iconport single-hole device. He oversaw the completion of the main content of the study.

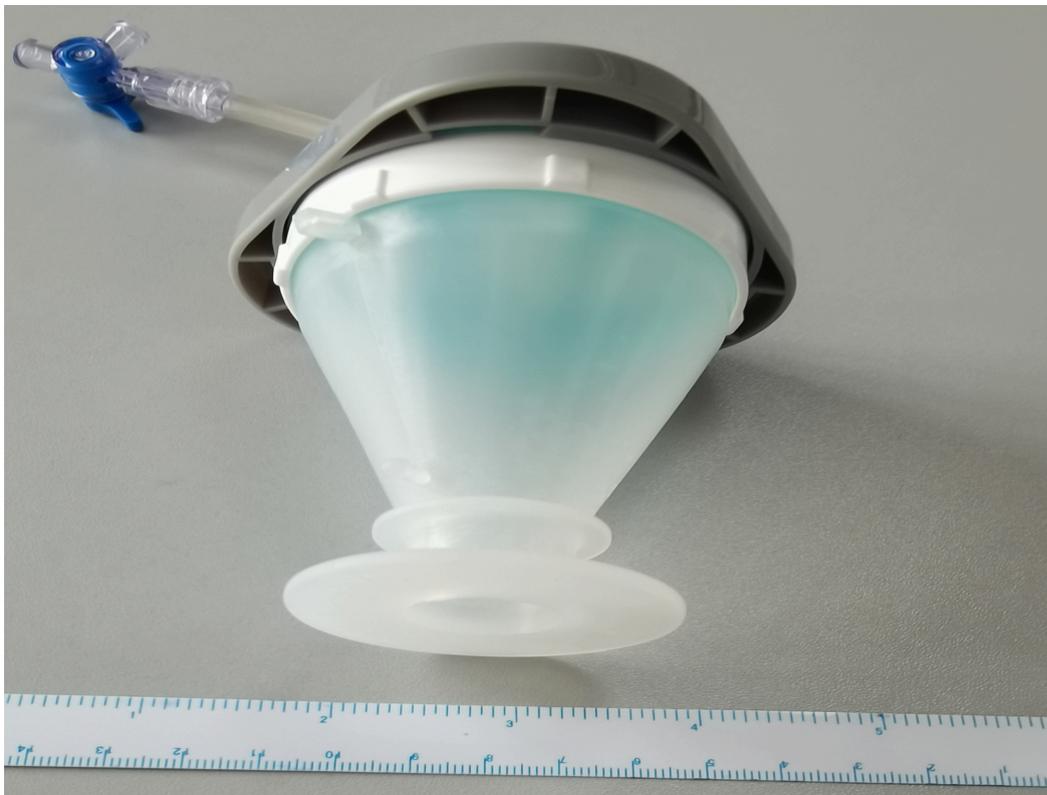
## REFERENCES

1. Filipovic-Cugura J, Kirac I, Kulis T, Jankovic J, Bekavac-Beslin M. Single-incision laparoscopic surgery (SILS) for totally extraperitoneal (TEP) inguinal hernia repair: first case. *Surg Endosc* 23:920-921. <https://doi.org/10.1007/s00464-008-0318-x>.
2. Cugura JF, Kirac I, Kulis T, Sremac M, Ledinsky M, Beslin MB. Comparison of single incision laparoscopic totally extraperitoneal and laparoscopic totally extraperitoneal inguinal hernia repair: initial experience. *J Endourol* 26:63-66. <https://doi.org/10.1089/end.2011.0352>.
3. Agrawal S, Shaw A, Soon Y. Single-port laparoscopic totally extraperitoneal inguinal hernia repair with the TriPort system: initial experience. *Surg Endosc* 24:952-956. <https://doi.org/10.1007/s00464-009-0663-4>
4. Kim JH, Park SM, Kim JJ, Lee YS. Initial experience of single port laparoscopic totally extraperitoneal hernia repair: nearly-scarless inguinal hernia repair. *J Korean Surg Soc* 81:339-343. <https://doi.org/10.4174/jkss.2011.81.5.339>
5. Kim JH, Lee YS, Kim JJ, Park SM. Single port laparoscopic totally extraperitoneal hernioplasty: a comparative study of short-term outcome with conventional laparoscopic totally extraperitoneal hernioplasty. *World J Surg* 37:746-751. <https://doi.org/10.1007/s00268-013-1925-9>
6. Kim JH, An CH, Lee YS, Kim HY, Lee JI. Single incision laparoscopic totally extraperitoneal hernioplasty (SIL-TEP): experience of 512 procedures. *Hernia* 19:417-422. <https://doi.org/10.1007/s10029-014-1337-2>
7. Choi BJ, Jeong WJ, Lee IK, Lee SC. Single-port versus conventional three-port laparoscopic totally extraperitoneal inguinal hernia repair: a randomized controlled trial. *Hernia* 20:789-795. <https://doi.org/10.1007/s10029-016-1499-1>
8. Han YD, Park S, Kim WR, Baek SJ, Hur H, Min BS, et al. Safety and efficacy of single-incision laparoscopic totally extraperitoneal inguinal hernia repair: comparative study with conventional laparoscopic totally extraperitoneal inguinal hernia repair. *J Laparoendosc Adv Surg Tech A* 27:253-258. <https://doi.org/10.1089/lap.2016.0336>.

9. Wakasugi M, Masuzawa T, Tei M, Omori T, Ueshima S, Tori M, et al. Single-incision totally extraperitoneal inguinal hernia repair: our initial 100 cases and comparison with conventional three-port laparoscopic totally extraperitoneal inguinal hernia repair. *Surg Today* 45:606-610. <https://doi.org/10.1007/s00595-014-0967-4>.
10. Kuang-Shun Chueh, Hsiang Ying Lee, Hsin-Chih Yeh, Chia-Chun Tsai, YiiHer Chou, Chun-Nung Huang, Wen-Jeng Wu & Ching-Chia Li (2019): Comparison between singleincision and multiple-incision laparoscopic surgery for totally extraperitoneal inguinal hernia repair, *Minimally Invasive Therapy & Allied Technologies*, DOI: 10.1080/13645706.2019.1637895.
11. Wakasugi M, Tei M, Akamatsu H. Single-incision totally extraperitoneal inguinal hernia repair after previous inguinal hernia repair. *Surg Laparosc Endosc Percutaneous Tech* 26:e149-e152. <https://doi.org/10.1097/sle.0000000000000346>.
12. Wakasugi M, Tei M, Suzuki Y, Furukawa K, Masuzawa T, Kishi K, et al. Single-incision totally extraperitoneal inguinal hernia repair is feasible and safe in patients on antithrombotic therapy: a single-center experience of 92 procedures. *Asian J Endosc Surg* 10:301-307. <https://doi.org/10.1111/ases.12368>
13. Wakasugi M, Suzuki Y, Tei M, Anno K, Mikami T, Tsukada R, et al. The feasibility and safety of single-incision totally extraperitoneal inguinal hernia repair after previous lower abdominal surgery: 350 procedures at a single center. *Surg Today* 47:307-312. <https://doi.org/10.1007/s00595-016-1376-7>.
14. Wakasugi M, Nakahara Y, Hirota M, Matsumoto T, Kusu T, Takemoto H, et al. Learning curve for single-incision laparoscopic totally extraperitoneal inguinal hernia repair. *Asian J Endosc Surg* 12:301-305. <https://doi.org/10.1111/ases.12639>.
15. Masaki Wakasugi, Yujiro Nakahara, Masaki Hirota, Takashi Matsumoto, Hiroyoshi Takemoto, Ko Takachi, Kiyonori Nishioka & Satoshi Oshima. Efficacy of single-incision laparoscopic totally extraperitoneal repair for irreducible or incarcerated inguinal hernia. *Asian J Endosc Surg* (2018):1-6, DOI: 10.1111/ases.12488.
16. Masaki Wakasugi, Yujiro Nakahara, Masaki Hirota, Takashi Matsumoto, Takashi Kusu, Hiroyoshi Takemoto, Ko Takachi, and Satoshi Oshima. Efficacy of Single-incision Laparoscopic Totally Extraperitoneal Inguinal Hernia Repair for Overweight or Obese Patients *Surg Laparosc Endosc Percutan Tech Volume 00, Number 00,* 2019.
17. Wang X, Fei T, Zhou E. Application of a custom-made single-incision sealing device in laparoscopic surgery for totally extraperitoneal herniorrhaphy: initial experience. *Ann Transl Med* 2022; 10(10): 598. doi: 10.21037/atm-21-6809.
18. Wang X, Zhang Y, Shuai Y, Zuo J. Application of self-made single port device for laparoscopic appendectomy: a report of 30 cases. *Chin J Minim Invasive Surg* 14: 837-838,860.



*Fig. 1:* Iconport single-incision sealing device (underside)



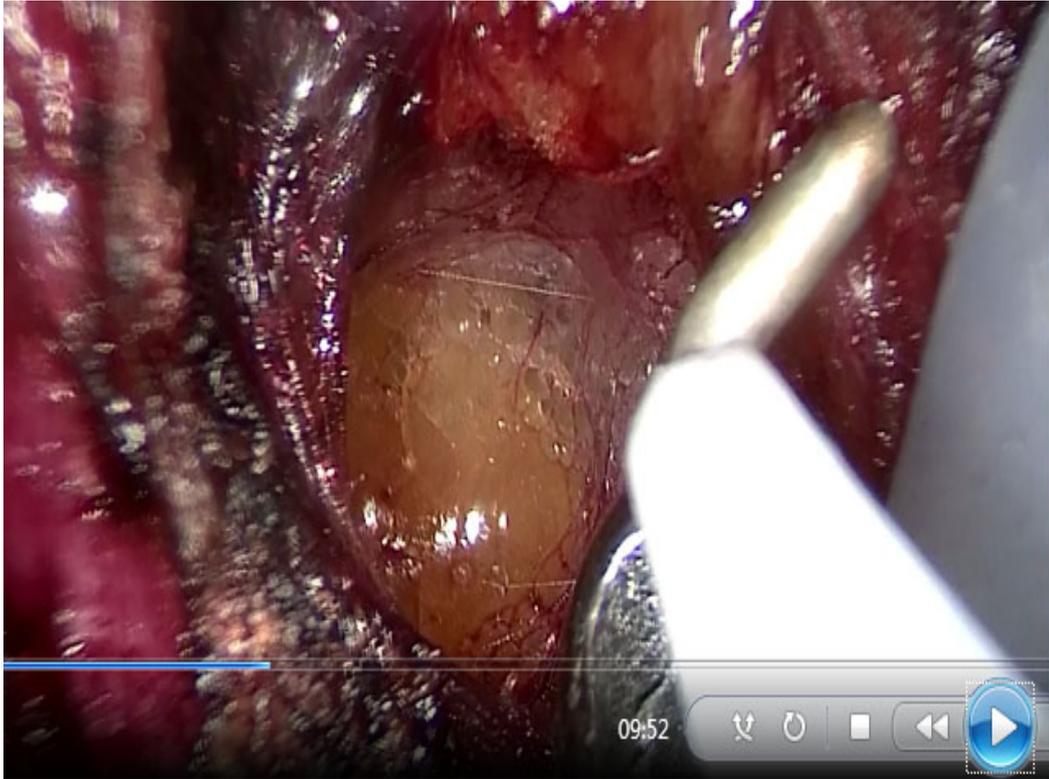
*Fig. 2:* Iconport single-incision sealing device (the obverse side)



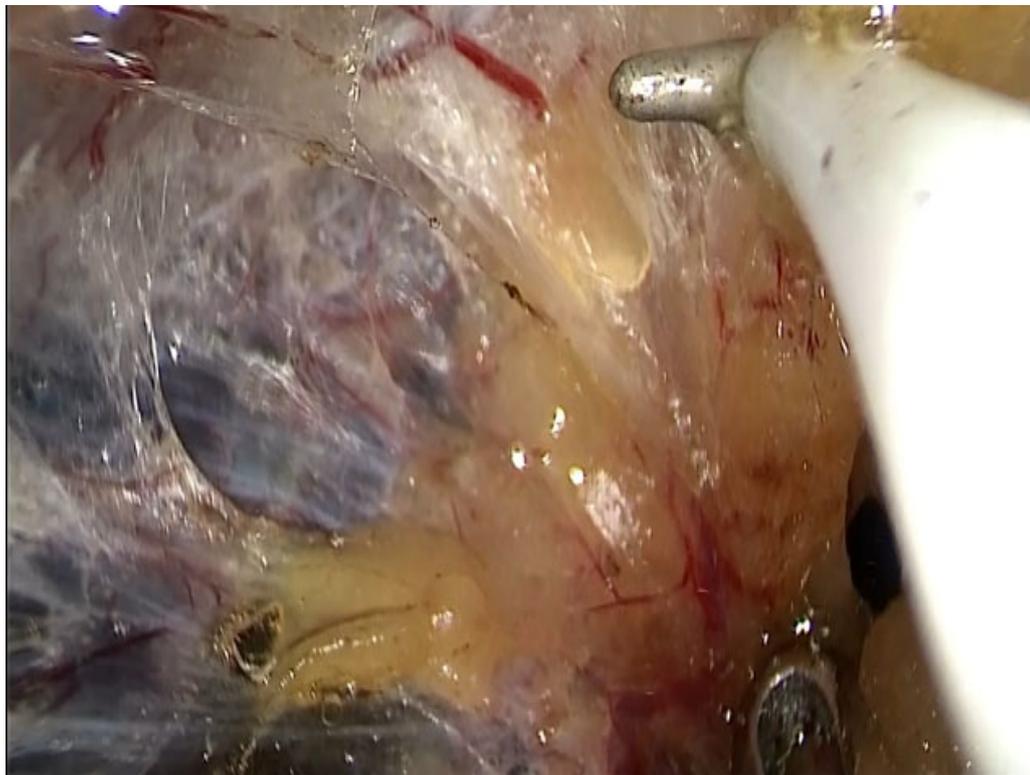
*Fig. 3:* Navel incision



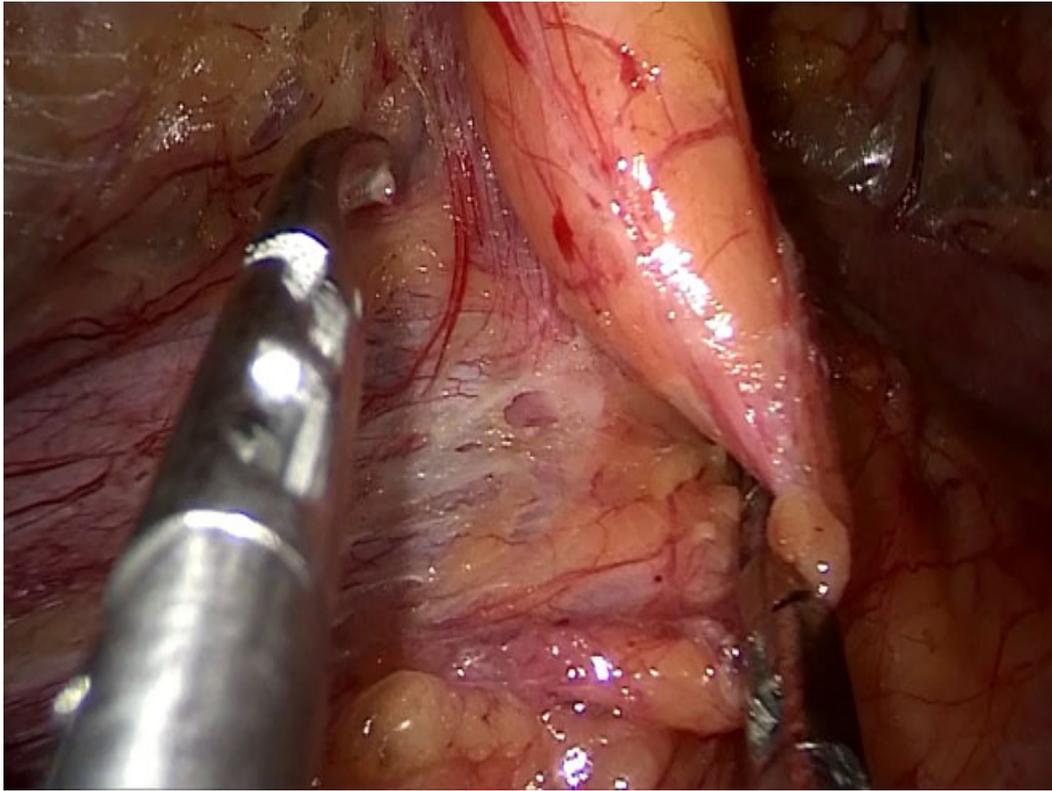
*Fig. 4:* Insertion of the silica gel seal sleeve inside the incision



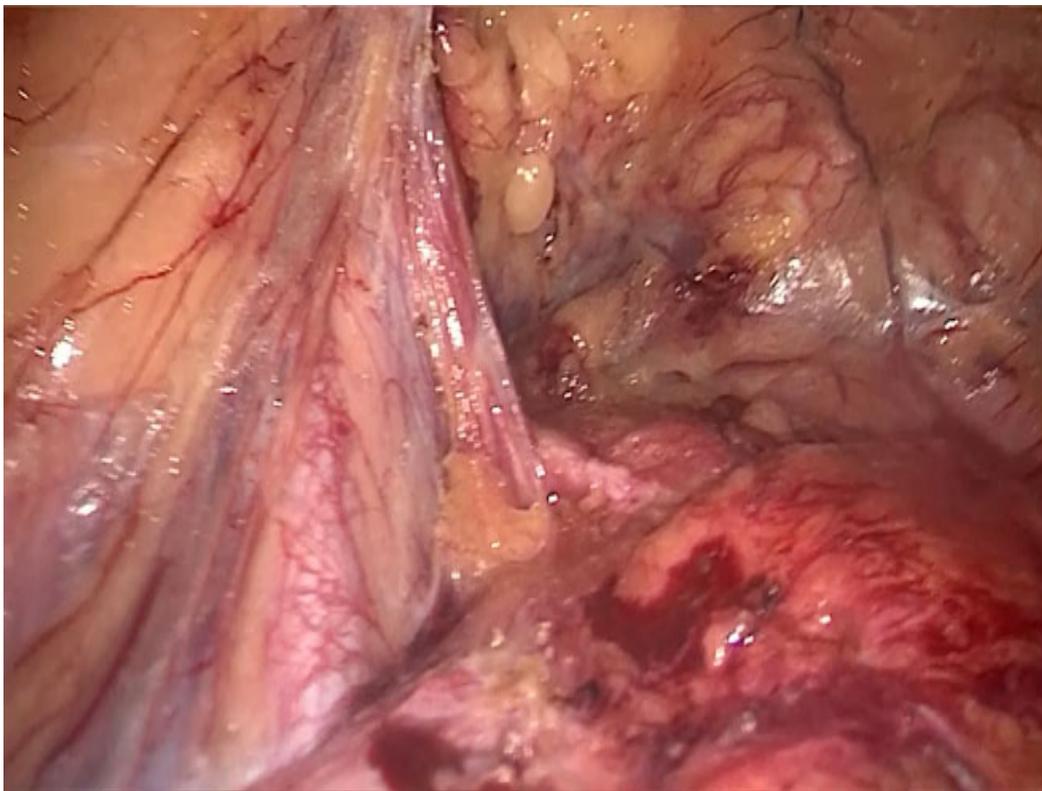
*Fig. 5:* Peritoneal space initially under the posterior rectus abdominis sheath in an umbilical incision



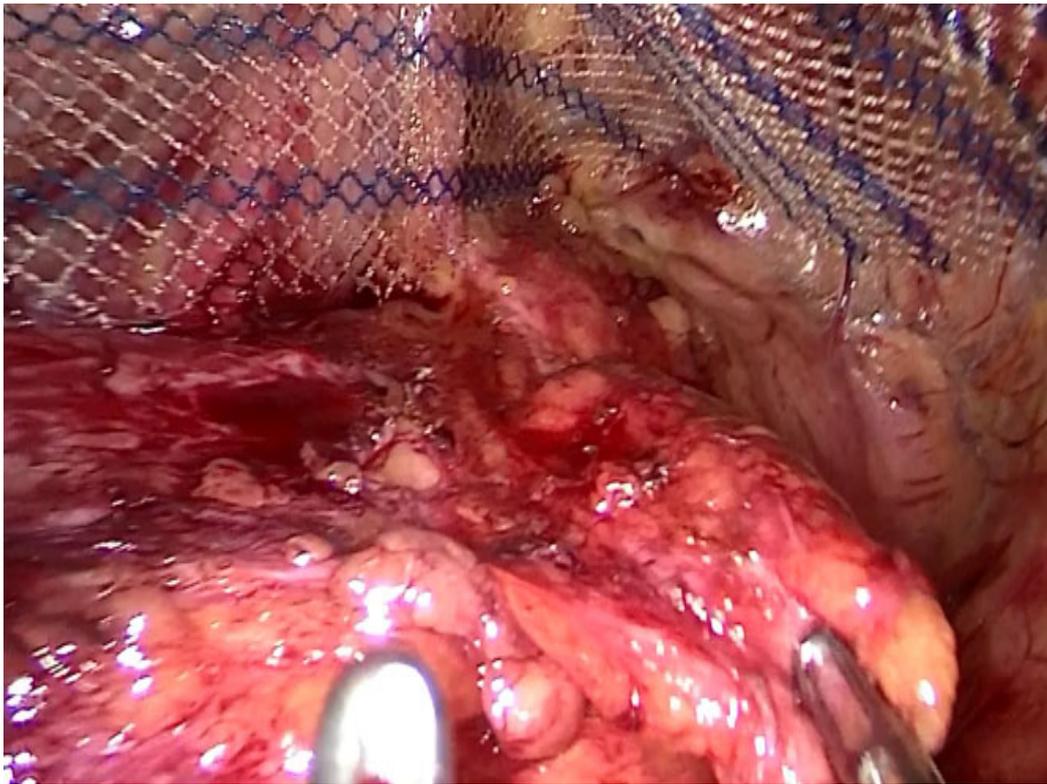
*Fig. 6:* Intraoperative laparoscopic view of the preperitoneal space



*Fig. 7:* Stripping of the indirect hernia sac



*Fig. 8:* Intraoperative laparoscopic view of the preperitoneal space



*Fig. 9:* Mesh deployed to cover the whole myopectineal orifice



*Fig. 10:* Photograph of the postoperative incision