Chapter 4

Individualized Treatment of Inguinal Hernia in Children

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.68875

Abstract

The incidence of inguinal hernias in various age groups of children ranges from 0.8 to 4.4%. Pediatric indirect inguinal hernia is congenital, originating in the patent processus vaginalis. The inguinal hernia repair is one of the most common pediatric operations. The traditional high hernia sac ligation is the primary treatment for younger patients from 1 to 13 years of age and can correct the condition. The authors performed the high ligation of the hernia sac by the laparoscopic approach for the patients under 13 years old and achieved good therapeutic results in the last 10 years. However, through our clinical study, the authors found that the simple high ligation of hernia sac is inadequate for patients from 13 to 18 years of age, who had a longer medical history, larger diameter of the internal inguinal ring, and more serious defects of the transverse fascia. Pediatric inguinal hernias are prone to postoperative recurrence if the patients were only treated with the high ligation of hernia sac. To repair the transverse fascia and strengthen the posterior wall of the inguinal canal, Lichtenstein hernioplasty with a biological patch was performed for the patients from 13 to 18 years in the authors' department. The aims of this chapter are to narrate the individualized treatment of inguinal hernia in children and try to provide relatively reasonable operative methods.

Keywords: hernia, inguinal, children, herniorrhaphy, laparoscopic, biological patch, individualized

1. Introduction

The incidence varies from 0.8 to 4.4% for inguinal hernia in children less than 18 years [1]. A unilateral hernia is approximately 85% of children with an inguinal hernia. The incidence of incarceration ranges from 6 to 18% for the untreated hernias in infants and young children, but it is about 30% in infancy [2]. A surgical intervention for inguinal hernia is one of the most

common operations performed in children [3]. The individualized treatment program was established for pediatric inguinal hernia in the authors' department and provided a relatively reasonable surgical treatment. This chapter was mainly to describe the individualized treatment program applied to pediatric inguinal hernia.

2. Etiology

Indirect inguinal hernias in children are basically caused by embryologic development, which is mainly composed of patency of processus vaginalis (**Figure 1**). At the early stage of gestation, the testes begin to descend from retroperitoneum and remain at the level of the internal inguinal rings as the kidney ascends into its usual position. The final descent of testes into the scrotum through canalis inguinalis occurs between gestation weeks 28 and 36 [4], combining peritoneum, transversalis fascia, and abdominal wall muscles. The testes descent is "guided" by the gubernaculums. Descending peritoneum ultimately forms the processes vaginalis, and the distal portion of the processus vaginalis wrapped around the testes becomes the tunica vaginalis. In the normal development, the processus vaginalis closes between 36 and 40 weeks of gestation or even shortly after birth [5]. The rate of patency is inversely proportional to the age of children, approximately 80% close to 2 years of age [4]. The left testis descends before the right one and the closure of the patent processus vaginalis on the left also precedes closure on the right, therefore, indirect inguinal hernia occurs more on the right side.

Though the embryology has been widely described, the cell-molecular mechanism is still unclear. Inguinal hernias most probably are inherited [6]. Zhang et al.'s [7] team have found that the functional sequence variants of some genes may be a risk factor for indirect inguinal hernia, such as gene TBX1, gene TBX3, gene SIRT1, and gene GATA6. These variants may affect the differentiation and proliferation of human skeletal muscles and fibroblasts [7–10].

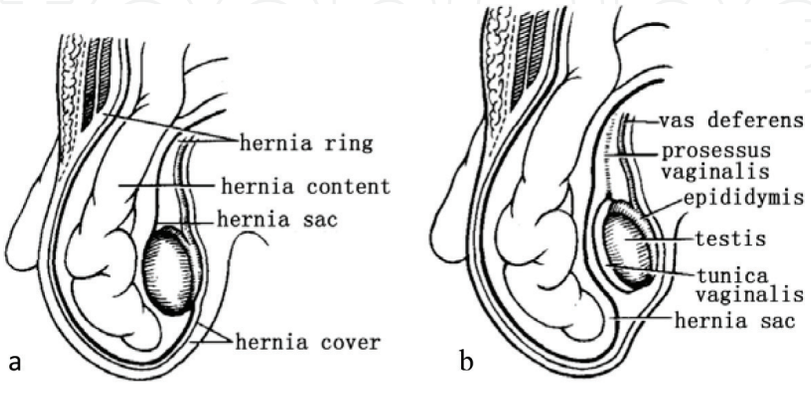

Figure 1. (a) Congenital indirect inguinal hernia and (b) acquired indirect inguinal hernia.

3. Clinical manifestation

A reducible bulge or mass in the inguinal region or unilateral or bilateral enlargement of the scrotum (**Figure 2a** and **b**) is the main diagnostic finding in most groin hernias. These symptoms can occur when abdominal pressure increases, such as while standing, coughing, crying, constipation, and playing, and disappears when patients lie down or fall asleep. Children less than two years of age will express themselves only by crying and screaming, so if children continue crying without obvious reasons, groin hernia should be considered.

There may be associated pain or vague discomfort in the region. Groin hernias are usually not extremely painful unless incarceration (**Figure 2c**) or strangulation has occurred [11]. The bowels inside the hernia sac being incarcerated or strangulated may cause intestinal obstruction, and the testis may turn red gradually. At this time, the spermatic cord is oppressed and the testicle may be diagnosed with ischemic necrosis. As the age increases, the size of hernia sac will gradually increase. The falling bowels pull down the mesentery and cause not only abdominal pain, nausea, and other gastrointestinal symptoms but also walking inconvenience. In addition, the spermatic cord being pressed continuously by the hernia sac will cause spermatic vessel reflux disorder and blood supply reduction as well as spermophlebectasia and testicular atrophy.

Figure 2. Pediatric hernias. (a) Right inguinal hernia, (b) bilateral inguinal hernia, (c) incarcerated left inguinal hernia.

4. Physical and accessory examination

The inguinal region is examined with the child in the standing position or with the infant held in the vertical position by parents. The examiner visually inspects and palpates the inguinal region, looking for asymmetry, bulge, or a mass [11]. Having the patient cough or cry can facilitate in the identification of a hernia. The examiner puts a fingertip into the external inguinal ring by invaginating the scrotum to detect a small inguinal hernia. If a bulge moves from lateral to medial in the inguinal canal, an indirect hernia is suspected. A bulge progressing from the deep to superficial through the inguinal floor suggests a direct hernia [11].

Ultrasound is very useful in the diagnosis, which can avoid the adverse effects of radiation in CT on children's development. There is a high degree of sensitivity and specificity for ultrasound in the detection of occult hernias [11]. An ultrasound can determine the hernia sac, the defect, the hernia contents (the bowel, the omentum, or the bladder), and complications such as hydrocele, guiding the surgical treatment.

5. Diagnosis and differential diagnosis

The diagnosis of inguinal hernia in children is mainly suggested by the history of the bulges or masses in groin area, usually found in children crying or regular physical examination. For slightly older children, blowing bubbles, tickling them to make them laugh, or having them blow up balloons (e.g., examination gloves) will increase intra-abdominal pressure and the hernias may appear. When they are in supine position, the bulges or mass may reduce by itself or by hands, which is called reduction.

For typical cases, it is generally not difficult to make the diagnosis, while for the unclear inguinal abnormalities, doctors can combine with the results of ultrasonic testing or further examination just like CT or MRI if it is necessary. Mainly depending on the different degree and level of processus vaginalis obliteration failure, these methods may help to find the abnormality of inguinal canal, including various types of hydrocele (communicating, non-communicating, funicular), spermatic cord cyst in males, hydrocele of the canal of Nuck in females, cyst of the round ligament of uterus, and indirect inguinal hernias [12]. Communicating hydrocele results from the patent processus vaginalis throughout its length. The fluid collection communicates with the peritoneal cavity and the scrotum. Non-communicating hydrocele happens at the time processus vaginalis obliterates and some fluid accumulates between the cavities of the tunica vaginalis enclosing the testis. Spermatic cord hydrocele results from an abnormal closure of the processus vaginalis, leading to fluid accumulation alongside the spermatic cord, which is separated from and located above the testis. A transillumination test, an ordinary means to distinguish the hydrocele and hernia, is widely used in clinical works. The scrotum is exposed in a dark room with a flashlight under it. If it contains fluid, light is allowed to go through. When it is opaque, a hernia will be detected. Hydrocele and cyst of the canal of Nuck are caused by the incomplete obliteration of the processus vaginalis in girls, which is unusual. The hernia of the canal of Nuck is also an uncommon condition in females, which is homogenous to the indirect inguinal hernia in males. The distinction of these abnormalities, facilitating diagnosis for early surgical intervention, needs to be paid much attention in specific conditions.

6. Treatment

6.1. Indications for surgery

The processus vaginalis is a finger-like projection of peritoneum that typically closes between the 36th and 40th week of gestation. It is thought that 40% closes in the first few months after birth and an additional 20% by the age of 2 [4]. Congenital inguinal hernia is a common

malformation in children that requires operative treatment [13]. Surgery is indicated for all pediatric patients in whom the diagnosis of inguinal hernia has been made. The hernia in infants younger than 6 months should be operated as soon as possible due to high incidence of incarceration. Surgical treatment can be booked selectively for older children with few symptoms [14, 15]. Surgical procedure is provided for inguinal hernia to avoid the complications such as incarceration and obstruction, potentially resulting in ischemia/necrosis of the hernia contents and surrounding cord structures. In females, it is also possible that torsion/ischemia of the ovary can happen [16, 17].

Repair of inguinal hernias is one of the most common pediatric surgical procedures. Indirect inguinal hernias are congenital in origin due to a patent processus vaginalis. In recent years, with the development of materials technology and minimally invasive surgical techniques, surgical treatments of inguinal hernia in children were transitioned from the traditional open surgery to the laparoscopic high ligation of hernia sac and the use of biological patch in open surgery. The different techniques have their own indications and advantages. The authors carried out the individualized treatment of inguinal hernia in children, receiving significant clinical results.

The high hernia sac ligation is the primary treatment for younger patients from 1 to 13 years old. These patients had shorter medical history, smaller diameter of the hernia ring, and less serious defects of the transverse fascia or the inguinal canal posterior wall, therefore, the traditional high ligation of hernia sac can correct the condition. In the last 10 years, the authors have performed laparoscopic hernia sac ligation for the patients younger than 13 years old and have obtained satisfactory results.

According to the results of our clinical study [18], the authors found that the simple high hernia sac ligation is inadequate for adolescents (13 to 18 years old) with a longer medical history, larger diameter of internal inguinal ring, and more serious transverse fascia defects. The inguinal hernia treated with simple high hernia sac ligation in adolescents is prone to postoperative recurrence; therefore, the procedure, similar to the treatment of adult inguinal hernia, should be taken, for example, repairing the transverse fascia and strengthening of the posterior wall of the inguinal canal.

The therapy for pediatric inguinal hernia was carried out by the individualized treatment program in authors' department, which can provide a relatively reasonable surgical treatment. Individualized treatment programs consisted of three kinds of surgical procedures as described below.

6.2. Modified open pediatric inguinal hernia repair

The etiology of pediatric inguinal hernia is a patent processus vaginalis; therefore, inguinal hernias were generally repaired with open simple high ligation of the hernia sac for the patient younger than 13 years. The traditional open technique with high ligation of hernia is the classic surgical treatment method for pediatric inguinal hernia. An inguinal approach is taken for the traditional open technique of inguinal hernia repair. A 3–4-cm-long inguinal incision is made on the same side as the inguinal hernia that is to be corrected. The procedure includes the slit of external oblique aponeurosis, the isolation of the hernia sac from the surrounding cord structures which consist of the cremasteric muscle, vas deferens, and the testicular vessel

surrounding the ligament. A high ligature is located on the proximal separated sac. The distal sac is divided and resected. The external inguinal ring is reconstructed. Although the traditional open inguinal approach is effective for hernia repair in the pediatric population [19–21], it carries numerous risks, including immediate and long-term postoperative complications [22–24]. Postoperative pain, surgical trauma, local swelling usually last 3–5 days for children. In addition, visualization of possible contralateral defects is limited and there remains a risk of hernia recurrence [25].

For the patients with a small hernia sac, the modified open operation of inguinal hernia repair with a small incision in the external inguinal ring could be performed to correct this pathological condition without slitting of the external oblique aponeurosis and ligating highly the hernia sac. This modified approach can maintain the normal anatomy of the inguinal canal to reduce complications. The modified open operation is widely used in Chinese primary hospitals at present, where it is relatively easy to do operations with low recurrence rate but has not been done for a long time in the authors' department.

6.2.1. Operative steps for the modified open pediatric inguinal hernia repair

A small skin incision of about 1–1.5 cm is made along the skin crease, which is located on the surface projection of external inguinal ring supra pubic tubercle. Incision is carried down through the dermis to expose the subcutaneous fat, Camper's fascia. Using sharp and blunt dissection, Scarpa's fascia is identified, grasped, and incised in the direction of the external inguinal ring. A gentle retraction is needed to maintain excellent exposure. Cremaster muscle is dissected to expose spermatic cord and the hernia sac within the external inguinal ring. The external inguinal ring is not opened. The hernia sac is elevated off the inguinal floor and isolated from the surrounding tissue with a blunt dissection in the internal inguinal ring. The hernia sac is opened (**Figure 3a**). If the hernia sac is small, it is directly ligated at its neck where extraperitoneal fat can be seen. If it is large, it is cut to about 2 cm, away from its neck, and then sutured and ligated at its neck (**Figure 3b**). The internal inguinal ring is sutured for 1–2 stitches for repair, if it is large. Subcutaneous tissue and skin are subsequently closed after hemostasis is done carefully.

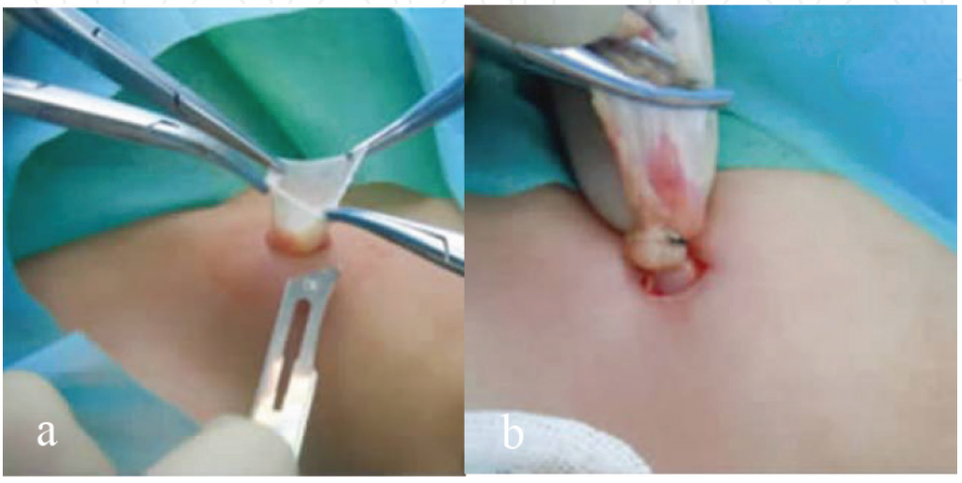

Figure 3. (a) The hernia sac was opened and (b) the hernia sac was sutured and ligated at its neck.

6.3. Laparoscopy high hernia sac ligation assisted with a needle-type grasper

In the last 2 decades, the advent of minimally invasive surgery has completely changed the management of pediatric inguinal hernias [26, 27]. Laparoscopic surgery, since its advent in the early 1990s, is increasingly being preferred by the surgeons and patients worldwide due to its overall benefits, evident by operative results and patient satisfaction [28]. Montupet is credited with performing the first intracorporeal laparoscopic pediatric hernia repair in 1993 [26]. The authors treated pediatric inguinal hernia with laparoscopy high ligation of the hernia sac with the aid of a needle-type grasper (**Figure 4**) [29]. With almost similar results to open mesh repair, laparoscopy provides an alternative to inguinal hernia repair especially in bilateral or recurrent cases [30].

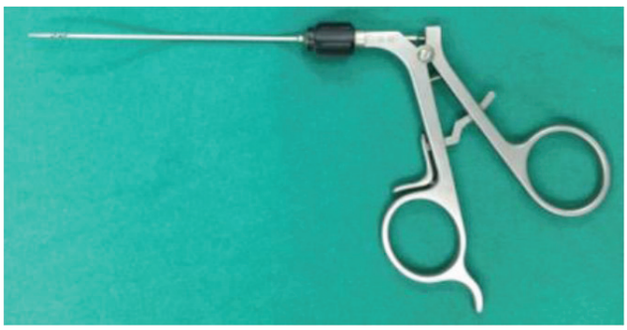

Figure 4. Needle-type grasper.

6.3.1. Preoperative preparation

Preoperative preparation includes fasting for 6 h. To be intraoperatively better exposed and minimize the risk of bladder injury, the bladder should be emptied before surgery.

6.3.2. Patient and team position

All patients underwent general anesthesia. The patient is positioned supine with both arms tucked (**Figure 6a**). To remove the intestine away from the operative area and to improve exposure of the working area, the patients are changed in 15–20° of the Trendelenburg position during the procedure (**Figure 6b**). The surgeon is on the opposite side of the defect to be repaired. The assistant with the camera is on the same side as the hernia to be treated, and surgical nurse should be located on the right side of the patient near the patient's knee. The monitor is placed at the foot of the operating bed.

6.3.3. Surgical procedures

An incision at the infra or supra umbilicus is then made for placement of a 5-mm trocar (we use a 5-mm 30° laparoscope). Access of the peritoneal cavity is achieved using standard techniques with a Veress needle to create the pneumoperitoneum. The pneumoperitoneal pressure was maintained at 8–10 mmHg. Once access to the peritoneal cavity has been established,

an inspection of bilateral internal inguinal ring is made in search of hernia defects. A 1.5-mm incision at or above the linea alba midpoint between the umbilicus and pubic symphysis is made for entering the needle-type grasper. Another 1.5-mm small incision is made at the 12 o clock surface projection of internal inguinal ring. Through it, the endo-closure device (**Figure 5**) with No. 4 polyester thread was rotated back and forth and entered into the pre-peritoneal space at 11 (right side) or 1(left side) o clock of the internal inguinal ring under laparoscopic monitoring. The endo-closure device was then advanced along the lateral side of inferior epigastric vessels within the extraperitoneal space and around the internal inguinal ring and bypassed the vas deferens and spermatic vessels with the aid of needle-type grasper (**Figure 6d–f**). The tip of endo-closure device was pierced the peritoneum into the abdominal cavity at 6 o clock of internal inguinal ring. No. 4 polyester thread was pulled out from the endo-closure device with a needle-type grasper and cleaved into the abdominal cavity (**Figure 6g**), and the endo-closure device was pulled out of the body. The endo-closure device was inserted into the same skin incision again. From 12 o clock of internal inguinal ring to the beginning, the endo-closure device was rotated back and forth and advanced along the lateral side of internal inguinal ring beneath the peritoneum. The endo-closure device entered into the abdominal cavity at the same peritoneal hole as the No. 4 polyester thread had gone through (**Figure 6h**). The endo-closure device was then taken and the No. 4 polyester thread was taken out of the body. After squeezing the air out of the scrotal and groin area, No. 4 polyester thread was then tightened and tied, and the knot was subcutaneously buried. The high ligation of hernia sac was finished (**Figure 6i**). Bilateral indirect hernia was treated the same way. An inspection of the abdominal cavity is made before ending operation. The needle-type grasper is removed under laparoscopic monitoring. A 5-mm trocar was removed after the abdominal cavity air was emptied. Umbilical incision was sutured, and skin incision was intradermally sutured and stuck together with glue.

The manipulation of laparoscopy high hernia sac ligation with the aid of the needle-like grasper is easy to bypass the structure of the vas deferens and spermatic vessels under direct vision and does not injure it. Laparoscopic approaches offer the superior visualization to potentially avoid trauma to the vas deferens and spermatic vessels and the opportunity to accomplish a safe high ligation of the hernia sac at the internal ring [23, 31–33].

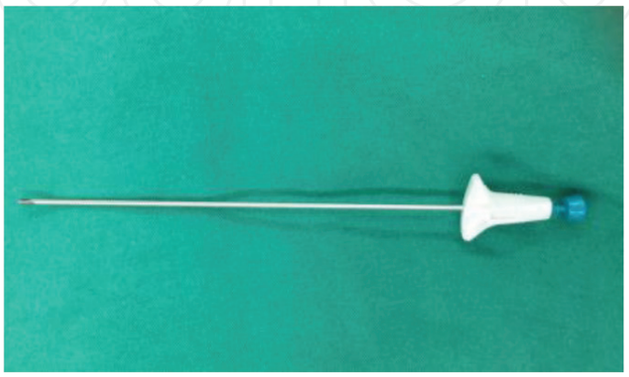

Figure 5. Endo-closure device (COVIDIEN).

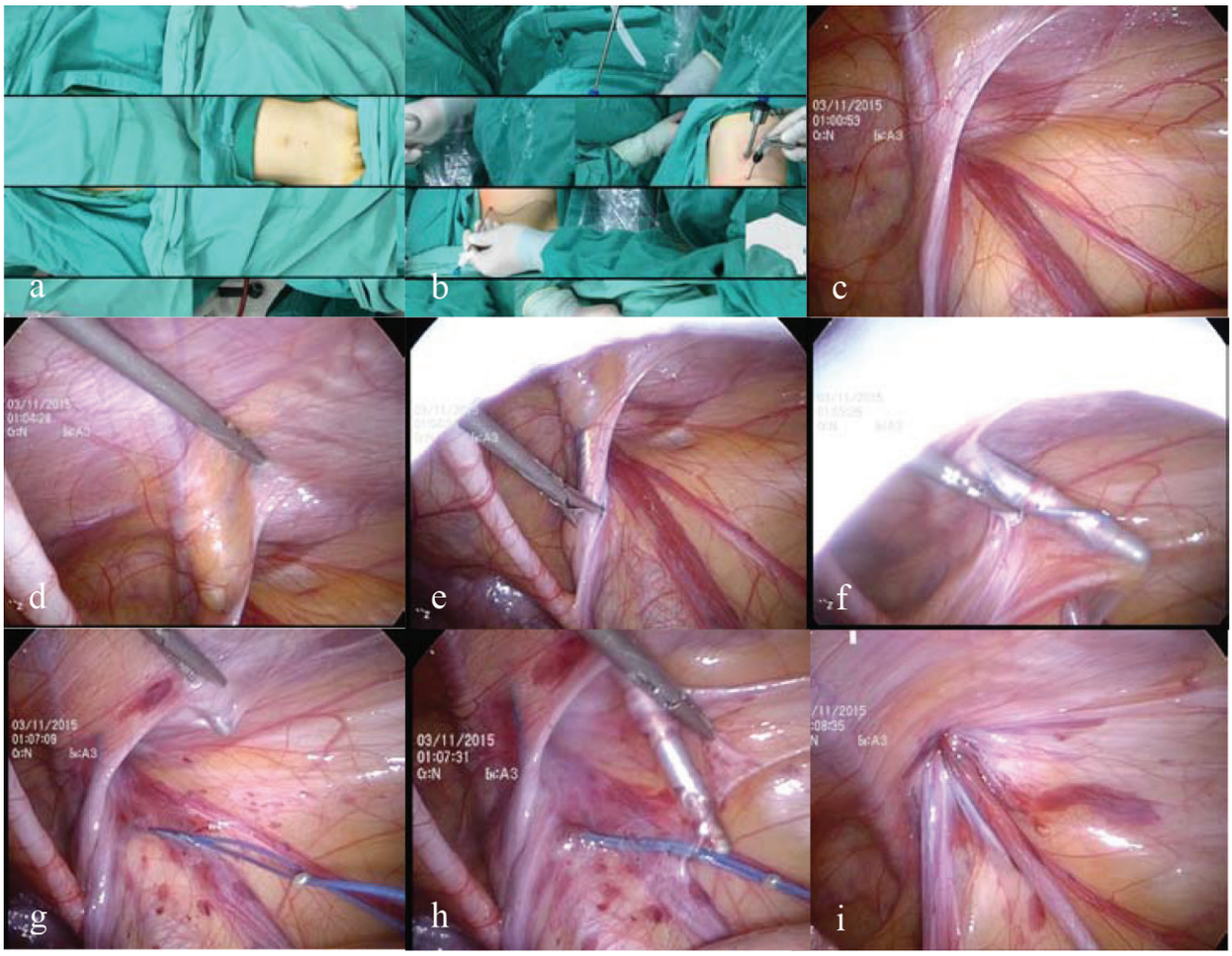

Figure 6. (a) The child with inguinal hernia has been disinfected and draped, (b) intraoperative location of the laparoscopic, needle-type grasper, and endo-closure device with the thread, (c) indirect inguinal hernia, (d) and (e) endo-closure device with No. 4 polyester thread entering into the pre-peritoneal space and then advanced along the lateral side of inferior epigastric vessels and around internal inguinal ring, (f) with the aid of needle-type grasper, the tip of endo-closure device bypassed the vas deferens which was under the tip of endo-closure device in this picture, (g) and (h) the endo-closure device advanced along the lateral side of internal inguinal ring beneath the peritoneum and entered into the abdominal cavity at the same peritoneal hole as the No. 4 polyester thread had gone through, and (i) high hernia sac ligation was finished.

Laparoscopic approaches offer the opportunity to visually inspect the contralateral canal for the presence of an occult hernia without incision, and the contralateral hernia, hiding hernia (**Figure 7**), or other affections can be intraoperatively diagnosed and repaired at the same time while diagnosing unilateral cases, preoperatively. The sensitivity and specificity of laparoscopic examination for detecting hidden PV patency have been reported to be 99.4 and 99.5%, respectively [1]. Compared to the traditional open approach, the advantages of laparoscopic hernia repair include minimal dissection, excellent visual exposure, less complications, comparable recurrence rates, as well as improved cosmetic results. In addition, laparoscopic hernia repair also makes it possible for contralateral inguinal hernias to be defined and repaired in the same operation [34–36]. Up to now, no scrotal hematoma or effusion has been found in the authors' department. At present, laparoscopy high hernia sac ligation assisted with the needle-type grasper is more favorable than open pediatric inguinal hernia repair, which is

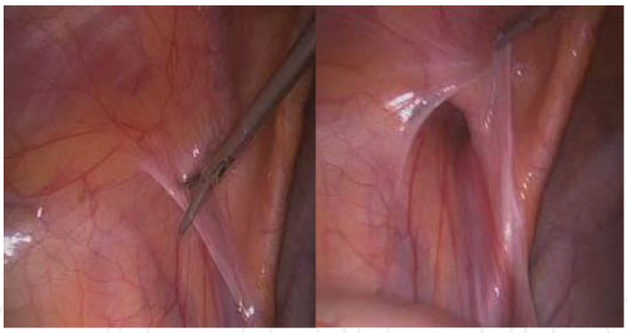

Figure 7. Hidden hernia was found with the aid of a needle-type clamp.

one of the most common surgical procedures in the authors' department. The operation could be implemented as long as there were no anesthetic or pneumoperitoneum contraindications.

The laparoscopic high inguinal hernia sac ligation must establish pneumoperitoneum, which can only be used in general anesthesia, which needs the endotracheal intubation and ventilator-assisted breathing and increases surgical costs and anesthesia-related problems. In addition, the families of children have some psychological concerns with the side effects of general anesthesia, which had a bad effect on surgical treatment.

6.4. Lichtenstein hernioplasty using a biological patch

As for the children from 13 to 18 years old, because simple hernia sac ligation surgery is not enough, the recurrence rate is high. The posterior wall of inguinal canal should also be repaired and strengthened in order to prevent recurrence. At present, it wasn't advocated for the children with hernia, from 13 to 18 years old, to be treated with non-biological synthetic patch (e.g., polypropylene) because they are still in the growth and development stage. Not stretching or contracting, the non-degradable patch can result in local postoperative obvious traction; local foreign body sensation and chronic pain may also cause spermatic cord adhesion and even affect fertility. For children and adolescents, their muscle and fascia tissue will gradually become strong in the growth and development stage. The absorbable biological materials can rely on their own characteristics to repair defects in the early stage and generate the new tissue plates through tissue replacement to prevent recurrence of hernia in the long term. After the biological materials are absorbed or degraded gradually, the biological patch will be replaced by autologous tissue without affecting the growth and development.

The authors found that the simple high hernia sac ligation is inadequate for adolescents who had a longer medical history, larger diameter of internal inguinal ring, and more serious transverse fascia defects and that the procedure similar to the treatment of adult inguinal hernias should be taken in order to repair the transverse fascia and strengthen of the posterior wall of the inguinal canal. The authors proposed the application of the biological patch to the treatment of the inguinal hernia of the patients who are 13–18 years old, and results show that compared with the traditional high ligation of hernia sac, the biological patch tension-free hernia repair surgery did not significantly increase the wound infection, male scrotal effusion, chronic pain or local foreign body sensation, and other complications.

Open "tension free" mesh repair technique, pioneered by Lichtenstein in 1984, is still considered the method of choice for primary inguinal hernia [37, 38]. For children from 13 to 18 years of age, inguinal hernia was treated with Lichtenstein hernioplasty with the biological patch, in which biological patch is placed in front of the transversalis fascia to reinforce the posterior wall of the inguinal canal.

6.4.1. Surgical procedures

The operative steps include dissection of the spermatic cord, dissection and resection of the hernia sac with high ligation (**Figure 8b–d**), and reconstruction of the floor of the inguinal canal. The inguinal canal is dissected to expose the shelving edge of the inguinal ligament, the pubic tubercle, and the sufficient area for biological patch. The biological patch must be large enough to overlap 1.5–2 cm medial to the pubic tubercle. The lateral portion of the patch is split into two tails such that the superior tail constitutes two-thirds of its width, and the inferior tail is the remaining one-third of its width (**Figure 8e**). The lateral tail of the biological patch passed through beneath the spermatic cord from medial to lateral and then sutured together with the medial tail using two vicryl 2/0 interrupted stitches, leaving a hole as large as the diameter of the spermatic cord, which was placed around the spermatic cord at the internal ring, but not too tight to strangulate it (**Figure 8f**). Two interrupted sutures with vicryl 2/0 thread were used to fix the inferior edge of the patch to the shelving edge of the inguinal ligament. The upper edge of the patch was then fixed to the inferior surface of external oblique aponeurosis with two vicryl 2/0 interrupted stitches. The tails were then placed on the surface of internal oblique muscle and fixed with glue. The medial edge of the patch was overlapped the pubic tubercle by 1.5–2 cm and fixed with medical glue in order to prevent medial recurrence. The reinforcement of the floor of the inguinal canal was finished

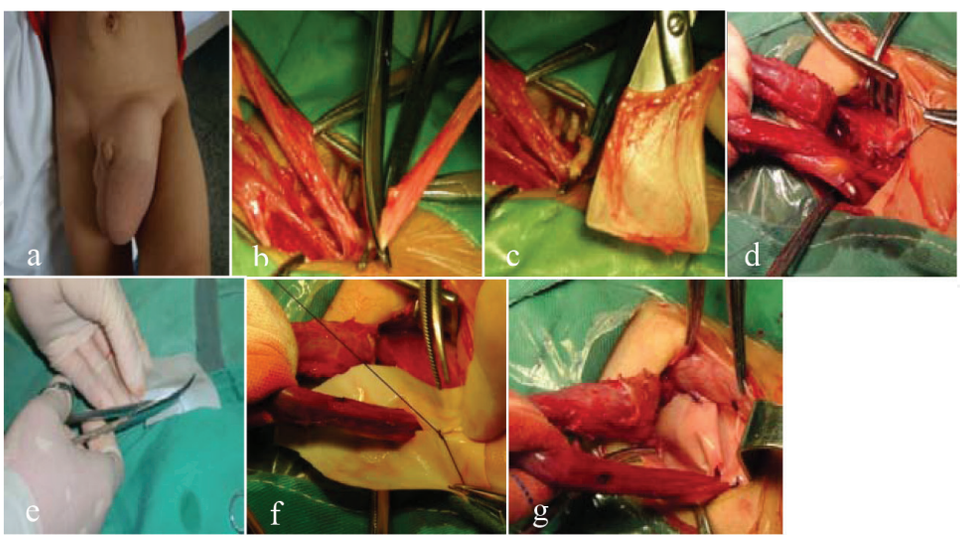

Figure 8. (a) The child with big indirect inguinal hernia, (b) and (c) the hernia sac was dissected and sheared, (d) the hernia sac was sutured and ligated at its neck, (e) a cellular tissue matrix patch (Grandhope Biotech Co., Ltd.) was prepared, (f) the two tails of the biologic patch were sutured together with 2/0 vicryl to surround the spermatic cord, (g) the fixation for the biological patch was finished.

(**Figure 8g**). External oblique aponeurosis was sutured with vicryl 2/0. Subcutaneous tissue is closed with vicryl 4/0. The skin incision was intradermally sutured with vicryl 4/0 and stuck together with medical glue.

Generally, it is not difficult to diagnose inguinal hernia in children; however, before surgery, there is no effective auxiliary examination to diagnose how much the hernia ring defect ranges, which is based on the options of individualized treatment of pediatric inguinal hernia. For some patients who are 13–18 years old, if the extent of hernia ring defect belonged to Gilbert type I or II, laparoscopic high hernia sac ligation could still be used. Preoperative non-invasive examinations, such as ultrasound, which can define the size of the hernia ring defect in most cases, are helpful to choose the surgery and carry out the individualized treatment program of inguinal hernia in children.

The individualized treatment of inguinal hernia in children is currently an effective and relatively reasonable treatment program to improve treatment of morbidity. However, it does not take a long time to use laparoscopic high hernia sac ligation and the biological patch repair. It must be further observed for the long-term effects and needs to be studied on the basis of the present in order to improve the clinical effects and reduce the postoperative complications.

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