



Comparison of laparoscopic percutaneous extraperitoneal closure versus conventional herniotomy in extremely low birth weight infants

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Abstract

Purpose Laparoscopic percutaneous extraperitoneal closure (LPEC) has become routine for repairing pediatric inguinal hernia (IH). Reports on the effective repair of IH in challenging cases, such as extremely low birth weight infants (ELBWI) who become symptomatic soon after birth and have surgery before 1 year of age, are rare; and conventional herniotomy (CH) in ELBWI requires extensive experience of neonatal surgery. We compared LPEC with CH for treating ELBWI with IH.

Methods Consecutive ELBWI with IH treated by either LPEC ($n=17$) or CH ($n=22$) before 1 year of age between 2012 and 2017 were reviewed. LPEC were performed by consultant pediatric surgeons (CPS; $n=3$) with experience of at least 200 cases each. In CH, 11 cases were treated by CPS and 11 by CPS-supervised surgical trainees.

Results There were no intraoperative complications. Operative time and anesthesia time for bilateral IH repairs were both shorter in LPEC. Postoperative sequelae were recurrence (LPEC; $n=1$; repaired by redo LPEC 2 months after the initial repair) and intravenous rehydration (CH; $n=1$; for persistent post-anesthetic vomiting). Recovery was unremarkable in all cases without additional analgesia.

Conclusion LPEC would appear to be a viable option for treating IH in ELBWI, especially bilateral cases.

Keywords Inguinal hernia · Laparoscopic percutaneous extraperitoneal closure · Laparoscopic surgery · Extraperitoneal approach · Conventional herniotomy · Extremely low birth weight infants

Introduction

Inguinal hernia (IH) is one of the most common morbidities treated by pediatric surgeons, affecting 1–4% of children [1]. Traditionally treated by open surgery, IH is now most likely to be treated laparoscopically. Initially, reports in the late 1990s described laparoscopic IH repair involving an intracorporeal Z-suture, followed by reports of an extracorporeal ligation technique [2]. Takehara et al. were the first to perform laparoscopic percutaneous extraperitoneal closure

(LPEC) for pediatric IH in 1995, but only published a report about LPEC in English in 2006 [3]. As a consequence of its proven efficacy, LPEC has become the routine method for repairing pediatric IH, especially in Asia [4, 5]. However, the effectiveness of LPEC in challenging cases, such as extremely low birth weight infants (ELBWI) who become symptomatic in early infancy, remains unclear.

This study aims to evaluate the feasibility of LPEC in ELBWI with IH, by comparing the surgical outcomes of LPEC and conventional herniotomy (CH).

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Materials and methods

Patient selection

This multi-center study involved retrospective review of the medical records of consecutive ELBWI with IH treated before 1 year of age between 2012 and 2017 from three different hospitals (Juntendo University Hospital, Juntendo

Urayasu Hospital, and Seirei Hamamatsu General Hospital) to compare preoperative characteristics and surgical outcomes. Of the 39 cases identified, IH repair was LPEC ($n = 17$) or CH ($n = 22$).

Operative procedures

LPEC was performed by one of three surgeons each with at least 200 cases' experience according to the technique described by Takehara et al. with some modifications [3] (Fig. 1). We inserted two 3 mm trocars, one through the umbilicus and the other on the right side of the patient's abdomen; the former was used for a scope, and the latter was used for a grasping device. Pneumoperitoneum was maintained at 5–10 mmHg, at a CO₂ flow rate of 1–3 L/min. A 2-0 non-absorbable suture was placed around the internal inguinal ring, using a unique 19G LAPA-HER-CLOSURE[®] needle (Hakko Medical, Nagano, Japan) and the internal inguinal ring closed securely. If the contralateral processus vaginalis was patent, it was closed in a similar fashion at the same time.

CH was performed by consultant pediatric surgeons in 11 cases (50%) and surgical trainees in 11 cases (50%) under the direct supervision of consultant pediatric surgeons. CH was performed according to the classic technique described by Lucas-Championniere through an incision in the suprapubic skin crease [6].

After discharge from hospital, patients were asked to visit our outpatient department for routine follow-up in the absence of any complications or concerns, 1 week and 1 month after surgery.

Statistics and ethics

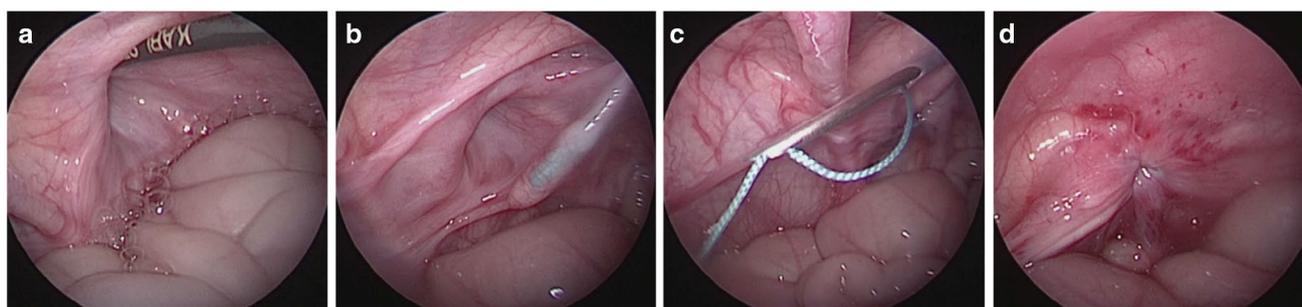
Patient demographics were compared using the Chi square test. The distribution of continuous data was evaluated using the Student's *t* test, and categorical data were compared using Fisher's exact test.

Juntendo University Hospital Institutional Review Board approved this study waiving the need for patients to consent to participate because our study was retrospective, anonymous, and non-interventional.

Results

Subjects

Patient demographics are shown in Table 1. Mean gestational age at birth was 25.4 weeks (range 22–29) in LPEC and 26.7 weeks (range 23–32) in CH; ($p = 0.13$; not significant). Mean birth weight was 669 g (range 460–990) in LPEC and 651 g (range 370–942) in CH; ($p = 0.72$; not significant). There were 15 males (88.2%) and 2 females (11.8%) in LPEC, and 21 (95.5%) males and 1 female (4.5%) in CH. Mean age at surgery was 4.5 months (range 1–12) in LPEC and 8.7 months (range 5–12) in CH; ($p = 0.41$; not significant). Mean weight at surgery was 4890 g (range 2700–8820) in LPEC and 5869 g (range 3670–8300) in CH ($p = 0.018$; significant).



a: Wide hernia orifice.

b: LAPA-HER-CLOSURE[®] being advanced along the lower edge of the internal inguinal ring.

c: Extracorporeal ligation.

d: Completely closed hernia orifice.

Fig. 1 The operative procedure. **a** Wide hernia orifice. **b** LAPA-HER-CLOSURE[®] being advanced along the lower edge of the internal inguinal ring. **c** Extracorporeal ligation. **d** Completely closed hernia orifice

Table 1 Clinical and demographic data

		LPEC <i>n</i> = 17	CH <i>n</i> = 22	Significance <i>p</i>
Gender	Male	15 (88.2%)	21 (95.5%)	0.40
	Female	2 (11.8%)	1 (4.5%)	
Inguinal hernia	Right-sided	5 (29.4%)	6 (27.3%)	0.04
	Left-sided	1 (5.9%)	11 (50.0%)	
	Bilateral	11 (64.7%)	5 (22.7%)	
Mean gestational age at birth		24.4 ± 2.2 weeks	26.7 ± 2.9 weeks	0.13
Range		22–29	23–32	
Mean birth weight		669 ± 175 g	651 ± 157 g	0.72
Range		460–990	370–942	
Mean age at surgery		4.5 ± 2 months	8.7 ± 2.2 months	0.41
Range		0–12	5–12	
Mean weight at surgery		4890 ± 1790 g	5869 ± 1191 g	0.018
Range		2700–8820	3670–8300	

LPEC laparoscopic percutaneous extraperitoneal closure, CH conventional herniotomy

Preoperative incarceration

Five cases in LPEC (29.4%) and two cases in CH (16.7%) developed incarcerations prior to surgery. All were reduced by manual reduction successfully.

Bilateral repairs and concurrent procedures

Bilateral repairs were performed in ten LPEC cases (58.8%) and six CH cases (22.7%). Of these, 8/10 in LPEC (80.0%) and 6/6 in CH (100.0%) had bilateral symptoms preoperatively. The remaining two LPEC cases (20.0%) had incidental patent processus vaginalae identified during laparoscopic examination for unilateral IH repair, and these were closed prophylactically.

One patient in LPEC required a tracheostomy at the time of surgery because of tracheomalacia. Four patients in LPEC underwent concurrent umbilicoplasty for umbilical hernia. One patient in LPEC and two patients in CH had Ommaya reservoirs inserted at the time of surgery for the treatment of concurrent hydrocephalus secondary to intra ventricular hemorrhage.

Operative and anesthesia times; postoperative analgesia

Mean operative time for LPEC (49.2 ± 25.2 min) was significantly shorter than for CH (70.2 ± 32.8 min) ($p = 0.035$). There was no significant difference in mean anesthesia time for LPEC (105.1 ± 36.4 min) and CH (128.2 ± 49.7 min) ($p = 0.017$). See Table 2.

Bilateral repairs were performed significantly quicker in significantly shorter anesthesia time with LPEC compared with CH; 61.3 ± 23.8 min versus 108.8 ± 31.5 min

($p = 0.004$) and 118.0 ± 36.9 min versus 188.3 ± 42.8 min ($p = 0.004$), respectively.

Postoperative pain was controlled in all cases by infiltration of local anesthetic with caudal epidural block according to the preference of the anesthesiologist. No case required additional postoperative analgesia.

Complications, recurrences, and hospitalization

There were no intraoperative complications in either group.

One CH case required intravenous rehydration due to persistent vomiting during postoperative recovery that subsided overnight. There was one recurrence in LPEC (5.9%) 3 days after surgery, and no recurrences in CH. Metachronous contralateral inguinal hernia was not seen in either group. No patients developed ascending testis requiring subsequent orchiopexy.

Hospital discharge was usually on the day after surgery; however, two LPEC cases had other surgery and were not strong enough to be discharged until 1 month after IH repair. IH repair in these two cases did not influence the length of their hospitalization or the timing of discharge.

Discussion

To the best of our knowledge, this is the first study to compare surgical outcome of IH in ELBWI repaired by LPEC or CH during infancy. We confirmed that operative time was significantly shorter for LPEC compared with CH and that anesthesia time, especially for bilateral repairs, was also shorter for LPEC compared with CH.

ELBWI usually become symptomatic soon after birth, and CH in these cases is one of the most challenging

Table 2 Operative and anesthesia times

All IH	LPEC <i>n</i> = 17	CH <i>n</i> = 22	Significance <i>p</i>
Mean operative time	49.2 ± 25.2 min	70.2 ± 32.8 min	0.035
Range	15–61	34–167	
Mean anesthesia time	105.1 ± 36.4 min	128.2 ± 49.7 min	0.17
Range	60–134	68–249	
Unilateral IH	<i>n</i> = 6	<i>n</i> = 17	
Mean operative time	31.9 ± 15.7 min	55.8 ± 18.9 min	0.008
Range	35–105	34–97	
Mean anesthesia time	86.7 ± 28.9 min	105.7 ± 29.4 min	0.17
Range	61–168	68–166	
Bilateral IH	<i>n</i> = 11	<i>n</i> = 5	
Mean operative time	61.3 ± 23.8 min	108.8 ± 31.5 min	0.004
Range	35–105	77–167	
Mean anesthesia time	118.0 ± 36.9 min	188.3 ± 42.8 min	0.004
Range	61–168	122–249	

IH inguinal hernia, LPEC laparoscopic percutaneous extraperitoneal closure, CH conventional herniotomy

procedures for pediatric surgeons, because the hernia sac in ELBWI is usually large and fragile; dissecting the hernia sac safely from vital structures, such as the testicular vessels and the vas deferens is tedious, requiring extensive experience and advanced skills, and prolonged operative and anesthesia times.

In addition, because of the nature of IH in ELBWI with repeated herniation of abdominal contents, adhesions develop around the hernia sac. Dissecting such adhesions during CH is a cause of postoperative scrotal edema. In LPEC, dissection is limited to just around the internal ring. Testicular vessels and the vasa deferentia do not need to be touched, no matter how large the hernia sac, and no matter how severe adhesions may be. Thus, there is less postoperative edema with LPEC with preservation of testicular vasculature and circulation.

In our series, we performed LPEC soon after incarceration in some cases, and both surgery and postoperative recovery were uneventful. While CH after incarceration may be more challenging due to edema around the sac, which renders the border between the sac and the vas deferens indistinct, it is not an issue during LPEC. Another benefit of LPEC is that the surgeon can confirm the viability of tissue that was involved in the incarceration, laparoscopically.

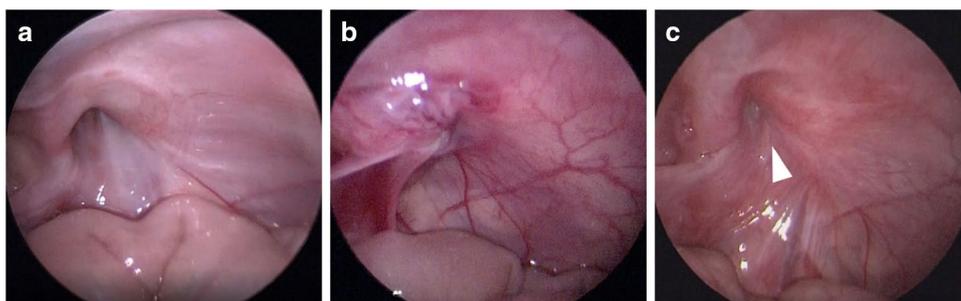
Some surgeons consider the deeper anesthesia and requirement for endotracheal intubation to maintain pneumoperitoneum to be a disadvantage of LPEC [7, 8]. However, general anesthesia is still required for CH and in ELBWI usually involves endotracheal intubation [9]. Therefore, in ELBWI, requirement for endotracheal intubation is not a specific disadvantage of LPEC. In fact, we found

anesthetic time in LPEC was shorter than in CH, with no complications related to anesthesia or pneumoperitoneum. Although one patient in LPEC had a tracheostomy at the surgery for tracheomalacia, no patient had a history of severe chronic lung disease requiring respiratory support or oxygenation and ventilation was maintained sufficiently during pneumoperitoneum.

One male LPEC patient had recurrence of IH 3 days after surgery. Bilateral signs and symptoms were present preoperatively and simultaneous bilateral repair was performed. Despite unremarkable postoperative recovery, fullness was noticed on the right side. Redo LPEC was performed 2 months after the initial surgery. At redo, a knot tied during the initial surgery at the pouch of the recurrent hernia sac was found to be intact, indicating that recurrence was not due to slacking of the knot, but to prolapse of peritoneum into residual space in the original hernia sac (Fig. 2). The peritoneum in ELBWI is extremely pliable and prone to prolapse. Redo LPEC was successful with complete resolution of symptoms and signs. To prevent further recurrence in this case, we applied gentle downward traction on the testis during ligation of the circuit suture to include as much peritoneum as possible to prevent further prolapse (Fig. 3).

An interesting finding was that 58.8% of LPEC cases had bilateral IH; two of which were incidental. Thus, the incidence of incidental contralateral patency in our series was 20% while 30% has been reported in the literature [10]. We believe our results support the hypothesis that ELBWI have a higher risk for bilateral IH. Although both incidental cases were asymptomatic, at the time of prophylactic LPEC, the internal inguinal ring was widely open suggesting that it was

Fig. 2 Recurrence of IH in an LPEC case. Intraoperative findings. **a** The internal inguinal ring at the time of initial surgery. **b** The internal inguinal ring after extraperitoneal ligation. **c** The internal inguinal ring at the time of redo surgery. A knot tied during the initial LPEC repair was intact (arrow head). *IH* inguinal hernia, *LPEC* laparoscopic percutaneous extraperitoneal closure



a: The internal inguinal ring at the time of initial surgery.
b: The internal inguinal ring after extraperitoneal ligation.
c: The internal inguinal ring at the time of re-do surgery.
 Note: A knot tied during the initial LPEC repair was intact (arrow head).

IH: inguinal hernia
 LPEC: laparoscopic percutaneous extraperitoneal closure

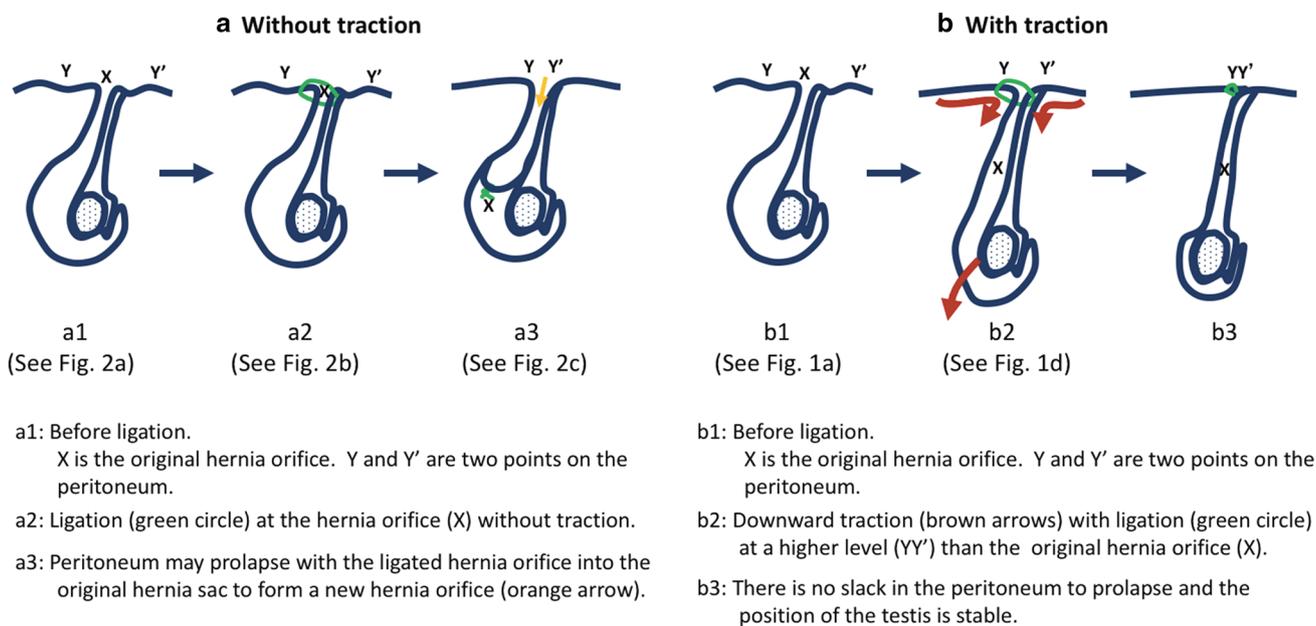


Fig. 3 Diagrams showing the benefit of downward testis traction during ligation. **a** Without traction. **a1** Before ligation. X is the original hernia orifice. Y and Y' are two points on the peritoneum (see Fig. 2a). **a2** Ligation (green circle) at the hernia orifice (X) without traction (see Fig. 2b). **a3** Peritoneum may prolapse with the ligated hernia orifice into the original hernia sac to form a new hernia orifice

(orange arrow) (see Fig. 2c). **b** With traction. **b1** Before ligation. X is the original hernia orifice. Y and Y' are two points on the peritoneum (see Fig. 1a). **b2** Downward traction (brown arrows) with ligation (green circle) at a higher level (YY') than the original hernia orifice (X) (see Fig. 1d). **b3** There is no slack in the peritoneum to prolapse and the position of the testis is stable

only a matter of time before they became symptomatic. We assert the value of LPEC, especially in ELBWI over babies born at term, for enabling inspection and possible early treatment of potential IH.

Postoperative ascending testis is a known complication of IH repair [1, 11]. Theoretically, LPEC can minimize postoperative adhesions around the spermatic cord because the

inguinal canal is untouched, and reduce the risk for postoperative ascending testis. Wang et al. suggested that the incidence of ascending testis in patients after laparoscopic IH repair was no different to the incidence in age-matched boys without IH and that any postoperative change in position of a testis was not iatrogenic but induced by a natural reaction of the remnant process vaginalis [12]. While this

is a reasonable concept, we believe that avoidance of excessive dissection and gentle downward traction on the testis during ligation contribute more to preventing postoperative ascending testis.

We are aware that the relatively small number of subjects in this study is a limitation. There may also be some degree of sample bias with regard to operative and anesthetic techniques because subjects were enrolled from three different hospitals, and operator bias because of differences in experience and prowess of treating surgeons. In addition, our follow-up period is also a limitation because LPEC is a relatively new technique that has not been performed routinely for very long.

Conclusion

LPEC would appear to be a viable option for treating IH in ELBWI, especially bilateral cases. We plan to collate data from follow-up outpatient attendances to present the long-term outcome of our cases, with particular emphasis on the general impact of surgical stress in the short-, medium-, and long-term, as well as fertility status to fully assess the feasibility of LPEC for treating all children, including ELBWI.

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