

# Single-center, retrospective study of the outcome of laparoscopic inguinal herniorrhaphy in children

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## Abstract

Laparoscopic hernia repairs are used increasingly in children.

The purpose of this single-center cohort observational research study was to analyze the outcome of children treated surgically for unilateral or bilateral inguinal hernia using laparoscopy.

We did a STROBE-compliant retrospective outcome analysis of pediatric, laparoscopic hernia repair. Consecutive laparoscopic herniorrhaphies in 123 children done between March 2, 2010, and March 1, 2014, were included in this analysis. Data analysis was based on reviewing the hospital records and a prospective questionnaire. We evaluated postoperative hernia recurrence rate, occurrence of postoperative complications, duration of postoperative pain medication, and wound cosmesis.

We first performed laparoscopic inguinal herniorrhaphy according to the techniques described by Schier et al and Becmeur et al in March 2010. We treated 46 girls and 77 boys with laparoscopically confirmed inguinal hernias, and their ages ranged from 0 to 16 years. Of these, 77 children suffered from unilateral hernias, 30 from unilateral hernias with contralateral patency of the vaginal process, and 16 from indirect bilateral hernias. The median follow-up interval was 38 months (range: 13–58 months). Overall, 8 (6.5%) of these 123 patients experienced a recurrence of the inguinal hernia. Two patients (1.6%) suffered a postoperative infection. Postoperative pain medication was administered by parents for 1 to 3 days in 67 (63.8%) of the 105 families who answered the question, and no pain medication was administered by 5 (4.0%) parents. Wound cosmesis was rated by the parents as invisible or barely visible in 106 (86.2%) of 123 patients and esthetically disturbing in 4 (3.2%) children.

Laparoscopic inguinal hernia repair carries a learning curve and is safe and efficient in children thereafter. Further prospective studies are required to evaluate the long-term outcome of laparoscopic inguinal hernia repair in children.

**Abbreviations:** CPPV = contralateral patent processus vaginalis, LPEC = laparoscopic percutaneous extraperitoneal closure.

**Keywords:** child, complication, inguinal hernia, laparoscopy, recurrence

## 1. Introduction

Most inguinal hernias in children are characterized by a protrusion of the peritoneum through the inguinal canal.<sup>[1]</sup> In

children, indirect inguinal hernias enter the abdominal wall laterally to the epigastric vessels at the region of the inner inguinal ring.<sup>[2]</sup> While the majority of inguinal hernias in children are repaired by open surgery, the laparoscopic operation represents a minimally invasive treatment option.<sup>[3]</sup>

Excellent visual exposure, minimal dissection, fewer complications, comparable recurrence rates, and improved cosmetic results are the advantages of laparoscopic hernia repair compared with the traditional open approach.<sup>[4–6]</sup> Other reported advantages of laparoscopic hernia repair include the ease of examining the contralateral internal ring, avoidance of access damage to the vas deferens and blood vessels during mobilization of the hernial sac, decreased operative time, and ability to identify unsuspected direct or femoral hernias.<sup>[7,8]</sup> Moreover, this approach enables accurate examination of contralateral groin pathology and prevents metachronal hernia and excessive scar formation.<sup>[5]</sup> Faster recovery, less postoperative pain, simultaneous repair of a contralateral wide-open patent processus vaginalis or hernia sac, and better cosmesis are further advantages of laparoscopic hernia repair over conventional surgery.<sup>[9,10]</sup> Many studies were done in adult patients who underwent laparoscopic herniorrhaphy, but only few studies in pediatric patients exist.<sup>[2,3]</sup>

The first laparoscopic inguinal hernia repair was reported by Ger et al in 1990.<sup>[11]</sup> Since then, laparoscopic hernia repair has been refined into an attractive alternative to open hernia repair.<sup>[11]</sup> For the repair of pediatric inguinal hernia, several laparoscopic techniques have been described, but most of them fall into 2 categories based on the approach (intra- or

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extraperitoneal) to repair the internal inguinal ring and the number of ports used, such as 3-, 2-, or single-port technique.<sup>[12]</sup>

In our children's hospital, laparoscopic surgery is preferably used to treat inguinal hernia. This study assessed the recurrence rate of inguinal hernia and occurrence of complications in children aged 0 to 16 years.

## 2. Materials and methods

### 2.1. Study design

We performed a STROBE-compliant retrospective, single-center outcome analysis of laparoscopic inguinal hernia repair in children. Our study was approved by the local Ethics Committee (EKNZ 2014–247). Consecutive laparoscopic herniorrhaphies in 123 children between March 2, 2010, and March 1, 2014, were included in this study. Data analysis was based on the hospital records and a prospective questionnaire (sent by mail or filled in during a structured telephone interview). The follow-up interval between the operation and answering the questionnaire by families amounted to a median of 38 months (range: 13–58 months). Patients were followed up by their pediatrician at regular intervals. In case of occurrence of any alteration at the groin region, the child was examined by a board-certified pediatric surgeon at our institution. Hernia recurrences were diagnosed by clinical examination, and imaging of the groin region was not obtained on a regular basis. Recurrences were treated and confirmed by open or laparoscopic operation.

The parents of the patients provided information on their children's recovery, the postoperative course, and wound cosmesis.

### 2.2. Patients

In 2 (1.6%) children, the preoperatively suspected unilateral hernia was not confirmed during laparoscopy, and these children were excluded from the analysis. In 2 (1.6%) children, a wide-open processus vaginalis was detected incidentally during other operations (hydrocele repair, orchiopexy), and these patients were also excluded from this analysis. Among the remaining 123 children suffering from laparoscopically confirmed indirect inguinal hernias, 77 (62.6%) had unilateral hernias, 30 (24.4%) suffered from unilateral hernias with laparoscopically confirmed contralateral patency of the processus vaginalis (CPPV), and 16 (13.0%) had bilateral hernias (Table 1). In total, 123 patients (46 girls and 77 boys aged between 0 and 16 years) were included in this analysis.

### 2.3. Surgical procedure

Children who underwent laparoscopic inguinal hernia repair at our hospital were operated in general anesthesia with tracheal intubation. They were operated in our day-surgery center and discharged on the same day.

During the operation, the patient was placed in supine position, using a slight Trendelenburg position with a 15° tilt with legs tucked up. Using CO<sub>2</sub>, a pneumoperitoneum of 8 to 10 mm Hg pressure (flow 1–4 L/min) was established. For the 30° laparoscope, 1 optical 5 mm port was inserted surgically through an umbilical incision, and two 2 mm or 3 mm ports were placed at the lateral border of the rectus abdominis muscle at the umbilical level or slightly below under laparoscopic observation. When necessary, the content of the hernia sac was reduced. The

**Table 1**

Patient demographics are presented with regard to recurrence.

Patient demographics and location of inguinal hernia	No recurrence	Yes (recurrence occurred)
n	115	8
Weight [mean (SD)]	15.4 (9.4)	16.0 (7.8)
Age [mean (SD)]	3.9 (3.5)	4.1 (2.6)
Gender, female, n (%)	43 (37.4)	3 (37.5)
Age group, n (%)		
Newborn	3 (2.6)	0 (0.0)
Infant	33 (28.7)	2 (25.0)
Toddler to teen	79 (68.7)	6 (75.0)
Location of inguinal hernia at operation, n (%)		
Right	56 (48.7)	6 (75.0)
Left	14 (12.2)	1 (12.5)
Unilateral hernia with CPPV	29 (25.2)	1 (12.5)
Bilateral hernia	16 (13.9)	0 (0.0)

The number of children with laparoscopically confirmed patent processus vaginalis (CPPV) was 123.

internal ring was then closed with a nonabsorbable 4/0 suture. All surgical procedures were performed by pediatric surgeons and hospital staff according to the technique described by Schier et al<sup>[5,13]</sup> and Becmeur et al.<sup>[13]</sup> The knot was tied intra- or extracorporally and checked to ensure proper closure of the internal ring. Two different surgical techniques were used in our study. In 119 (96.7%) of 123 patients, we applied the intraperitoneal, intracorporal knot technique. In 4 (3.3%) children, surgeons applied the epifascial, extracorporal/extraperitoneal knot technique. The pneumoperitoneum was then deflated. All abdominal incisions were closed with absorbable sutures.

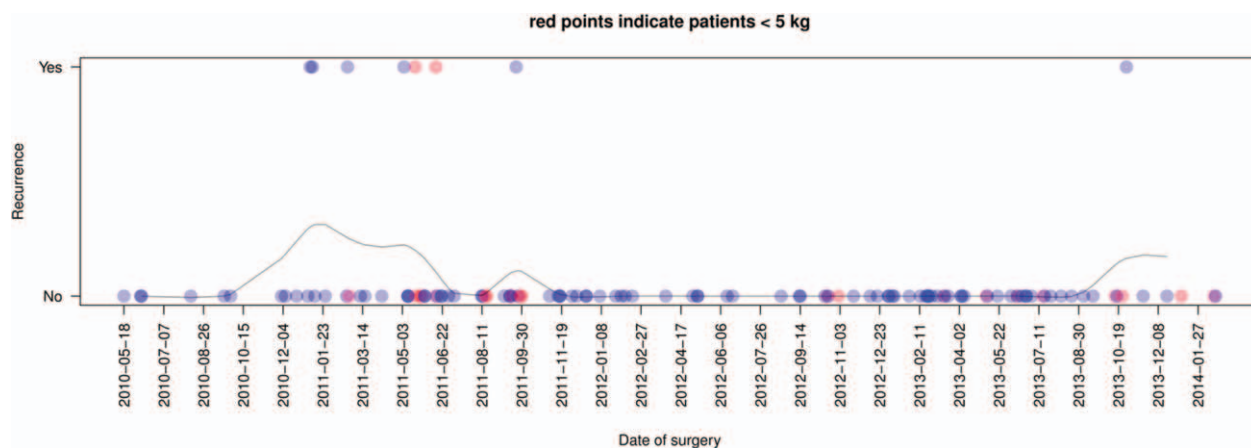
All patients received the same postoperative care. The patients and their parents were instructed to use pain medication when necessary. Follow-up evaluations were performed by pediatricians 3 to 5 days after the operation and 3 months postoperatively. The patients were examined clinically for inguinal swelling, hernia recurrence, or hydroceles.

### 2.4. Statistical analyses

We analyzed patient characteristics (age, gender, hernia location), the type of laparoscopic intervention (2 different operation techniques), and the outcome parameters (hernia recurrence, postoperative complications such as infections, duration of postoperative pain medication intake). Data were entered into an Excel table for further statistical evaluation.

Recurrence rate was estimated together with its 95% confidence interval (CI) according to Blaker.<sup>[14]</sup> Furthermore, the associations between hernia recurrence and experience of the surgeon (senior/junior) and age of the patients were assessed in a generalized linear model with logit link and binary error distribution (logistic model).

Body weight was not included, as due to the strong correlation between age and weight in children, an efficient estimation of the association between “age and recurrence” and “weight and recurrence” was not possible to be determined simultaneously. The operations with and without recurrence were plotted on a time-line at the point the surgery was performed (i.e., each dot represents an operation). Furthermore, the rate of successful repairs was estimated using moving averages and presented as a line. The moving averages were estimated using a linear



**Figure 1.** Inguinal hernia repairs and hernia recurrence by body weight (n = 123). Blue dots indicate a patient weighing 5 kg or more and red dots indicate a patient weighing less than 5 kg.

symmetrical filter of length 6 followed by interpolating these points using cubic spline. Other variables were presented using descriptive methods. Categorical data were presented as frequencies and percentages. For continuous variables, the mean and standard deviation (SD) were presented. A *P* value <.05 was considered significant.

**3. Results**

In total, 138 patients underwent laparoscopic inguinal hernia repair at our hospital between March 02, 2010, and March 01, 2014. Two patients were excluded because they were older than 16 years at the time of the operation. In addition, 9 (6.6%) of 136 families did not return the questionnaire sent to them. The follow-up interval between operation and answering the questionnaire by families amounted to a median of 38 months (range: 13–58 months).

In 2 (1.6%) of the remaining 127 children, the suspected indirect unilateral hernia was not confirmed by laparoscopy. In 2 (1.6%) patients, a wide-open processus vaginalis was detected incidentally during an operation for cryptorchidism or hydrocele and the internal inguinal ring was closed laparoscopically. These 2 patients were also excluded. Thus, 123 patients with laparoscopically confirmed inguinal hernia were finally included in the analysis (Table 1).

**3.1. Recurrence of inguinal hernia**

In 8 of these 123 patients, inguinal hernia recurred (Table 1). Therefore, the recurrence rate was 6.5%; (95% CI, 0.03–0.12). Unilateral hernia recurrences were noted at follow-up in 4 of 44 children (9.0%) treated with the laparoscopic repair technique according to Schier et al,<sup>[5]</sup> in 3 of 75 patients (4.0%) operated

with the laparoscopic technique according to Becmeur et al,<sup>[13]</sup> and 1 of 4 treated with epifascial knot technique.

Figure 1 shows the recurrence rate of inguinal hernia by weight of the patients.

The hernia recurrences were treated successfully with laparoscopic repair in 5 children and by open hernia repair in 3 children. In these 3 children, the inguinal canal was considered weak and was therefore reconstructed by open hernia repair.<sup>[15]</sup>

One metachronic hernia occurred together with an ipsilateral recurrent hernia. Both hernias were repaired successfully with the laparoscopic technique described by Becmeur et al.<sup>[13]</sup>

**3.2. Experience level of the surgeon**

Senior surgeons carried out 96 (78.0%) of 123 operations. There were 6 senior surgeons (board-certified pediatric surgeons) and 6 junior surgeons (board-certified pediatric senior resident surgeons and junior residents) who performed the inguinal herniorrhaphies. Table 2 presents the association between recurrence rate, experience level of the surgeon, and age of the patient at surgery. We noted no significant association between these parameters.

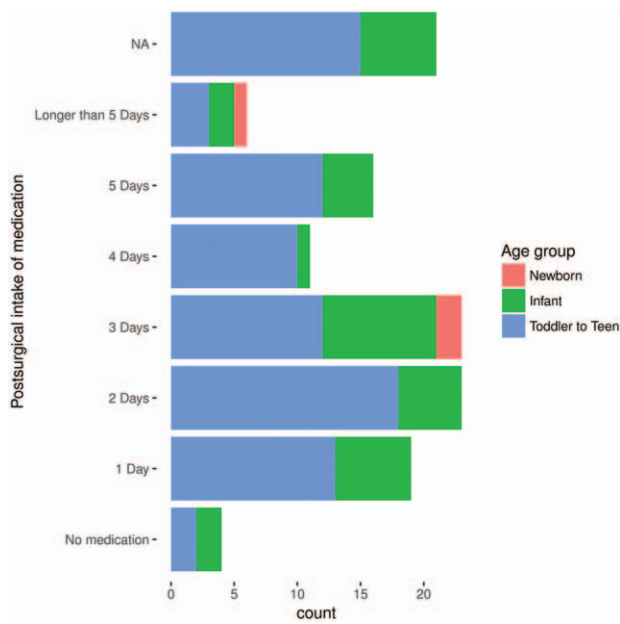
**3.3. Postsurgical intake of pain medication**

Figure 2 shows the details of postoperative pain management for 123 children of different age groups. Overall, 20 (19.0%) patients required postoperative pain medication for 1 day and 23 (21.9%) for 2 days. In total, 24 (22.9%) of patients received postoperative pain treatment for 3 days, while 11 (10.5%) and 16 (15.2%) of patients required pain treatment for 4 and 5 days, respectively. Only 6 (5.7%) patients needed pain medication for more than 5 days. Five (4.8%) patients did not receive any pain medication. Twenty families did not answer this question.

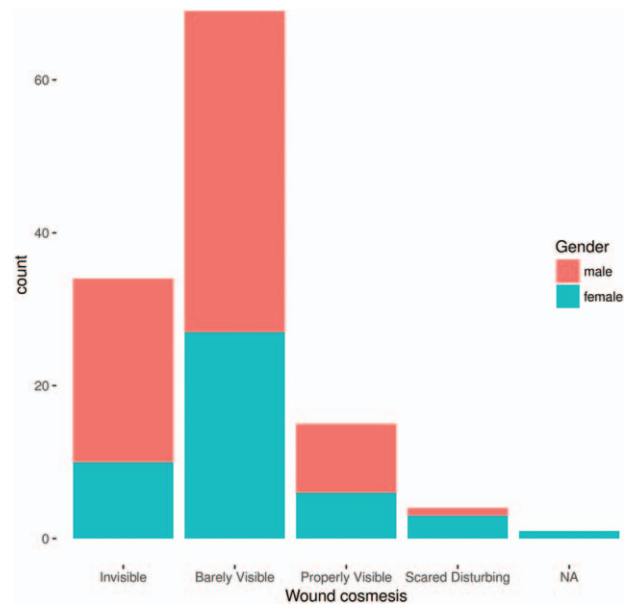
**Table 2**  
Model of estimated association between recurrence, age of the patient at surgery, and experience level of the surgeon (n = 123).

Operative details and association with hernia recurrence in 123 patients	OR	CI	P
(Intercept)	0.032	[0.002–0.213]	NA
Experience level of the surgeon (senior vs junior)	2.120	[0.348–40.796]	.458
Patient’s age at surgery	1.027	[0.820–1.243]	.796

CI=confidence interval, OR=odds ratio, NA=not applicable.



**Figure 2.** Duration of postoperative pain medication intake by age group of children (n=123). NA = not answered.



**Figure 3.** Rating of wound cosmesis by families (n=123). NA = not answered.

### 3.4. Wound cosmesis

Figure 3 shows the results of wound cosmesis by gender. The parents of the patients were asked to judge the appearance of the scar at the incision sites. The scars at the navel region and abdominal wall were rated: invisible in 36 (29.2%) cases, barely visible in 70 cases (56.9%), clearly visible in 15 (12.2%) cases, and scarred and esthetically disturbing in 4 (3.2%) cases.

### 3.5. Detection of inguinal hernia

In 77 (62.6%) children, inguinal hernias were detected preoperatively and confirmed intraoperatively on the same side. In 30 (24.4%) children, we detected hernias preoperatively only on one side, but intraoperatively, we detected an opening of the

inguinal ring on both sides. In 16 (13.0%) children, we detected hernias on both sides, at first preoperatively and then intraoperatively (Table 3).

Incarceration that occurred immediately before the operation was observed during surgery in 2 (1.6%) patients.

### 3.6. Postoperative complications

Postoperative problems were observed in 2 (1.6%) patients. These were postanesthetic problems such as sore throat and cough.

Disturbing postoperative pain was reported by parents of 7 (5.6%) patients. Postoperative infections (granuloma or abscess at the umbilical incision site) during the first month after surgery were observed in 2 (1.6%) patients.

## 4. Discussion

Patients with bilateral inguinal hernias benefit most markedly from the laparoscopic technique. Using laparoscopy, bilateral hernias can be repaired in a single operation without additional incisions or without the need for additional ports.<sup>[3,7]</sup> The main advantage of treating inguinal hernias laparoscopically in pediatric patients appears to be the possible discovery of a contralateral patent vaginal process and the possible avoidance of a metachronal, contralateral hernia after unilateral inguinal herniorrhaphy.<sup>[3,16–19]</sup> Laparoscopic search for the presence of a contralateral patent processus vaginalis (CPPV) causes no injury to vas deferens and testicular blood vessels and proved to be specific (99.5%) and sensitive (99.4%).<sup>[20]</sup>

A Cochrane meta-analysis reviewed 41 trials of open versus laparoscopic inguinal hernia repair in adults.<sup>[21]</sup> The analysis showed that laparoscopic repairs took an average of 15 minutes longer than open repair, and the risk of rare, serious complication was higher. However, postoperatively, there was less persistent pain and numbness, the return to usual daily activities was faster,

Preoperative diagnosis, surgical details, and outcome of laparoscopic inguinal hernia repairs	n (%)
Inguinal hernia confirmed by laparoscopy	123 (100.0)
Inguinal hernia detection	
Preoperatively one side, intraoperatively on the same side	77 (62.6)
Preoperatively one side, intraoperatively ipsilateral hernia, and CPPV	30 (24.4)
Preoperatively both sides, intraoperatively both sides	16 (13.0)
Preoperative incarceration of hernia; n (%)	2 (1.6)
Experience level of the surgeon, senior; n (%)	96 (78.0)
Surgical technique, epifascial, extracorporeal knots; n (%)	4 (3.2)
Postoperative problems; n (%)	2 (1.6)
Infection; n (%)	2 (1.6)
Hernia recurrence, n (%)	8 (6.5)
Metachronal hernia; n (%)	1 (0.8)
Postoperative pain; n (%)	7 (5.7)

CPPV = contralateral patent processus vaginalis.



and hernia recurrence rates were similar after open mesh and laparoscopic techniques in adults.<sup>[21]</sup>

The added costs resulting mainly from the use of disposable instruments represents a major drawback of laparoscopic hernia repair over the open repair.<sup>[22]</sup>

General endotracheal anesthesia is almost always necessary for laparoscopic operations in children. This is another disadvantage of laparoscopy over open hernia repair. The cost of setting up and running the laparoscopic procedure in rural settings or in developing countries makes it an inviable option in such situations.<sup>[23]</sup>

#### 4.1. Recurrence of hernia

A main complication of inguinal hernia repair is hernia recurrence.<sup>[24]</sup> The factors affecting recurrence seem to be failure to ligate the hernia sac high enough at the internal ring, operative trauma leading to injury of the floor of the inguinal canal, failure to close the internal ring tightly in females, and postoperative hematoma and wound infection.<sup>[19]</sup> Some authors hypothesize that these possible causes of recurrence can be avoided by the laparoscopic technique.<sup>[25]</sup> Insufficient suture material and use of absorbable sutures represent other significant causes of recurrence.<sup>[26]</sup>

We observed a recurrence rate of 6.5% after laparoscopic hernia repair in children. This is higher than the recurrence rate published in the literature where recurrence rates after laparoscopic hernia repair between 0% and 4.4% are described.<sup>[5,27–36]</sup> There is only 1 publication by Grimsby et al,<sup>[26]</sup> which compared the use of nonabsorbable sutures with the use of absorbable sutures. They reported significantly higher rates of hernia recurrences associated with the use of absorbable sutures when compared with the group repaired with nonabsorbable sutures (recurrence rates: 29% vs 4%).<sup>[26]</sup> Our recurrences mainly occurred during the learning curve for laparoscopic hernia repair according to the technique described by Schier et al<sup>[5]</sup> and we observed less recurrences during the learning curve for the technique according to Becmeur et al.<sup>[13]</sup> The increased rate of recurrences seemed to cluster with more surgeons adopting the laparoscopic technique of hernia repair, followed by a decline of complications over time. We hypothesize that this observation is indicative of a learning curve. Shalaby et al<sup>[37]</sup> described a hernia recurrence rate of only 0.23% with several techniques of laparoscopic inguinal hernia repair and noted that recurrences occurred only among the early cases, which is indicative of a learning curve. Shalaby et al<sup>[37]</sup> recommend coagulation of the upper half portion of the hernia sac opposite of the testicular vessels and spermatic duct, to allow for a durable occlusion of the hernial sac opening without causing harm to the spermatic duct and testicular vessels.

Esposito et al<sup>[38]</sup> stressed that it is crucial to section the periorificial peritoneum before closing it, and to use a nonabsorbable suture for the closure of the internal inguinal ring. Schier et al<sup>[5]</sup> decided to incise the peritoneum lateral to the internal inguinal ring after starting their series of laparoscopic hernia repair, because they noted recurrences. This recommendation is supported by our findings.

In a follow-up quality assessment of inguinal hernias treated by the open approach in the same time interval, we noted a recurrence rate of 1 in 48 children (2.1%) after open repair of inguinal hernias in our institution, which compares well to reports published in the literature.<sup>[27]</sup> In the group of children treated with the traditional open approach, we noted occurrence

of 2 metachronic hernias at follow-up (4.2%). Unfortunately, results on minor complications and wound cosmesis were not recorded in this quality assessment analysis. The mean age at operation (4.04 years), follow-up rate, and follow-up interval of the group of children we treated with laparoscopic repair did not differ significantly from the mean age of the group of children treated with open repair (4.44 years). However, as the choice of the operative method was made on the discretion of the surgeon, we are not able to rule out selection bias and other biases.

When comparing the recurrence rate of inguinal hernias after laparoscopic and open repair, no significant difference was noted in a systematic review of the literature published during the last 2 decades.<sup>[39]</sup> However, it must be kept in mind that in this systematic review, shorter follow-up intervals were noted after laparoscopic inguinal hernia repair when compared with open repair.<sup>[39]</sup>

We noted no hydrocele formation after laparoscopic hernia repair. This is in contrast to the results of Shalaby et al<sup>[37]</sup> who described hydrocele formation in up to 2.07% of boys treated with laparoscopic inguinal hernia repair.

The laparoscopic herniorrhaphy procedure in children is simplified by the laparoscopic percutaneous extraperitoneal closure (LPEC) technique, and it is easier to perform for less experienced surgeons. Thus, this technique is widely accepted. Initially, the recurrence rate after LPEC was 1.16%. This recurrence rate was caused by premature absorption of the suture materials before stable scar formation at the level of the internal inguinal ring took place. As the introduction of nonabsorbable suture materials, the recurrence rate of inguinal hernias has diminished.<sup>[40]</sup> Some reports suggest resecting or dissecting the hernia sac to reduce the incidence of recurrence.<sup>[13]</sup>

In our study, we observed recurrence of inguinal hernia in 8 of 123 patients. Therefore, the recurrence rate after laparoscopic hernia repair was 6.5% (95% CI, 0.03–0.12), which is very high.

Table 2 presents the association between recurrence rate of inguinal hernia, experience level of the surgeon, and age of the patient at the time of herniorrhaphy. We noted no significant association between these variables (*P*-value for experience level of the surgeon was .458 and *P*-value for patient's age was .796). However, it has to be kept in mind that in an observational design as applied in our study, no causal relationship could be estimated.

Figure 1 shows the recurrence rate of inguinal hernia over time. At the beginning of the study period, a limited number of surgeons performed a low number of laparoscopic inguinal herniorrhaphies, and we observed no recurrence of inguinal hernia. After a few months, more surgeons performed a higher number of laparoscopic inguinal herniorrhaphies, and consequently, the rate of recurrence rose. Subsequently, the recurrence rate fell again. This observation is indicative of a learning curve. It has to be kept in mind that due to the low number of recurrences, the accuracy of the estimated rate was low.

Figure 1 shows the recurrence rate of inguinal hernia by weight of the patients. In total, 21 patients weighed less than 5 kg, and among these, 2 infants (9.5%) suffered a recurrence. Overall, 102 patients weighed 5 kg or more, and among these, 6 (5.9%) suffered a recurrence. This difference was not significant (Fisher exact test: *P* = .626).

#### 4.2. Metachronic hernia

We noted metachronic hernia in 1 (0.8%) child after unilateral laparoscopic inguinal hernia repair. In this child, the surgeon had

reported a closed internal inguinal ring during laparoscopy and thus the contralateral side had not been treated.

The rate of wide-open CPPV with hernia on the right side was reported 26% in boys, and 11% in girls. In boys with hernia on the left side, the rate of a wide-open processus vaginalis on the right side was reported to be 30% and 38% in girls.<sup>[116]</sup> However, the authors stress that an open internal inguinal ring discovered intraoperatively at laparoscopy is not equivalent to clinical manifestation of inguinal hernia.<sup>[116]</sup>

In children suffering from unilateral inguinal hernias who underwent laparoscopic inguinal hernia repair, a CPPV was detected during laparoscopy in 19.9% to 66% of cases.<sup>[39,41,42]</sup> However, it must be noted that only 10% to 30% of CPPV in children will progress into an inguinal hernia when the CPPV is left untreated.<sup>[38]</sup> The authors advocate to close a patent CPPV, which is detected at laparoscopy, to avoid development of a metachronic hernia.<sup>[38]</sup> Saad et al<sup>[43]</sup> identified a patency of the CPPV using groin laparoscopy in 23% of pediatric patients with clinical unilateral inguinal hernia. They found that the percentage of patent CPPV in children suffering from clinical unilateral inguinal hernia declines with age from 44% in infants younger than 1 year to 17% in patients 9 to 18 years old.<sup>[43]</sup>

In a quality assessment after unilateral open inguinal hernia repair in 48 children, we noted occurrence of 2 metachronic hernias (4.2%).

Our findings are in good agreement with the findings of a meta-analysis conducted by Yang et al<sup>[44]</sup> who reported a lower rate of metachronic contralateral hernia after laparoscopic hernia repair when compared with open repair. The incidence of metachronic hernia after unilateral hernia repair reported in the literature ranges from 5.8% to 29%.<sup>[45,46]</sup>

Watanabe et al<sup>[47]</sup> hypothesized that unilateral hernia closure itself might be a cause of metachronic contralateral hernia.

#### 4.3. Age group

A higher recurrence rate after laparoscopic hernia repair was observed in older children when compared with infants (4% vs 1%,  $P=.17$ ).<sup>[28]</sup> Complications requiring surgery and total complications were similar in both age groups. In infants, the incidences of bilateral inguinal hernia and CPPV were significantly higher (total 61%) compared with 35% in older children.<sup>[48]</sup>

#### 4.4. Weight of the patient

Turial et al<sup>[49]</sup> reported a very low hernia recurrence rate in infants weighing less than 5 kg. A trend toward higher recurrence rate in older children when compared with infants was reported by Choi et al.<sup>[48]</sup>

In our study, we included 21 infants weighing less than 5 kg. Among these, 2 (9.5%) suffered a recurrence. Overall, we investigated 102 children weighing 5 kg or more. Among these, 6 (5.9%) suffered a recurrence. This difference was not statistically significant (Fisher exact test:  $P=.626$ ).

#### 4.5. Level of experience of the surgeon

The level of experience of the surgeon is reflected by the “learning curve.” A longer learning curve is required for the laparoscopic approach.<sup>[50,51]</sup> The surgeon’s lack of familiarity with the laparoscopic inguinal anatomy and the time it takes to develop the skills to operate in a confined space are the principal reasons

for the long learning curve.<sup>[50]</sup> After a necessary learning curve, the operating time can be shortened to that of open hernia repair, and most technical pitfalls can be avoided.<sup>[51]</sup>

In our study, 96 (78.0%) of 123 of laparoscopic inguinal herniorrhaphies were carried out by senior surgeons (Table 3). There were 6 senior surgeons (board-certified pediatric surgeons) and 6 junior surgeons (board-certified senior pediatric surgical residents and junior residents) who performed the laparoscopic inguinal herniorrhaphies. Table 2 summarizes the association between recurrence rate, experience level of the surgeon, and age of the patient at surgery. We noted no significant association between these parameters.

#### 4.6. Surgical technique

The development of LPEC led to the simplification of the laparoscopic herniorrhaphy procedure in children, thus making it widely accepted.<sup>[40]</sup> Initially, the recurrence rate after LPEC was 1.16%, but this was caused by the premature absorption of the suture materials before completed scar formation at the internal inguinal ring. The use of nonabsorbable suture materials to close the internal inguinal opening has led to a clear reduction of inguinal hernia recurrences.<sup>[26,40]</sup>

In our study, the extracorporeal/extraperitoneal knot technique was used in only 4 (3.2%) children, while the intraperitoneal, intracorporeal knot technique was used in all other children. We were not able to calculate the difference in outcome due to the limited number of the patients who underwent the epifascial, extracorporeal/extraperitoneal method.

Evidence in favor of 1 laparoscopic hernia repair technique over another is still missing.<sup>[52]</sup>

#### 4.7. Postoperative pain management

Advantages of laparoscopic herniorrhaphy include less postoperative pain, faster recovery, and better cosmesis.<sup>[9,10]</sup> In adults, the reduction of postoperative pain is probably associated with single-port access surgery or single-site laparoscopic surgery.<sup>[53]</sup>

Patients who underwent open hernia repair required more postoperative analgesics than those treated laparoscopically. However, the difference was not significant.<sup>[54]</sup> In contrast, Chan et al<sup>[55]</sup> reported the need for more postoperative analgesics after laparoscopic than open herniorrhaphy, but the limited data in this meta-analysis did not permit conclusive comparisons.

We assessed the postsurgical intake of pain medication by age group (Fig. 2). Postoperative pain medication lasted 1 to 3 days in 67 (63.8%) patients.

#### 4.8. Postoperative complications

No difference in short-term adverse events, such as seroma/hematomas, wound infections, pneumonia, urinary retention, and ileus was found between open versus laparoscopic hernia repairs in a meta-analysis focusing on postoperative complications.<sup>[56]</sup> A significant reduction of postoperative wound infection and abscess formation with the laparoscopic approach compared with open hernia repair in adults was reported by Salvilla et al.<sup>[57]</sup>

In our study, postoperative problems were observed in 2 of 123 (1.6%) patients (Table 3). These comprised minor postanesthetic problems such as sore throat and cough.

We observed postoperative infections (granuloma or abscess formation at the umbilical incision site) during the first month after

surgery in 2 (1.6%) of 123 patients. This represents an acceptable rate of complications. All these complications were managed without further surgical intervention at the outpatient clinics.

#### 4.9. Wound cosmesis

In our investigation, parents rated scar appearance as invisible or barely visible in 106 (88.2%) of 123 children. This compares well with the findings of Esposito et al<sup>[38]</sup> who reported that cosmetic outcome was judged excellent by parents and physicians for all patients. Chang et al<sup>[24]</sup> reported on a “no-scar” laparoscopic herniorrhaphy in children with 1 trocar laparoscopic transperitoneal closure.

#### 4.10. Limitations of the study

Our results should be interpreted with caution due to the retrospective design of this study, the limited number of patients, and the possible biases. We are unable to provide long-term results in our patients (median follow-up interval: 38 months; range 13–58 months). However, we used a generalized linear model with logic link and binary error distribution (logistic model) to reduce bias. The follow-up of our patients is short and further long-term results are required to compare the main outcome variables of laparoscopic hernia repair to the outcome of open hernia repair in children.

### 5. Conclusion

Laparoscopic herniorrhaphy in children represents a safe and effective technique to repair inguinal hernias in children after a learning curve. The laparoscopic technique allows for intraoperative verification of a contralateral wide-open vaginal process and closure of the internal inguinal ring without additional skin incision. The high hernia recurrence rate reported here (6.5%) is obviously related to the learning curve and should be studied in a larger prospective long-term investigation.

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