



Laparoscopic totally extraperitoneal ligation for pediatric inguinal hernia: a novel surgical treatment

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Received: 1 December 2020 / Accepted: 15 February 2021
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Abstract

Background Laparoscopic repair is widely performed for the management of pediatric inguinal hernia (PIH), and different laparoscopic surgical methods are used. Herein, we present the application of laparoscopic totally extraperitoneal ligation (TEPL), which is a novel surgical method for PIH repair and is similar to traditional high ligation.

Methods In this study, 103 pediatric patients underwent laparoscopic TEPL for inguinal hernia. Data including demographic characteristics, clinical presentation, time of surgery, length of hospital stay, and postoperative complications were analyzed retrospectively.

Results The patient's median age at surgery was 4.3 years, and the median body weight at surgery was 18 kg. The preoperative diagnoses were as follows: $n = 53$, right inguinal hernia; $n = 45$, left inguinal hernia; and $n = 5$, bilateral inguinal hernia. All patients were discharged on the day of surgery. The operative times were 27.2 min for unilateral inguinal hernia and 28.8 min for bilateral inguinal hernia. All patients, except one who had scrotal bruise, did not present with postoperative complications.

Conclusions Laparoscopic TEPL, which is similar to traditional high ligation, is used for the treatment of PIH. Moreover, it is safe, beneficial, and feasible. Double ligation is performed on the extraperitoneal space, and the assessment of contralateral patent processus vaginalis is not complex. However, further studies should be conducted to assess for long-term outcomes.

Keywords Inguinal hernia · Pediatrics · Child · Herniorrhaphy · Totally extraperitoneal · Laparoscopy

Pediatric inguinal hernia (PIH) is the most common cause of surgery among children. PIH is attributed to the protrusion of intra-abdominal organs via the patent processus vaginalis. High ligation is the ligation of the proximal hernia sac and is the traditional management for PIH [1–3]. This procedure is considered effective, and it has been the treatment of choice for over 100 years [4]. Open repair is routinely performed via transverse inguinal crease incision [1]. Meanwhile, since laparoscopic inguinal hernia repair was first introduced by Montupet in 1993 [5], various laparoscopic surgical techniques have been recommended for PIH. So far, there are at least 34 methods for laparoscopic PIH repair [3].

These techniques can be divided into two categories. One is intraperitoneal suture ligation of the internal ring, which requires the use of a telescope and intracorporeal suture of the internal ring with or without herniotomy [5, 6]. The other is extraperitoneal suture ligation of the internal ring via percutaneous suture needle insertion under laparoscopic-guided visualization [7, 8]. However, neither of the concepts of laparoscopic PIH repair fully reproduces the traditional method of high ligation. Herein, we propose the use of laparoscopic TEPL of the sac for PIH repair, which is a technical concept that is most similar to traditional high ligation.

Materials and methods

In total, 103 patients underwent laparoscopic TEPL for PIH between November 2017 and January 2019. Electronic medical records were reviewed retrospectively. All surgeries were performed by a single pediatric surgeon (E. Jung). Data on demographic characteristics, hernia site,

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and perioperative data were collected, and the operative procedure was described in detail. Moreover, information on operative site, time of surgery, length of hospital stay, and postoperative complications was analyzed. This study was approved by the ethics committee/institutional review board of Keimyung University School of Medicine, Dongsan Medical Center (IRB: 2020-07-102).

Preoperative assessment/patient selection

PIH was diagnosed based on the presence of inguinal bulging. When it was challenging to evaluate, the most important sign is a history of inguinal bulging, and photos taken by parents' using their cell phone were also helpful. The preoperative evaluation of PIH was standardized at our center, and it included medical history taking, physical examination, and serum biochemical studies. Detailed data about hernia site, cord thickness, and testicular status were obtained during physical examination. Abdominal ultrasonography was performed to evaluate the inguinal and scrotal areas and to identify the contents of the hernia sac and status of the contralateral patent processus vaginalis (CPPV).

There are no detailed guidelines for the indications of laparoscopic TEPL. The surgery is based on the operator's decision with consideration of the ergonomic range of laparoscopic instruments. Newborns were excluded because they have extremely thin peritoneum and narrow operative field. In case of unilateral inguinal hernia, routine exploration of the CPPV was performed, and ligation was conducted with the same method used if CPPV was observed.

Operative technique

After the induction of general anesthesia, the patient laid in supine position, and the Credé's maneuver was routinely performed to empty the bladder. Manual reduction should be performed before skin preparation. All trocars were inserted along the midline (Fig. 1). A 5 mm umbilical skin incision was made at the ipsilateral side of the inguinal hernia using a number 11 blade. Subcutaneous dissection was performed to expose the anterior fascia of the rectus muscle. Then, a transverse incision was made at the exposed anterior fascia of the rectus muscle, and the inferior leaflet of the incised fascia was clamped with Mosquito. The rectus abdominis was dissected, and a short tunnel was established in the space between the rectus abdominis and the peritoneum attached beneath the posterior fascia of the rectus. This process is essential when using the extraperitoneal approach for groin hernia. A 5 mm bladeless trocar was inserted via the created tunnel; then, the space was inflated using carbon dioxide with a pressure of 8 mmHg. A 5 mm 30° camera was inserted via the umbilical trocar. The tunnel was then dissected in the direction of the symphysis pubis using the

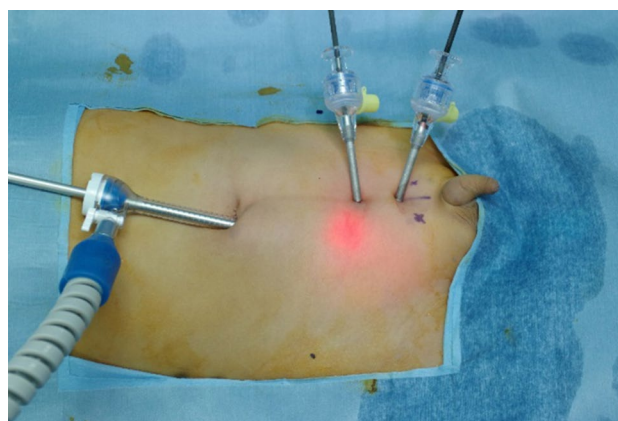


Fig. 1 One 5 mm umbilical trocar and two 3 mm trocars are inserted at the abdominal midline in a patient with right inguinal hernia

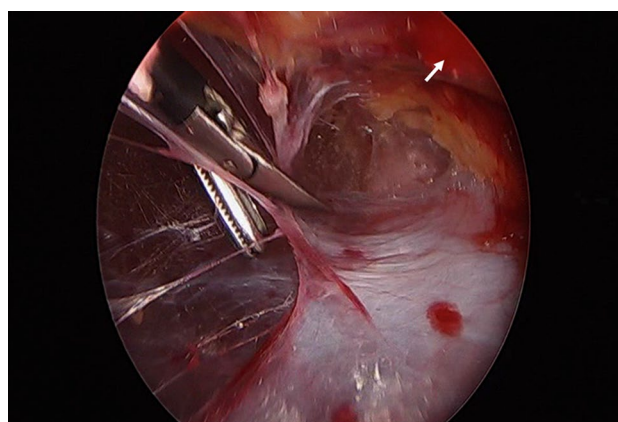


Fig. 2 Extraperitoneal space dissection was performed with a 5 mm telescope. During dissection, rectus abdominis muscle is seen superiorly (arrow) and fascia of transversalis is seen inferiorly

camera scope. Visualization of the extraperitoneal space with the rectus muscle superiorly and the peritoneum inferiorly was facilitated (Fig. 2). After blunt dissection of the extraperitoneal space with a camera, two 3 mm ports were placed in the suprapubic area and in the midline between the symphysis pubis and the umbilicus. A 3 mm atraumatic and a 3 mm dissector were used for extraperitoneal dissection. To identify the hernia sac, the procedure was continued until anatomical landmarks such as the inferior epigastric vessels and the inguinal ligament were exposed (Fig. 3). Caution must be taken not to tear the peritoneal and hernia sacs. The peritoneum surrounding the internal ring was dissected to reach and to identify the hernia sac with the spermatic cord structure. Then, the hernia sac, which was located at the anteromedial side of the cord structure, was separated from both the vas deferens and the spermatic vessels at the level of the proximal internal ring (Figs. 4, 5). The hernia sac should be cautiously separated to prevent

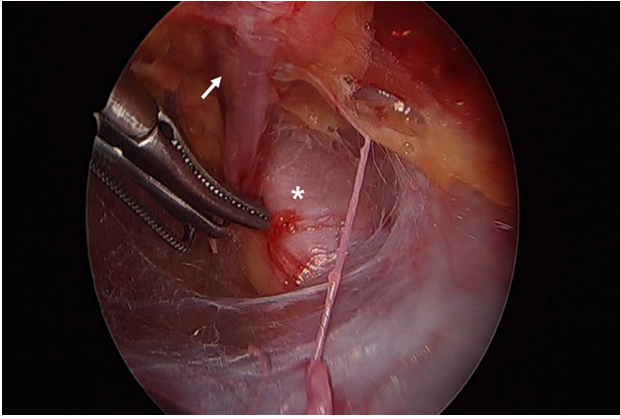


Fig. 3 The hernia sac with a spermatic cord structure was exposed (asterisk). Inferior epigastric vessels were observed above (arrow)

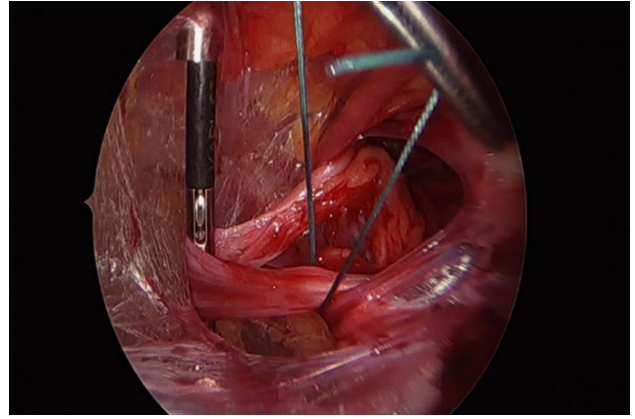


Fig. 6 The unabsorbable thread was placed around the hernia sac for high ligation

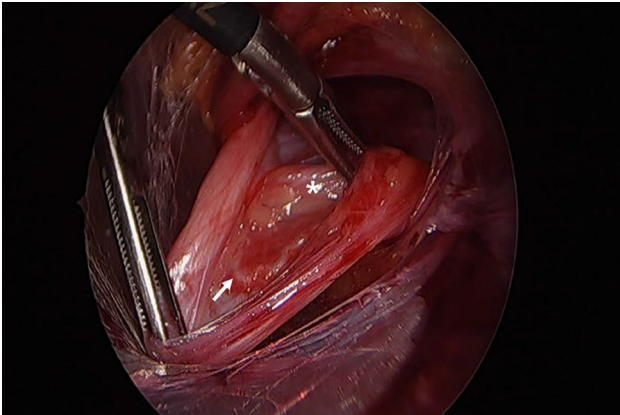


Fig. 4 The hernia sac was located anteromedially to the spermatic cord structure: vas deferens (arrow) and spermatic vessels (asterisk) were identified

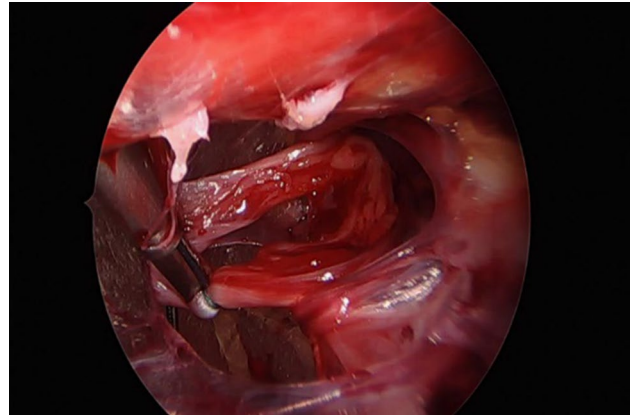


Fig. 7 Ligation was performed with a laparoscopic knot pusher

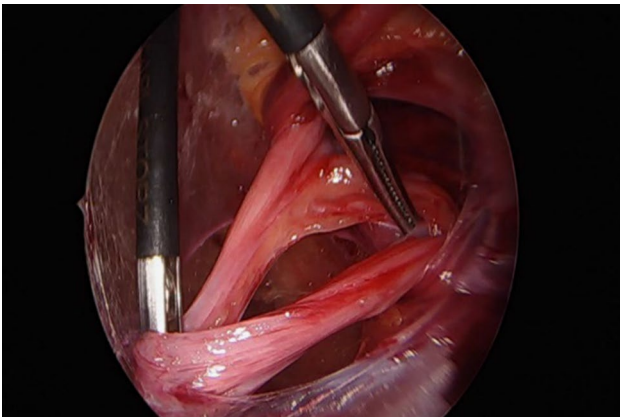


Fig. 5 The hernia sac was clearly separated from the cord structure

injury in the vas deferens and testicular vessels using the same technique utilized in open inguinal hernia repair. The

magnified laparoscopic view facilitated a clear visualization of the hernia sac, vas deferens, and spermatic vessels. The separated inguinal hernia sac should not contain any herniated contents. Once the hernia sac was separated from the spermatic cord structure, the proximal sac must be further dissected to achieve a successful high ligation. We placed a 3-0 ETHIBOND thread via the 3 mm trocar, and it was set around the sac at the level of the proximal internal ring and was removed using the same trocar (Fig. 6). Ligation was performed with a 3 mm laparoscopic knot pusher (Fig. 7). The device was pushed extracorporeally to make a knot in the extraperitoneal inguinal space. After assessing whether the vital structures were free from the ligated hernia sac, hernia sac ligation was performed again for double ligation similar to open high ligation. The presence of CPPV on the opposite side was evaluated using the same method after unilateral inguinal hernia ligation was completed (Fig. 8). Then, it was ligated regardless of its size if it was opened. No further surgery should be performed if CPPV is closed. After inspecting for the dissected areas for hemostasis,

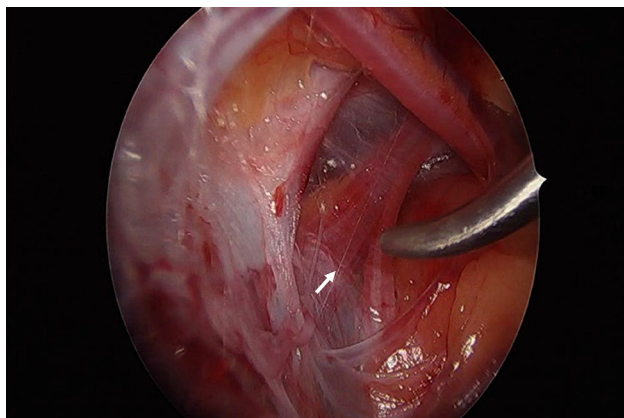


Fig. 8 Exploration for CPPV was performed. The peritoneal lining (arrow) was observed without a herniated structure. This indicates that CPPV was closed

the extraperitoneal space was decompressed by releasing CO₂. The periumbilical fascia was closed with 4-0 Monosyn sutures. The skin was then closed using a subcuticular interrupted suture. A skin tape (Steri-strip®) was applied to approximate skin edges for each 3 mm trocar site.

Results

The demographic characteristics of patients are presented in Table 1. Male predominance was observed in the study population ($n = 68$ male patients and $n = 35$ female patients). The median age at surgery was 4 years (range 4 months–11 years), and the median body weight at surgery was 18 (range 7–40) kg. The body weight of all patients, except for two, at surgery was > 10 kg. The incidence of right-sided inguinal hernia was two times higher than that of left-sided inguinal hernia. Only five patients were diagnosed with bilateral inguinal hernia (Table 1).

Table 1 Characteristics of patients and preoperative diagnosis

Sex	$N = 103$
Male	68 (66.1%)
Female	35 (33.9%)
Age at surgery (median, years)	4.3 (range 4 months–11.3 years)
Body weight at surgery (median, kg)	18 (range 7–40)
Gestational age	
< 37 weeks	4 (3.9%)
≥ 37 weeks	99 (96.1%)
Sites (preoperative diagnosis)	
Right	53 (51%)
Left	45 (44.1%)
Bilateral	5 (4.9%)

Table 2 depicts postoperative outcomes. In total, 64 patients underwent unilateral repair of PIH, and 39 bilateral repairs due to the presence of CPPV. All surgeries were performed as 1 day surgeries. Patients with stable vital signs were discharged 6 h after surgery. 1 week after surgery, the patients underwent routine check-up for wound infection or scrotal swellings. None of the patients presented with wound infection or pain after a week. One patient had scrotal bruise, which improved after 1 week. Further, recurrence was not observed.

The procedure was converted to transabdominal internal ring suture with herniotomy in a 4-year-old boy weighing 15 kg. Due to peritoneal tearing during dissection of the TEP space and collapsed surgical field, the surgery became challenging. One patient presented with metachronous hernia 6 months after unilateral laparoscopic TEPL. This 15-month-old female patient had left inguinal hernia. Cord lipoma excision was performed in a 5-year-old male patient with left inguinal hernia. Excision of the cord lipoma was performed easily with hook electric cauterization. The pathological diagnosis was confirmed as lipoma.

Discussion

High ligation is the most common surgery among pediatric patients [1–3]. Traditional high ligation has been used as an alternative to minimally invasive surgery, despite the use of small incisions. Several studies have been compared these techniques, and results showed that laparoscopic hernia repair is a useful and safe procedure for pediatric patients [9, 10]. There are two main categories of laparoscopic repair for PIH. One is intracorporeal, and the other is extracorporeal or percutaneous [1]. However, both categories are different from the traditional high ligation. Intracorporeal ligation involves laparoscopic suture ligation at the level of the internal ring with or without peritoneal incision. The

Table 2 Postoperative outcomes

Operative site	
Right	39 (37.9%)
Left	25 (24.3%)
Bilateral	39 (37.9%)
Operative time (mean, mins)	
Unilateral	27.2
Bilateral	28.8
Length of hospital stay	1 day surgery
Complications	1 (scrotal bruise)
Conventional laparoscopic repair	1
Metachronous inguinal hernia	1
Cord lipoma	1

surgical knot is left and exposed in the peritoneal space [5, 6, 11, 12]. Extracorporeal or percutaneous ligation is the extracorporeal ligation of the internal ring via percutaneous incision under laparoscopic-guided visualization [7, 8, 13]. Ligation of the sac is performed extra-peritoneally; however, it is not a totally preperitoneal approach because the suture material is passed through and the surgical knot may be located in the subcuticular space squeezing a part of the abdominal muscle or its aponeurosis. Our approach is different from other laparoscopic ligation techniques because it is a totally preperitoneal approach. Furthermore, methods including separation of the hernia sac from the spermatic cord structure, double ligation using a knot pusher, and presence of a surgical knot in the extraperitoneal space are similar to traditional high ligation. The only difference is the need for skin crease incision. All procedures could be performed extra-peritoneally via laparoscopy.

Our technique is similar to laparoscopic totally extraperitoneal (TEP) hernia repair in adults, which was first described in 1993 [14]. This method has been equally effective as compared to other surgical techniques for adult inguinal hernias so far [15]. Our technique is similar to adult TEP in terms of dissection and separation of the hernia sac, but not the application of a prosthetic mesh. The extent of dissection is less than that of in an adult. Since the purpose of laparoscopic TEPL is high ligation and there is no need to have space for mesh application, the dissection around the spermatic cord structure is sufficient. High ligation of the separated hernia sac without prosthetic reinforcement is the main difference between this technique and laparoscopic adult TEP. Though we could not validate pain score in this study, all the cases were performed as single day surgery. Further study for the comparison of pain score with other surgical technique is needed.

To evaluate for CPPV, exploration of the opposite side was routinely performed. When CPPV was found and even if there were no symptoms including inguinal bulging preoperatively, TEPL is performed. However, there was one metachronous case in which the contralateral side was not fully visualized because of minor peritoneal injury sustained during contralateral dissection. Nevertheless, CPPV on laparoscopy does not guarantee that metachronous hernia can be prevented based on previous studies [16, 17].

There was no specific inclusion criterion for laparoscopic TEPL. Patients were selected by the surgeon with consideration of the ergonomic range of laparoscopic instrument movement. The procedure was not performed on newborns and small infants because they have extremely thin peritoneum and small surgical field. In relation to this reason, our study showed that the body weight of all patients, except two, was > 10 kg. Laparoscopic TEPL might be a challenging procedure in small infants because they have a small space between the umbilicus and the suprapubic area. Port

insertion and dissection of the surgical field are challenging. Furthermore, the peritoneum can easily tear, leading to surgical field collapse. However, we believe that laparoscopic TEPL can be successfully performed on patients weighing < 10 kg if there are technical advancements and smaller reliable instruments are available. Even though there was no incarcerated hernia including ovaries, small intestine, and omental tissue in our study period; we believe that the procedure could be performed in such situations. A part of sac can be incised and the incarcerated organ can be managed with incised window. However, if incarcerated organ is strangulated or suspected jeopardized, routine laparoscopic exploration should be followed. We also believe that laparoscopic TEPL can be performed without difficulty in case of prior open or conventional PIH repair. However, further studies are needed to apply such recurrent cases.

In one patient, laparoscopic TEPL was converted to conventional laparoscopic repair of the internal ring with herniotomy. Peritoneal tearing occurred when the extraperitoneal space was dissected. The inflow of CO₂ gas caused intra-abdominal cavity swelling. Hence, the extraperitoneal space could not be maintained. In this case, surgeons can convert to any surgical method as per their discretion.

We encountered a case of inguinal hernia with cord lipoma in a male patient. Karabulut has reported that the incidence rate of cord lipoma was 4.5% among pediatric patients with inguinal hernia [18]. The International Endo-Hernia Society guidelines recommend that the symptomatic protruding cord lipomas be removed [19]. Approaching the cord lipoma via conventional laparoscopic surgery is not easy. However, it was safely performed with the extraperitoneal approach in this case.

In our technique, we double ligated the sac without sac division or excision. In previous studies describing both open and laparoscopic inguinal hernia ligation, ligation of the indirect sac without sac division or sac excision had higher recurrence rate [11, 20]. However, in the textbook of pediatric surgery, authors still describe that the distal sac excision is not needed [1]. Although no recurrence was observed in our study, this study is focused on short term results and feasibility. Hence, long-term follow-up and further study is mandatory for analyzing the effect of ligation of the indirect sac without sac division.

The advantages of laparoscopic TEPL are similar to those of classical high ligation and conventional minimal incision of laparoscopy. Important structures such as the vas deferens and the spermatic vessels can be magnified from a laparoscopic view, which prevents damage. The hernia sac can be tied correctly at the level of the internal ring without kinking the vas deferens and the testicular vessel. Laparoscopic TEPL may be a safe procedure. It is less invasive than conventional laparoscopic repair since it is performed in the extraperitoneal space. Thus, penetration

of the intraperitoneal cavity is prevented, and this reduces complications including intraperitoneal bowel injury and postoperative functional ileus. The pressure and flow CO₂ required to maintain the extraperitoneal space in this procedure is less than that in the conventional laparoscopic method. Thus, complications correlated to CO₂ absorption might be reduced.

The current study had several limitations. That is, it is neither a prospective research nor a randomized controlled trial. Selection bias caused by the operator might have existed. Thus, further studies on long-term outcomes should be conducted. In addition, the main operator (E. Jung) has extensive experience in laparoscopic totally extraperitoneal inguinal hernia repair in adults. Laparoscopic TEPL cannot be easily performed without a full understanding of the extraperitoneal anatomy. However, further studies must be conducted to validate the efficacy of this technique including learning curve, postoperative pain, and its extension. Further evaluation for comparing open repair and other laparoscopic techniques is required.

In conclusion, laparoscopic TEPL is a novel laparoscopic version of high ligation for PIH. It does not cause peritoneal penetration and can facilitate a safe separation of the sac. The surgical knot is located on the extraperitoneal space; double ligation can be performed; cord lipoma can be dealt with easily; and exploration for CPPV is possible. However, further studies on long-term outcomes must be performed, and this technique should be compared with open high ligation or other laparoscopic methods for hernia repair.

Acknowledgements Thanks to RN Jaesoon Park and Jihee Yun for organizing data.

Compliance with ethical standards

Disclosures Eun-jung Koo and Eunyoung Jung have no conflicts of interest or financial ties to disclose.

References

- Snyder CL, Escolino M, Esposito C (2020) Inguinal hernia. In: Holcomb GW III, Murphy JP, St Peter SD (eds) *Holcomb and Ashcraft's pediatric surgery*, 7th edn. Elsevier, China, pp 784–804
- Read RC (2009) Herniology: past, present, and future. *Hernia* 13:577–580
- Smith AK, Speck KE (2018) Pediatric laparoscopic inguinal hernia repair: a review of techniques. SAGES, <https://www.sages.org/wiki/pediatric-laparoscopic-inguinal-hernia-repair-a-review-of-techniques/>. Accessed 23 Feb 2021
- Johnson J, Roth JS, Hazey JW, Pofahl WE (2004) The history of open inguinal hernia repair. *Curr Surg* 61:49–52
- Schier F (2006) Laparoscopic inguinal hernia repair—a prospective personal series of 542 children. *J Pediatr Surg* 41:1081–1084
- Becmeur F, Philippe P, Lemandat-Schultz A, Moog R, Grandadam S, Lieber A, Toledano D (2004) A continuous series of 96 laparoscopic inguinal hernia repairs in children by a new technique. *Surg Endosc* 18:1738–1741
- Spurbeck WW, Prasad R, Lobe TE (2005) Two-year experience with minimally invasive herniorrhaphy in children. *Surg Endosc* 19:551–553
- Takehara H, Yakabe S, Kameoka K (2006) Laparoscopic percutaneous extraperitoneal closure for inguinal hernia in children: clinical outcome of 972 repairs done in 3 pediatric surgical institutions. *J Pediatr Surg* 41:1999–2003
- Esposito C, Escolino M, Farina A, Settini A (2014) Two decades of history of laparoscopic pediatric inguinal hernia repair. *J Laparoendosc Adv Surg Tech A* 24:669–670
- Esposito C, Escolino M, Turra F, Roberti A, Cerulo M, Farina A, Caiazza S, Cortese G, Servillo G, Settini A (2016) Current concepts in the management of inguinal hernia and hydrocele in pediatric patients in laparoscopic era. *Semin Pediatr Surg* 25:232–240
- Montupet P, Esposito C (1999) Laparoscopic treatment of congenital inguinal hernia in children. *J Pediatr Surg* 34:420–423
- Schier F (2000) Laparoscopic surgery of inguinal hernias in children—initial experience. *J Pediatr Surg* 35:1331–1335
- Parelkar SV, Oak S, Gupta R, Sanghvi B, Shimoga PH, Kaltari D, Prakash A, Shekhar R, Gupta A, Bachani M (2010) Laparoscopic inguinal hernia repair in the pediatric age group—experience with 437 children. *J Pediatr Surg* 45:789–792
- McKernan JB, Laws HL (1993) Laparoscopic repair of inguinal hernias using a totally extraperitoneal prosthetic approach. *Surg Endosc* 7:26–28
- Aiolfi A, Cavalli M, Micheletto G, Lombardo F, Bonitta G, Morlacchi A, Bruni PG, Campanelli G, Bona D (2019) Primary inguinal hernia: systematic review and Bayesian network meta-analysis comparing open, laparoscopic transabdominal preperitoneal, totally extraperitoneal, and robotic preperitoneal repair. *Hernia* 23:473–484
- Li Y, Wu Y, Wang C, Wang Q, Zhao Y, Ji Y, Xiang B (2019) Incidence of pediatric metachronous contralateral inguinal hernia and the relationship with contralateral patent processus vaginalis. *Surg Endosc* 33:1087–1090
- Zhong H, Wang F (2014) Contralateral metachronous hernia following negative laparoscopic evaluation for contralateral patent processus vaginalis: a meta-analysis. *J Laparoendosc Adv Surg Tech A* 24:111–116
- Karabulut B (2011) One surgeon experiences in childhood inguinal hernias. *J Korean Surg Soc* 81:50–53
- Bittner R, Arregui ME, Bisgaard T, Dudai M, Ferzli GS, Fitzgibbons RJ, Fortelny RH, Klinge U, Kockerling F, Kuhry E, Kukleta J, Lomanto D, Misra MC, Montgomery A, Morales-Conde S, Reinbold W, Rosenberg J, Sauerland S, Schgu-Paß C, Singh K, Timoney M, Weyhe D, Chowbey P (2011) Guidelines for laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia [International Endohernia Society (IEHS)]. *Surg Endosc* 25:2773–2843
- Stylianidis G, Haapamaki MM, Sund M, Nilsson E, Nordin P (2010) Management of the hernial sac in inguinal hernia repair. *Br J Surg* 97:415–419

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