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Umbilical double-port laparoscopy combined with extraperitoneal water injection for the treatment of giant inguinal hernias in infants and young children

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Abstract

Objective Exploration of the efficacy of treating large indirect inguinal hernias in infants and young children using umbilical double-port laparoscopy combined with extraperitoneal water injection.

Methods A retrospective analysis was conducted on 165 cases of primary unilateral large indirect inguinal hernias in infants and young children treated at our hospital from May 2018 to May 2023. Among them, 90 cases underwent umbilical double-port laparoscopic surgery combined with extraperitoneal water injection and high ligation of the hernia sac (Double-Port Group), and another 75 cases underwent conventional three-port laparoscopic high ligation of the hernia sac (Three-Port Group). The two groups were compared in terms of operation time, postoperative pain scores at 24 hours, hospital stay, incision complications, and recurrence within one year after surgery.

Results Both groups successfully completed the surgery without any intraoperative complications. The pain score at 24 hours postoperatively was lower in the Double-Port Group compared to the Three-Port Group, and there was no statistically significant difference in operation time, hospital stay, and incision complications between the two groups ($P > 0.05$). Both groups were followed up for one year postoperatively; the Three-Port Group had one recurrence that was cured after further treatment, while there were no recurrences in the Double-Port Group.

Conclusion Umbilical double-port laparoscopy combined with extraperitoneal water injection for the treatment of large indirect inguinal hernias in infants and young children has the advantages of being safe and reliable, with concealed and aesthetic incisions, and rapid recovery.

Keywords Double-port laparoscopic surgery, Infants and young children, Giant indirect inguinal hernia, Extraperitoneal water injection method

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Introduction

Inguinal hernia is a common disease in pediatric abdominal surgery, and treatment methods include traditional open surgery and laparoscopic minimally invasive surgery. With the continuous popularization of minimally invasive technology, the advantages of laparoscopic surgery, such as minimal trauma, aesthetic appeal, and rapid recovery, have gradually been recognized [1, 2]. Clinically, inguinal hernias are classified based on the diameter of the internal ring orifice: ≥ 15 mm is considered large, 5–15 mm is common, and < 5 mm is concealed [3]. For large hernias, scholars at home and abroad have proposed various schemes, mainly focusing on different treatments of the internal ring orifice, but there is still no unified surgical method [4–6]. The size of the internal ring orifice and its surgical treatment under laparoscopy are related to postoperative recurrence [7], especially in the pediatric population, where the abdominal cavity volume is small and the pressure is high. While ensuring the aesthetic appeal of the incision, more attention should be paid to the key points of internal ring ligation to ensure the success rate of the surgery. Therefore, this study retrospectively compares 90 cases of primary unilateral large inguinal hernias treated with umbilical double-port laparoscopy combined with extraperitoneal water injection and high ligation of the hernia sac at our hospital from May 2018 to May 2023, with 75 cases of conventional three-port laparoscopic high ligation of the hernia sac, to explore its efficacy and safety.

Materials and methods

General information

Inclusion criteria for case selection: Clinical diagnosis of reducible unilateral inguinal hernia, intraoperative laparoscopic measurement of the internal ring orifice

diameter ≥ 15 mm, no history of intra-abdominal surgery in the past 3 months, and no concurrent abdominal diseases. A total of 165 cases were included in both groups, with 102 males and 63 females, aged 9 to 36 months, with an average age of 26.15 ± 5.98 months. Clinical manifestations included a mass in the inguinal or scrotal area, with 95 cases on the left side and 70 cases on the right side. Caliper measurement of the maximum diameter of the hernia sac on the body surface ranged from 2.0 to 8.5 cm, with an average of 4.56 ± 1.82 cm. Preoperative ultrasound indicated unilateral inguinal hernia. Twenty-eight cases had a history of incarceration, all of which were manually reduced and rested for one week before surgery.

Before surgery, the family was fully informed of the advantages and disadvantages of both surgical options, and the choice of surgical method was made in conjunction with the family's wishes. Among them, 90 cases underwent umbilical double-port laparoscopic surgery combined with extraperitoneal water injection and high ligation of the hernia sac as the Double-Port Group (DG), and another 75 cases underwent conventional three-port laparoscopic high ligation of the hernia sac as the Three-Port Group (TG). There was no statistically significant difference in general data between the two groups ($P > 0.05$), making them comparable (Table 1).

All surgeries were done by the same team. The study was approved by the Startup Fund for scientific research, Fujian Medical University (Approval No: 2022QH1298) and the Fujian Natural Science Foundation (Approval No: 2022J011010).

Surgical techniques

The double-port group underwent transumbilical laparoscopic surgery combined with extraperitoneal saline injection and high ligation of the hernia sac under

Table 1 Baseline patient characteristics

Variables	TG (n = 75)	DG (n = 90)	Statistic	P
age in months, Mean \pm SD	25.40 \pm 5.71	26.77 \pm 6.15	t = -1.470	0.144
Sex, n(%)			$\chi^2 = 2.420$	0.120
Female	33 (44.00)	29 (32.22)		
Male	42 (56.00)	61 (67.78)		
Side, n(%)			$\chi^2 = 0.700$	0.403
Right	34 (45.33)	35 (38.89)		
Left	41 (54.67)	55 (61.11)		
incarceration, n(%)			$\chi^2 = 0.240$	0.627
No	63 (84.00)	73 (81.11)		
Yes	12 (16.00)	17 (18.89)		
Maximum diameter of hernia sac, n(%)			$\chi^2 = 1.650$	0.199
< 5 cm	22 (29.33)	35 (38.89)		
≥ 5 cm	53 (70.67)	55 (61.11)		

general anesthesia. Small incisions were made along the skin folds on both sides of the umbilicus. After establishing a pneumoperitoneum, a 5 mm trocar was inserted (Fig. 1A), along with laparoscopic operating forceps and an endoscope. Bilateral internal rings were explored, and the diameter of the internal rings was measured using a ureteral stent tube. If the diameter of the internal ring is ≥ 15 mm, a diagnosis of a giant indirect inguinal hernia (Fig. 1B) was confirmed and recorded. A syringe with a long needle was inserted through the skin surface at the affected internal ring to the peritoneal wall layer around the internal ring, and normal saline was slowly injected to float the peritoneum around the internal ring, reducing the diameter of the internal ring and separating the peritoneum from surrounding structures such as the iliac vessels and vas deferens (Fig. 1C). A non-absorbable suture with a needle was punctured into the abdominal cavity from the avascular area of the lateral abdominal wall, leaving the tail thread outside the body. Under laparoscopic guidance, a single-handed operation was performed with the right hand, holding the needle to

suture along the floating peritoneum (Fig. 1D), and the internal ring was completely sutured in a clockwise direction (Fig. 1E). After inspecting the abdominal cavity for any abnormalities, the pneumoperitoneum was closed, the laparoscopic instruments and trocar were removed, and the umbilical incision was sutured intradermally (Fig. 1F).

The three-port group underwent a conventional laparoscopic high ligation of the hernia sac under general anesthesia. A small incision was made at the skin fold on the left side of the umbilical ring, where a pneumoperitoneum needle was punctured into the abdominal cavity to establish a pneumoperitoneum. A 5 mm trocar and laparoscope were inserted. Additional 5 mm trocars were placed at the lateral edges of the rectus abdominis muscles on both sides of the umbilicus as operating ports, and operating forceps were inserted. Laparoscopic exploration revealed an unclosed single-sided internal ring, the diameter of which was measured and recorded. A non-absorbable suture was punctured into the abdominal cavity through the avascular area of the right abdominal

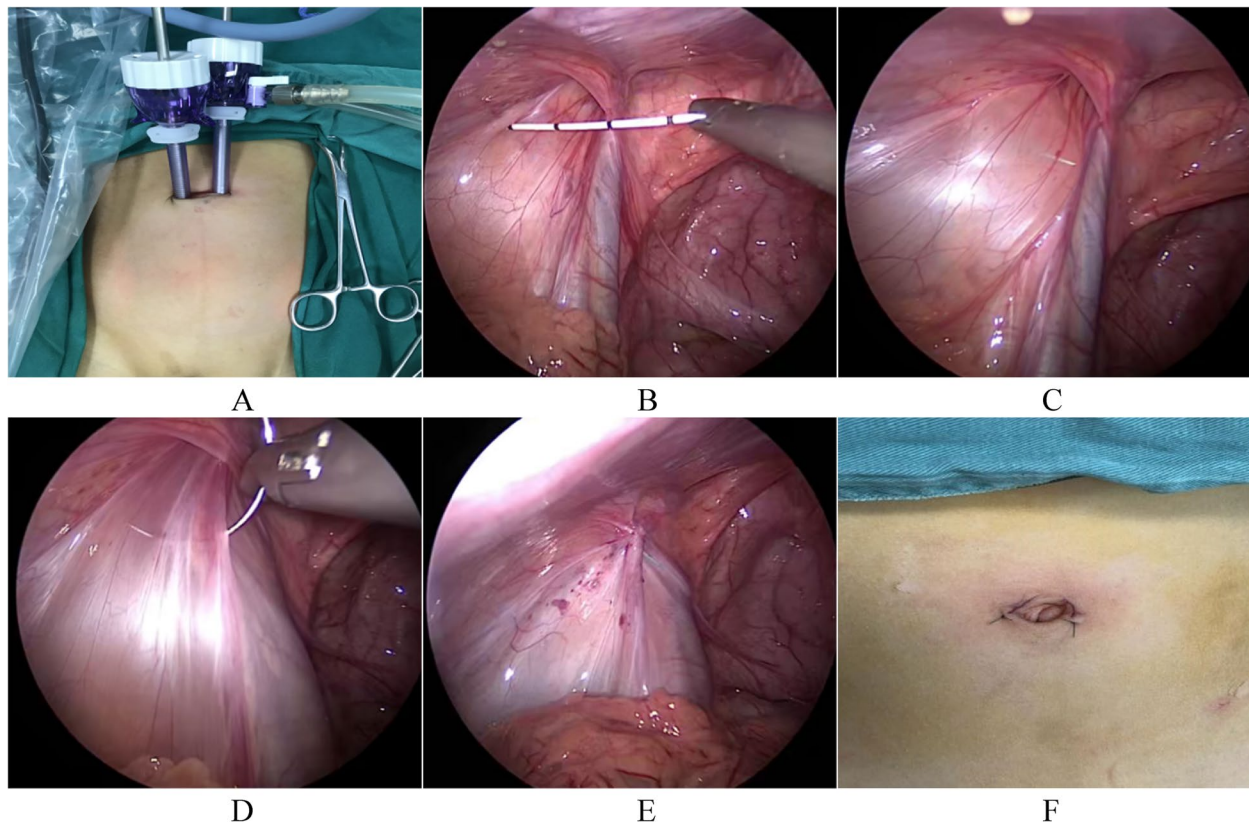


Fig. 1 Transumbilical double-port laparoscopic surgery combined with extraperitoneal saline injection and high ligation of the hernia sac: **A** Trocars are inserted on both sides of the umbilical ring; **B** The diameter of the internal ring is measured under laparoscopy to confirm a giant hernia; **C** Physiological saline is injected around the internal ring in the extraperitoneal space to float the peritoneal layer; **D** Purse-string suture of the internal ring is performed in the extraperitoneal space; **E** The internal ring is closed after purse-string suture; **F** External appearance of the umbilical incision

wall. With the left hand holding the forceps and the right hand holding the needle holder, a purse-string suture and knotting were performed at the affected internal ring. After inspecting the abdominal cavity for any abnormalities, the pneumoperitoneum was deflated, the laparoscopic instruments and trocars were withdrawn, and the wound was sutured with absorbable sutures.

Observation indicators

Observe the surgical duration, postoperative pain score at 24 h (Wong-Baker FACES Pain Rating Scale) [8], and hospital stay of the pediatric patients. Complications include incisional oozing, subcutaneous emphysema, suture line reaction, and recurrence.

Statistical analysis

The analysis was conducted using SPSS 23.0 statistical software. For continuous data, the Shapiro-Wilk test was used to assess normality. If the P-value of the Shapiro-Wilk test was greater than 0.05, the data were considered to follow a normal distribution; otherwise, they were considered not to follow a normal distribution. Normally distributed continuous data were expressed as mean \pm standard deviation, and comparisons between groups were made using the independent samples t-test. Continuous data not normally distributed were expressed as median (Q1, Q3), and comparisons between groups were made using the Mann-Whitney U test. Categorical data were compared using percentages (%), and differences between the two groups were assessed using the chi-square test with a significance level set at $P < 0.05$.

Results

Both groups successfully completed the surgery without intraoperative complications, and no antibiotics were used in the perioperative period. The double-port group had lower pain scores at 24 h postoperatively compared to the three-port group ($P < 0.05$). There were no statistically significant differences in surgical duration, hospital stay, or various complications between the two groups ($P > 0.05$), as seen in Table 2. Both groups were followed up for one year; one case in the three-port group recurred one week after surgery and was cured after a second surgery, while there were no recurrence cases in the transumbilical group.

Discussion

Infantile inguinal hernia occurs when the processus vaginalis fails to close after birth, and the increased abdominal pressure pushes the abdominal contents through the unclosed internal ring into the inguinal canal or scrotum, forming a bulge on the surface of the inguinal area [9]. If it cannot be reduced spontaneously, hernia incarceration will occur. The risk of hernia incarceration in children is about 4%, and it is as high as 8% in infants [10]. Therefore, it is clinically recommended to perform surgery as soon as possible after diagnosis. At present, the surgical treatment for pediatric inguinal hernia includes the traditional inguinal approach and the laparoscopic approach through the abdomen. The purpose of both operations is to close the internal ring [11–13]. Laparoscopic surgery has the advantages of minimal trauma, fast recovery, aesthetic incision, and low recurrence rate [14, 15], and it can also explore the bilateral internal rings simultaneously, which is widely used in clinical practice [16–20].

Table 2 Comparison of Surgical conditions between two groups

Variables	TG (n = 75)	DG (n = 90)	Statistic	P
Operative Time (min)	29.60 \pm 3.38	29.09 \pm 4.20	t = 0.870	0.387
Postoperative pain score at 24 h	2.88 \pm 0.84	1.99 \pm 0.64	t = 7.72	< 0.001*
Length of stay(day)	2.76 \pm 0.49	2.69 \pm 0.47	t = 0.960	0.341
Incisional bleeding, n(%)			$\chi^2 = 0.000$	1.000
No	72 (96.00)	86 (95.56)		
Yes	3 (4.00)	4 (4.44)		
Subcutaneous emphysema, n(%)			$\chi^2 = 0.000$	1.000
No	73 (97.33)	88 (97.78)		
Yes	2 (2.67)	2 (2.22)		
Notch knot reaction, n(%)			$\chi^2 = 0.030$	0.873
No	73 (97.33)	89 (98.89)		
Yes	2 (2.67)	1 (1.11)		
Recrudescence, n(%)			-	0.455
No	74 (98.67)	90 (100.00)		
Yes	1 (1.33)	0 (0.00)		

However, it still has a certain recurrence rate, which is related to the large hernia sac, incomplete ligation of the internal ring, and postoperative crying and constipation in infants and young children.

Giant indirect inguinal hernia, due to the long-term presence of intestines and other abdominal contents in the inguinal scrotum, leads to the dilation of the inguinal canal, enlargement of the canal lumen, reduction in elasticity of the inguinal canal fascia, and adhesion to surrounding tissues. During the open high ligation and dissection of the hernia sac, there is a risk of damaging the vas deferens and blood vessels around the sac wall. However, by using laparoscopic intra-ring purse-string suture, the dissection of the sac wall is avoided, which reduces the risk of injury and postoperative scrotal edema [21, 22]. At the same time, due to the different tissue tension and the growth and development potential in infants and young children, mesh repair is not necessary during the treatment of indirect inguinal hernia, unless the hernia sac is extremely large and there is a clear tendency for recurrence. In such cases, mesh can be used to reinforce the muscle layer to prevent recurrence.

[23].

The author has optimized the closure method of the internal ring and applied the transumbilical double-port laparoscopic surgery combined with extraperitoneal saline injection to treat huge indirect inguinal hernias in infants and young children, achieving good results. The following experiences are summarized: Firstly, the operating compression effect of the transumbilical double-port technique. Unlike the three-port laparoscopic approach, the double-port laparoscopy has a chopstick compression effect. Moreover, the abdominal cavity volume of infants and young children is small, which increases the difficulty of the operation. The surgeon needs to proficiently master laparoscopic technology, with the left hand holding the endoscope and the right hand operating the forceps. The endoscope lags behind the forceps, and the fiber optic angle is appropriately adjusted to expose the surgical field and ensure every step of the operation. Secondly, the extraperitoneal saline injection technique. A long needle is inserted into the extraperitoneal layer near the internal ring from the lateral side of the body surface under laparoscopic direct vision, and normal saline is gradually injected to float the peritoneal layer (Fig. 1C). This separates the peritoneal layer from important structures such as the genital vessels, iliac vessels, and vas deferens, avoiding damage to these vital structures, achieving a bloodless surgical field. After the peritoneum floats, it can also reduce the diameter of the huge internal ring at the same time, reducing the tension of the purse-string suture of the internal ring, which is of great significance for the firm knotting of the suture. Thirdly, the

treatment of the medial folds of the huge internal ring. Infants and young children with huge internal rings often have wide medial folds. When suturing to this area, it is easy to miss and fail to suture completely, leading to postoperative hernia recurrence. For such cases, the author uses the operating forceps to clamp and open these folds during the operation, observe the width and shape of the folds, and then inject saline through the extraperitoneal injection to float and spread the folds, separating them from the vas deferens or the round ligament of the uterus to avoid damage. If the folds are too large to be spread at one time, the abdominal wall suture can be used to pull and spread the folds, and suture the internal ring under direct vision to avoid missing the needle. Fourthly, purse-string suture of the internal ring (Fig. 1F). When suturing the internal ring, it is important to only suture the peritoneum, that is, the needle passes through the back layer of the peritoneum, avoiding bringing in peritoneal fat or tissue behind it. When suturing and knotting the huge internal ring, if too much extraperitoneal tissue is brought in, it will cause problems such as a large knot, unstable knotting, and loose knots, increasing the risk of postoperative recurrence.

In this study, both groups successfully completed the surgery. The double-port group had lower pain scores at 24 h postoperatively compared to the three-port group, mainly because the double-port surgical approach is located at the umbilical ring, where the pain sensation from a single incision at the umbilical area is less than that from three abdominal incisions [24]. Additionally, the extraperitoneal saline injection creates an avascular area, and during purse-string suturing, the probability of damaging important structures such as nerves, blood vessels, and vas deferens is reduced, resulting in less pain compared to the three-port group. Regular follow-up after surgery showed no recurrence in the double-port group, while one case of recurrence occurred in the three-port group one week after surgery. The analysis of the cause suggested that the child had an upper respiratory tract infection with coughing postoperatively, and the preoperative indirect inguinal hernia was large, with a hernia sac diameter of 8.0 cm and an internal ring diameter of 2.8 cm. The medial folds were thick, and the purse-string suture knot was large during surgery, all of which were related to the postoperative recurrence. The child underwent a second surgery three weeks postoperatively, where the loosened suture at the internal ring was found, and the internal ring was resutured and closed. Follow-up for one year showed no further recurrence.

Compared to the traditional three-port laparoscopic surgery, the transumbilical double-port laparoscopic surgery offers several significant advantages [25]. The double-port approach reduces the number of surgical

incisions, thereby decreasing surgical trauma and post-operative pain, while providing superior cosmetic results due to the incision site at the umbilicus. Moreover, the double-port surgery simplifies the procedural steps, although it demands that the surgeon possesses advanced laparoscopic skills to adapt to the smaller abdominal cavity of infants and young children. However, the limitations of double-port surgery include potential restrictions in the surgical field of view and range of manipulation, as well as interference between surgical instruments. In contrast, the three-port laparoscopic surgery provides a broader surgical field of view and higher operational flexibility, which is particularly suitable for dealing with complex or large hernias. The three operative ports reduce the interference of instrument manipulation, making the surgical process smoother. Nevertheless, the three-port surgery is relatively more invasive, may require a longer recovery time postoperatively, and may affect the cosmetic outcome [26].

For laparoscopic surgery on complex hernias, we have found it feasible in the hands of experienced surgeons and capable of reducing complications and improving patient prognosis. However, this necessitates appropriate training for the surgical team and a certain learning curve for the lead surgeon to ensure the safety and efficacy of the surgery [27]. Regarding antibiotic prophylaxis, our study adhered to current clinical guidelines; none of the surgeries used antibiotics, and there were no cases of incisional infection postoperatively.

In summary, for the treatment of large indirect inguinal hernias in infants and young children, the transumbilical double-port laparoscopic surgery combined with extraperitoneal saline injection is safe and reliable, especially in reducing postoperative pain and accelerating recovery. However, to achieve optimal results, professional training for the surgical team is required, and patient-specific considerations must be taken into account when making surgical decisions. Future research should focus on further reducing surgical costs and increasing the accessibility of the surgery.

Conflict of interest

All authors declare that no conflict of interest exists.

Authors' contributions

Zhixiang Xiao and Lijing Wu wrote the main manuscript text, Shaohua He and Jun Li prepared Fig. 1, Lizhi Li and Yingquan Kang prepared Tables 1, and 2. All authors reviewed the manuscript.

Funding

This work was supported by Startup Fund for scientific research, Fujian Medical University (Grant Number: 2022QH1298) and the Fujian Natural Science Foundation (Grant Number 2022J011010).

Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The retrospective medical review was approved by the institutional review board (IRB) of the Fujian Provincial Hospital. And the study was performed in accordance with the principles stated in the Declaration of Helsinki. All patients were managed with standard of care; and the parents or guardians of the patients were thoroughly informed about the procedure, its associated risks, and complications before the surgery. The study obtained informed consent from parents or legal guardians of all participants under the age of 16.

Consent for publication

All data in this study do not involve patient sensitive information, so this section is not applicable.

Competing interests

The authors declare no competing interests.

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Received: 17 June 2024 Accepted: 23 August 2024

Published online: 31 August 2024

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