



Recurrence after laparoscopic high ligation in adolescents: A multicenter international retrospective study of ten hospitals



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ABSTRACT

Purpose: Inguinal hernia repairs are among the most common operations performed by pediatric surgeons. Laparoscopic high ligation is a popular technique, but its recurrence rate in adolescents is unknown. We hypothesized that recurrence after laparoscopic high ligation in adolescents would be similar to open repair (1.8%–6.3%). **Methods:** We evaluated adolescent patients (12–18 years old at the time of surgery) who underwent laparoscopic high ligation across eleven hospitals. At least six months postoperatively, they were contacted by telephone for follow-up. Variables analyzed included demographics, operative details, recurrence, and other complications.

Results: A total of 144 patients were enrolled. One hospital ($n=9$) had a recurrence rate of 44.4%, compared to 3.0% (4/135) for the other hospitals. By accounting for 50.0% of recurrences, it represented a statistical outlier and was excluded, leaving 135 patients for analysis. The median age was 14 years, and 63.7% were male. Recurrence with the excluded center was 5.6% (8/144). Use of absorbable suture (OR 42.67, CI 4.41–412.90, $p<0.01$) and braided suture (OR 12.10, CI 1.54–95.25, $p=0.02$) was weakly associated with recurrence. Recurrence was not significantly different from published results.

Conclusion: Laparoscopic high ligation of adolescent inguinal hernias has a recurrence rate similar to open repair when performed by experienced surgeons.

Type of study: Prognosis study (retrospective study)

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Inguinal hernia repair is the second-most commonly performed operation in pediatric patients, representing 8%–10% of surgeries performed on children annually [1]. In young pediatric patients, these repairs are typically performed with a high ligation of the hernia sac, as opposed to the Lichtenstein repair or laparoscopic repair with mesh often performed on adult patients.

The approach to inguinal hernia repair among adolescents, however, is less consistent. This age group may be operated on by either pediatric or

adult surgeons, who may default to different operative approaches depending on their specialty [2]. This stark difference in surgical technique is likely related to the underlying disease etiology. Infants and young children almost universally have indirect hernias as a result of failure of involution of the processus vaginalis. Adults, on the other hand, are believed to acquire a weakness of the inguinal floor resulting in a direct hernia in about one-third of males and one-fifth of females [3]. The etiology in adolescent patients may be because of a combination of both.

This raises the concern that a high ligation may be an insufficient operation for adolescent patients, which could result in an unacceptably high recurrence rate. Previous studies evaluating adolescent patients after an open high ligation have shown a recurrence rate between 1.8% and 6.3% [4–8]. These rates are comparable to the long-term

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recurrence rate of 1.8%–2.2% after Lichtenstein repair [9–11], and of 2.6% after laparoscopic transabdominal preperitoneal (TAPP) repair [12].

While the evidence behind open high ligation in adolescent patients is reassuring, the increasing utilization of minimally invasive surgery raises a new question: Does the recurrence rate after laparoscopic high ligation in adolescent patients differ from that of open high ligation? Previous studies have shown equivalence in pediatric patients generally [13], and in patients less than the age of 12 years specifically [14,15], but there continues to be a lack of data for adolescents. We sought to fill this gap and hypothesized that the recurrence rate between laparoscopic and open high ligation would not be significantly different.

1. Methods

1.1. Study design and patient selection

All patients between the ages of 12 and 18 years at the time of laparoscopic inguinal hernia repair were eligible for enrollment in the study. Patients were identified by current procedural terminology (CPT) code for a laparoscopic surgical repair of an initial inguinal hernia (49650). Patients were excluded if they were not in the defined age range at the time of surgery or if the hernia was recurrent. Owing to the relative infrequency of this operation in the defined age group at any one center, a total of eleven institutions participated in order to increase the potential sample size. A retrospective review of each institution's electronic medical record was performed to obtain patient demographics (including sex, age, weight, and BMI) and operative details (including laterality, technique used for suturing of the internal ring, type of suture material, and whether or not there was intentional injury to the peritoneal surface of the internal ring). When performed, intentional injury to the internal ring was carried out with cautery, as previously described by Ostlie & Ponsky [16]. Approval for this retrospective study was granted by Akron Children's Hospital Institutional Review Board (IRB Number 1104874). The study was completed without additional funding.

1.2. Follow-up survey

Those patients who were at least six months postoperation were contacted by telephone. At the time of follow-up, those who consented to participate in the study were asked to fill out a five-question survey. The survey addressed: 1) whether or not the patient developed a complication (infection, stitch abscess, or hydrocele); 2) continued symptoms at least one month after surgery (pain, swelling, numbness, or itching); 3) hernia recurrence; 4) time to recurrence; and 5) reoperation for recurrence.

1.3. Data management

Participating centers entered data for each patient on REDCap (Research Electronic Data Capture) hosted at Akron Children's Hospital. REDCap is a secure, web-based software platform designed to support data capture for research studies [17,18].

1.4. Statistical analysis

Examination of data included calculation of full summary statistics and distributional assessments for continuous data, along with frequencies and percentages for categorical data. The Chi² goodness of fit test was used to compare proportion of recurrences to the published literature cited. Exploratory univariate logistic regression analyses were used to assess the potential predictive ability of selected demographic and clinical characteristics for recurrence. Analyses were completed using SAS 9.4 / 14.2©. Unless otherwise noted, all testing was two-tailed and evaluated at the type I error rate of alpha = 0.05 level of statistical significance.

Table 1
Patient demographics.

Median age in years (IQR)	14 (12–15.5)
Number of males (%)	86 (63.7)
Laterality (%)	
Right	61 (45.2)
Left	43 (31.9)
Bilateral	31 (23.0)
Average weight in kg (SD) (n = 116)	53.3 (16.1)
Average BMI in kg/m ² (SD) (n = 114)	20.2 (3.5)
Institution (%)	
1	7 (5.2)
2	8 (5.9)
3	13 (9.6)
4	5 (3.7)
5	5 (3.7)
6	39 (28.9)
7	29 (21.5)
8	16 (11.9)
9	9 (6.7)
10	4 (3.0)

2. Results

A total of 144 patients across the eleven institutions participated in the survey. This represented a follow-up rate of 38.9% (144/370). There were eight recurrences (5.6%) overall. One hospital had a recurrence rate of 44.4% (4/9 patients) and was excluded as a statistical outlier, as they accounted for 50.0% of all recurrences. For the remaining 135 patients, there were four recurrences (3.0%). The median age was 14 years (range, 12 to 18 years) and the majority were male (63.7%). Median time to follow-up was 2.5 years (interquartile range 1.8 to 6.4 years). Demographic data for the included patients are shown in Table 1.

The ten different hospitals included patients from more than 25 individual surgeons. In the vast majority of cases (88.1%; 119/135) a percutaneous method was utilized to suture the internal ring. Almost all repairs used a monofilament (91.1%; 123/135) and nonabsorbable (96.2%; 130/135) suture. There was less consistency regarding intentional injury to the peritoneal surface of the internal ring, with one-third (33.3%; 45/135) of cases including this maneuver. Operative details are shown in Table 2.

Of the four recurrences, two occurred within one year and the other two occurred after one year. All four recurrences underwent reoperation. Details about the four patients with a recurrence are shown in Table 3. When comparing the recurrence rate to published data for open repair in the same age group, there was no significant difference (3.0% vs. 1.8% [5], p = 0.310). Univariate logistic regression analyses of our data show significant prediction of recurrence owing to weight (OR 1.06, CI 1.01–1.13, p = 0.025), absorbable vs. nonabsorbable suture (OR 42.67, CI 4.41–412.90, p < 0.01), and braided vs. monofilament suture (OR 12.10, CI 1.54–95.25, p = 0.02). There was no evidence of predictive value by age (p = 0.67), BMI (p = 0.09), sex (p = 0.57), laterality

Table 2
Operative details.

Suturing technique (%)	
Extracorporeal/percutaneous	119 (88.1)
Intracorporeal	16 (11.9)
Suture material (%)	
BA	2 (1.5)
BN	121 (89.6)
MA	3 (2.2)
MN	9 (6.7)
Peritoneal injury (%)	
Yes	45 (33.3)
No	90 (66.7)

BA = braided, absorbable; BN = braided, nonabsorbable; MA = monofilament, absorbable; MN = monofilament, nonabsorbable.

Table 3
Recurrence details.

Recurrence	Sex	Laterality of hernia	Suturing technique	Suture material	Peritoneal injury	Time to recurrence	Laterality of recurrence
1	F	Bilateral	Extracorporeal	BN	N	> 1 yr	Unknown
2	M	Left	Extracorporeal	BN	Y	> 1 yr	Left
3	M	Bilateral	Intracorporeal	MA	N	< 1 yr	Right
4	F	Bilateral	Intracorporeal	MA	Y	< 1 yr	Right

F = female; M = male; BN = braided, nonabsorbable; MA = monofilament, absorbable.

($p = 0.44$), or ring injury ($p = 0.48$). Evidence for the predictive value of height was inconclusive ($p = 0.04$), as was intracorporeal versus extracorporeal closure ($p = 0.04$).

In addition to recurrence, other postoperative complications were evaluated. Complications included persistent pain (greater than one month) in four patients (3.0%), persistent numbness (greater than one month) in three patients (2.2%), stitch abscess in two patients (1.5%), and postoperative wound infection in one patient (0.7%). There were no hydroceles.

3. Discussion

With minimally invasive surgery becoming more prevalent among pediatric surgeons [19], it is important to verify that these techniques are not inferior to their open counterparts. Our data suggest that, similar to young children and infants [14,15], adolescents who undergo laparoscopic high ligation repair of their inguinal hernias have a similar rate of recurrence (3.0%) to even the lowest-reported recurrence after an open repair (1.8%) [5], with no significant difference between the two ($p = 0.310$). Our data also represent the largest study of laparoscopic high ligation repair of inguinal hernias in adolescent patients.

In addition to an equivalent recurrence rate, there were very few postoperative complications overall. The rate of postoperative pain of 3.0% is particularly noteworthy, as the lack of a foreign body reaction is one of the main theoretical advantages of high ligation over Lichtenstein repair or laparoscopic repair with mesh. When mesh is used, chronic postoperative pain is seen in 11% of adult patients, with one-third of these patients having limitations in their daily activities [20]. Although our rate is obviously nonzero, the lower risk is worth considering in a patient population that is continuing to grow and is generally more active.

While laparoscopic high ligation appears to have both a low recurrence rate and a low complication rate, it is important to emphasize that the technical aspects of the surgery have an associated learning curve. This difficulty is evident even in our study, where one center was excluded owing to a recurrence rate that was significantly higher than the other centers. The reason why the excluded center had such a high recurrence rate is likely technical in nature, since there were no differences in baseline characteristics between the outlier and the remaining hospitals. The excluded center routinely used braided suture, which was not used in the vast majority of the other centers and which had an association with recurrence (OR 12.10, CI 1.54–95.25, $p = 0.02$). Additionally, this center only used a single suture, while all other centers used two. This combination of technical considerations, as well as variables that were not tracked, likely contributed to the disproportionately high recurrence rate.

Though the small number of recurrences prevents true modeling for diagnostic variables, some weak associations were seen in the four recurrences in our study. From a technical standpoint, there may be less risk for recurrence if monofilament and nonabsorbable suture is used; this finding is consistent with a prior animal study [21]. Although intentional injury to the peritoneal surface with cautery has been shown to improve durability in an animal model [22], there was no trend towards significance seen for this technique in our patient population.

Our study has several limitations. As a retrospective study with a survey-based follow-up to determine outcomes, we were reliant on

successfully contacting patients by phone years after their surgery. As a result, we had a follow-up rate of only 38.9%. A majority of patients are therefore not included in follow-up, and it is obviously unknown whether or not these developed a recurrence or other complications. A prospective study would have been able to mitigate this problem, but owing to the greater cost associated with such a design and the paucity of literature describing this surgery in adolescents, a retrospective study was chosen for initial exploration. Our results can now be used to support a future prospective trial.

Furthermore, the fact that we statistically excluded one hospital narrowed our sample size. Of note, though, the recurrence rate of 5.6% with the center included still falls within the published range of 1.8%–6.0%, and is not significantly different from three of the four existing studies, including Ein & Ein (5.6% vs. 5.0%, $p = 0.169$) [4], Shen et al. (5.6% vs. 3.0%, $p = 0.072$) [6], and Lee et al. (5.6% vs. 3.5%, $p = 0.180$) [7].

An additional limitation is that the survey was conducted at a minimum of six months postoperation. Only about one-third of recurrences occur within the first six months [23], so there may be patients who did not have a recurrence at the time of the survey, but subsequently developed one afterwards. However, the median time to follow-up in our study was 2.5 years, and only ten patients (7.4%) had a follow-up period of less than a year. Since more than 80% of recurrences after laparoscopic hernia repair in children were found to occur within one year [24], this follow-up should have captured the vast majority of recurrences in our cohort, though the possibility of a missed recurrence certainly remains.

Furthermore, with ten hospitals and more than two dozen surgeons included, there was limited standardization in technique. As the high number of centers was necessary to recruit a large enough population and the survey was based on operations that were already performed, the variation in technique was unavoidable. We also did not attempt to evaluate which, if any, of these different techniques was superior, as the study was not powered to do so. Finally, although this is the largest study evaluating laparoscopic high ligation in adolescent patients, the rarity of recurrence means that it is largely descriptive, as the low number of recurrences prevents a proper evaluation of potential demographic and operative risk factors. It is well-known that maximum likelihood estimation of the logistic model suffers from small-sample bias. Therefore, the results of the exploratory regression analyses are considered preliminary in nature and further studies are needed to validate these predictors of recurrence.

4. Conclusion

Laparoscopic high ligation for inguinal hernias in adolescents has a similar recurrence to open high ligation repair when performed by experienced surgeons. Further studies are needed to evaluate predictors of recurrence.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jpedsurg.2020.09.026>.

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