Endoloop versus endostapler closure of the appendiceal stump in pediatric laparoscopic appendectomy

Arash Safavi, MD
Monica Langer, MD
Erik D. Skarsgard, MD

From the Department of Surgery, BC Children's Hospital and the University of British Columbia, Vancouver, BC

Presented as a poster at the 43rd Annual Meeting of the Pacific Association of Pediatric Surgeons in Kobe, Japan, May 23–28, 2010.

Accepted for publication Jan. 4, 2011

Correspondence to:
Dr. E.D. Skarsgard
K0-123 ACB, 4480 Oak St.
Vancouver BC V6H 3V4
eskarsgard@cw.bc.ca

DOI: 10.1503/cjs.023810

Background: There is little information available to inform choice of technique for appendiceal stump control in pediatric laparoscopic appendectomy (LA). We compared complications (stump leak, intra-abdominal abscess formation [IAA], surgical site infection [SSI]) in children undergoing LA for perforated (PA) and nonperforated appendicitis (NPA) by technique of appendiceal stump control.

Methods: All children who underwent LA for confirmed acute appendicitis between 2006 and 2009 were reviewed. Choice of stump control (endoloop [EL] or endostapler [ES]) was determined by surgeon preference. Interactions between stump closure techniques and other potential confounders (intra-abdominal drain, irrigation, different antibiotic regimens) were explored using a logistic regression model.

Results: Of 242 patients undergoing LA, 57 (23.6%) had PA. In the PA group the appendiceal stump was closed with EL in 47 (82.5%) patients, while in the NPA group EL was used in 161 (87%) patients. Among PA patients, IAA was more common in the ES than the EL group (5 of 10 [50%] v. 6 of 47 [12.7%]). There was no significant difference in rates of SSI. Among NPA patients, there were no differences in rates of IAA or SSI. There were no stump leaks in either group. Logistic regression analysis confirmed the predictive effect of ES use on IAA formation in PA (adjusted odds ratio 7.09; 95% confidence interval 1.08–46.13; $p = 0.042$).

Conclusion: Our data suggest that in most cases of PA, the appendiceal stump can be safely controlled with EL. Within the PA group, the higher rates of IAA seen in ES patients may be attributable to the quality of the appendiceal stump rather than the technique of closure.

Contexte : Il y a peu d'information disponible pour éclairer le choix de la technique de contrôle du moignon de l'appendice au cours d'une appendicectomie par laparoscopie (AL) en pédiatrie. Nous avons comparé les complications (fuite au niveau du moignon, apparition d'un abcès intra-abdominal [AIA], infection du champ opératoire [ICO]) chez des enfants qui ont subi une AL à cause d'une appendicite perforée (AP) et non perforée (ANP) effectuée au moyen de la technique du contrôle du moignon de l'appendice.

Méthodes : Nous avons étudié les dossiers de tous les enfants qui ont subi une AL à cause d'une appendicite aiguë confirmée entre 2006 et 2009. Le choix de la technique de contrôle du moignon (ligature endoloop [EL] ou agrafe endostapler [ES]) a été déterminé par la préférence du chirurgien. Nous avons exploré les interactions entre les techniques de fermeture du moignon et d'autres facteurs confusionnels possibles (drain intra-abdominal, irrigation, antibiothérapie différente) au moyen d'un modèle de régression logistique.

Résultats : Sur 242 patients qui ont subi une AL, 57 (23,6 %) avaient une AP. Chez les patients qui avaient une AP, le moignon de l'appendicite a été refermé par ligature EL dans 47 cas (82,5 %), tandis qu'on a utilisé la ligature EL chez 161 (87 %) des patients qui avaient une ANP. Chez les patients qui avaient une AP, l'ICO était plus fréquente chez ceux qui ont reçu des agrafes ES que chez ceux qui ont reçu une ligature EL (5 sur 10 [50 %] c. 6 sur 47 [12,7 %]). Il n'y avait pas de différence significative sur le plan des taux d'ICO. Chez les patients qui avaient une ANP, on n'a constaté aucune différence quant au taux d'apparition d'un AIA ou d'une ICO. Il n'y avait pas de fuite au niveau du moignon chez les membres des 2 groupes. L'analyse par régression logistique a confirmé l'effet prédicteur de l'utilisation de l'agrafe ES sur l'apparition d'AIA dans les cas d'AP (ratio d'incidence ajusté 7,09; intervalle de confiance à 95 %, 1,08–46,13; $p = 0,042$).

Conclusion : Nos données indiquent que dans la plupart des cas d'AP, il est possible de contrôler le moignon de l'appendice en toute sécurité au moyen d'une ligature EL. Chez les patients qui ont subi une AP, les taux plus élevés d'AIA constatés chez ceux qui ont reçu des agrafes ES peuvent être attribuables à la qualité du moignon d'appendice plutôt qu'à la technique de fermeture.

Appendectomy is one of the most common operations performed by pediatric surgeons, and whereas laparoscopic appendectomy (LA) has increased in popularity, its ability to offer a definitive outcome advantage over open appendectomy (OA) remains unproven.[1–6] Nevertheless, the cosmetic benefits of LA, the ease with which it can be learned and its value as a training tool for more complex laparoscopic procedures have increased its popularity among many pediatric surgeons. There are several technical variations that could potentially affect the outcome of LA, including single- versus multiple-port instrumentation,[7] techniques for dividing and sealing the mesoappendix[8] and the choice of technique for closure of the appendiceal stump.[9] The purpose of this study was to compare 2 techniques of appendiceal stump closure (endostapler [ES] v. endoloop [EL]) from the perspective of infectious complications (stump leaks, intra-abdominal abscess [IAA] formation and surgical site infections [SSI]) and duration of surgery in children undergoing LA.

Methods

We performed a retrospective review of all pediatric patients who underwent laparoscopic appendectomy for pathologically confirmed acute appendicitis at British Columbia Children's Hospital between 2006 and 2009. Patients undergoing open appendectomy, laparoscopic converted to open appendectomy or incidental appendectomies were excluded. Cases were categorized as perforated appendicitis (PA) if a hole was observed in the appendiceal wall or if a fecalith was identified outside of the appendiceal lumen at the time of surgery.[10] Laparoscopic appendectomy was performed using reusable instruments (except for the ES); division of the mesoappendix was performed with either monopolar or bipolar cautery.

The choice of technique of appendiceal stump closure was surgeon dependent: 1 surgeon used the ES (Ethicon Endosurgery) in all cases (PA and nonperforated appendicitis [NPA]), whereas 2 surgeons routinely used EL unless the condition of the appendiceal base favoured use of an ES to ensure sealing of healthy tissue. Endoloop stump closure consisted of 2 proximal and 1 distal 2–0 polydioxanone (PDS; Ethicon) ELs, with division of the appendiceal base between the middle and distal EL. Specimen retrieval devices were used routinely for PA and selectively for NPA. If purulent material or an abscess was encountered, it was evacuated with suction. Irrigation was used at the discretion of the surgeon.

All patients with NPA received a single, preoperative intravenous dose of a second-generation cephalosporin and were typically admitted to hospital for 24 hours or less, in accordance with a standardized protocol. Patients with PA received pre- and postoperative intravenous antibiotics, which were standardized by duration (5 d) but not choice of antibiotic (double v. triple intravenous regimen based on surgeon preference). Within the PA and NPA groups, infectious complications (stump leaks, IAA formation and SSI) detected before and after hospital discharge and mean durations of surgery were compared according to the technique used to close the appendiceal stump. We analyzed our outcomes according to technique of stump closure using odds ratios (ORs) and 95% confidence intervals (CIs). Interactions between stump closure techniques and other potential confounders (use of intra-abdominal drain, irrigation and different antibiotic regimens) were explored using a logistic regression model. We compared continuous variables using the Student *t* test.

Table 1. Comparison of laparoscopic appendectomy outcomes according to appendiceal stump closure technique

Characteristic	Nonperforated appendicitis, *n* = 185		*p* value	Perforated appendicitis, *n* = 57		*p* value
	Endoloop	Endostapler		Endoloop	Endostapler	
No. (%)	161 (87)	14	—	47 (82.0)	10	—
Age, mean (SD) yr	11 (3.0)	11 (4.2)	> 0.99	9 (3.4)	10 (3.6)	0.40
Duration of surgery, mean (SD) min	52 (17)	56 (25)	0.42	51 (19.0)	45 (24.0)	0.39
Surgical site infection, no (%)	2 (1.24)	0	0.25	2 (1.2)	0	0.78
Intra-abdominal abscess formation, no. (%)	5 (3.1)	0	0.61	6 (12.7)	5 (50.0)	0.016*

SD = standard deviation.
*Odds ratio 6.83, 95% confidence interval 1.51–30.83.

Definitions of infectious complications

The presence of an erythematous, painful wound with purulent drainage with only skin and subcutaneous tissue involvement that developed within 30 days after an operation and was diagnosed by an attending surgeon was considered to be an SSI. A patient who was febrile with typical sequelae (fever, elevated white cell count and ileus) and imaging demonstrating a fluid collection with characteristics of an abscess with either positive organisms cultured from surgically placed drain/blood or positive organisms on gram stain of drainage/tissue obtained during surgical operation/needle aspiration was considered to have an IAA.[11] The diagnosis of a stump leak required either confirmation by operation or the observation of fecal drainage through a radiologically placed catheter for abscess drainage.

Results

A total of 242 patients underwent LA during the study period and had complete data sets abstracted retrospectively from their medical records. Fifty-seven patients (23.6%) had PA, whereas 185 patients had NPA. The outcomes comparison according to technique of appendiceal stump closure is summarized in Table 1. Endoloops were used in 208 patients (86%), with no differences in proportional use between PA and NPA groups. Patient age and durations of surgery were similar between ES and EL groups for both PA and NPA. Within the PA group, IAA was more common among patients undergoing ES than EL (5 of 10 [50%] v. 6 of 47 [12.7%]; OR 6.83, 95% CI 1.51–30.83; $p = 0.016$), whereas rates of SSI were not affected by technique of stump closure. Within the NPA group, technique of stump closure had no effect on rates of either infectious complication.

Table 2 shows the effects of other treatment covariates on the development of IAA following LA for PA. Construction of a multiple logistic regression model controlled for these covariates (use of abdominal drain, abdominal irrigation and 2- v. 3-drug antibiotic regimen) confirmed the predictive effect of ES use on IAA formation in PA (adjusted OR 7.09, 95% CI 1.08–46.13; $p = 0.042$).

Table 2. Effects of individual treatment variables on intra-abdominal abscess formation following laparoscopic appendectomy for perforated appendicitis

Treatment variable	Unadjusted OR (95% CI)
Endostapler	6.83 (1.51–30.83)
Abdominal drain	0.38 (0.07–1.96)
Abdominal irrigation	1.08 (0.29–4.06)
2 antibiotics*	1.20 (0.32–4.49)

CI = confidence interval; OR = odds ratio.
*Use of a 2-drug versus a 3-drug regimen.

Discussion

Laparoscopic appendectomy is one of the most common procedures performed by pediatric surgeons. A population-based study of pediatric patients in the United States reported that LA rates for both NPA and PA had risen almost 3-fold from 18.6% in 1999 to 52.4% in 2006.[12] The stated advantages of LA over open appendectomy include earlier recovery, shortened length of stay in hospital and decreased rates of wound infection.[3,5] A recent meta-analysis of LA versus OA in children demonstrated a reduced rate of SSI among those undergoing LA; however, a subgroup analysis confined to randomized controlled trials demonstrated no difference in clinical outcome (postoperative fever, SSI, IAA, duration of ileus) between groups.[13] Despite the lack of a clear outcome benefit of LA, most cost studies confirm the substantially greater expense associated with LA compared with OA,[14–16] with most of the cost differential attributable to the use of expensive disposable equipment, notably ES.[17]

In this study, we sought to compare infectious outcomes between 2 established laparoscopic techniques of appendiceal stump closure: EL and ES. The technical preferences for stump closure among 3 surgeons who routinely performed LA for all cases of appendicitis at our centre enabled this comparison, as only 1 of the 3 used the ES in all cases. Although there were no differences in infectious complications among children treated for NPA, there was a significantly higher rate of IAA formation among children who underwent ES versus EL closure of the appendiceal stump. Whereas we did not perform a formal cost analysis, it is likely that such an analysis would favour EL based on the increased cost attributable to the disposable ES ($19.19 per EL × 3 = $57.57 per case v. $251.68 per ES per case) and the equivalence of duration of surgery between groups (costs in Canadian dollars).

Our study complements 2 existing retrospective cost studies that address the use of EL versus ES in pediatric LA. One study compared division of the mesoappendix with ultrasonic shears and ligation of the appendiceal stump with EL to division of the mesoappendix and appendix with an ES.[9] Based on comparable rates of complication for both PA and NPA, and longer duration of surgery and higher disposable equipment costs for EL, the authors concluded that ES offered an economic benefit in pediatric LA. Another retrospective cost analysis study comparing EL versus ES in pediatric LA yielded the opposite result. Although there were no outcome differences between groups, there was a 37% cost differential favouring the EL, owing primarily to reduced equipment costs.[18] Reports from the adult LA literature are similarly contradictory. One retrospective cohort study reported a significantly higher SSI rate and hospital readmission rate among adults with acute appendicitis managed by EL compared with ES and concluded that ES provided more

secure stump closure than EL,[19] whereas a recent meta-analysis reported no difference in complication rates between patients managed with EL versus ES.[20] One prospective trial of 1 versus 2 proximal ELs in LA found no outcome difference between groups and concluded that a minimally inflamed appendiceal base could be safely controlled by a single EL.[21]

Limitations

The observation of a significantly higher rate of IAA formation in the ES group in our study requires comment, as it may reflect a selection bias toward the use of ES for more inflamed appendiceal stumps, a specifically acknowledged limitation of this retrospective study. The other potential source of bias is surgeon specific, since one surgeon undertook most ES cases. However, in our teaching hospital, virtually all of the cases were performed by trainees (either general surgery or pediatric general surgery residents), which should eliminate most of this bias.

Conclusion

Regardless of bias and other limitations inherent to its retrospective nature, this study suggests that preferential use of EL for appendiceal stump closure in LA is associated with at least equivalent infectious outcomes, as well as cost savings, in comparison to routine use of ES. Finally, in a teaching facility, a learner's acquisition of the aptitude and depth perception required for accurate EL placement during LA, provides useful preparation for more advanced laparoscopic procedures.

Competing interests: None declared.

Contributors: M. Langer and E.D. Skarsgard designed the study and reviewed the article. A. Safavi acquired and analyzed the data. All authors wrote the article and approved its publication.

References

1. Nwokoma NJ, Swindells MG, Pahl K, et al. Advanced appendicitis: open versus laparoscopic approach. *Surg Laparosc Endosc Percutan Tech* 2009;19:110-3.
2. Pham VA, Pham HN, Ho TH. Laparoscopic appendectomy: an efficacious alternative for complicated appendicitis in children. *Eur J Pediatr Surg* 2009;19:157-9.
3. Yagmurlu A, Vernon A, Barnhart DC, et al. Laparoscopic appendectomy for perforated appendicitis: a comparison with open appendectomy. *Surg Endosc* 2006;20:1051-4.
4. Pokala N, Sadhasivam S, Kiran RP, et al. Complicated appendicitis — Is the laparoscopic approach appropriate? A comparative study with the open approach: outcome in a community hospital setting. *Am Surg* 2007;73:737-41.
5. Yau KK, Siu WT, Tang CN, et al. Laparoscopic versus open appendectomy for complicated appendicitis. *J Am Coll Surg* 2007;205:60-5.
6. So JB, Chiong EC, Chiong E, et al. Laparoscopic appendectomy for perforated appendicitis. *World J Surg* 2002;26:1485-8.
7. Ponsky TA, Diluciano J, Chwals W, et al. Early experience with single-port laparoscopic surgery in children. *Laparoendosc Adv Surg Tech A* 2009;19:551-3.
8. Ponsky TA, Rothenberg SS. Division of the mesoappendix with electrocautery in children is safe, effective, and cost-efficient. *J Laparoendosc Adv Surg Tech A* 2009;19 Suppl 1:S11-3.
9. Lukish J, Powell D, Morrow S, et al. Laparoscopic appendectomy in children: Use of the endoloop versus the endostapler. *Arch Surg* 2007; 142:58-61.
10. St. Peter SD, Sharp SW, Holcomb GW III, et al. An evidence-based definition for perforated appendicitis derived from a prospective randomized trial. *J Pediatr Surg* 2008;43:2242-5.
11. Garner JS, Jarvis WR, Emori TG, et al. CDC definitions for nosocomial infections. In: Olmsted RN, editor. *APIC infection control and applied epidemiology: principles and practice*. St. Louis (MO): Mosby; 1996. p. A-1-A-20.
12. Jen HC, Shew SB. Laparoscopic versus open appendectomy in children: outcomes comparison based on a statewide analysis. *J Surg Res* 2010;161:13-7.
13. Aziz O, Athanasiou T, Tekkis PP, et al. Laparoscopic versus open appendectomy in children: a meta-analysis. *Ann Surg* 2006;243:17-27.
14. Lintula H, Kokki H, Vanamo K, et al. The costs and effects of laparoscopic appendectomy in children. *Arch Pediatr Adolesc Med* 2004;158: 34-7.
15. Vernon AH, Georgeson KE, Harmon CM. Pediatric laparoscopic appendectomy for acute appendicitis. *Surg Endosc* 2004;18:75-9.
16. Billingham MJ, Basterfield SJ. Pediatric surgical technique: Laparoscopic or open approach? A systematic review and meta-analysis. *Eur J Pediatr Surg* 2010;20:73-7.
17. Visnjic S. Transumbilical laparoscopically assisted appendectomy in children: high-tech low-budget surgery. *Surg Endosc* 2008;22:1667-71.
18. Wehrman WE, Tangren CM, Inge TH. Cost analysis of ligature versus stapling techniques of laparoscopic appendectomy in children. *J Laparoendosc Adv Surg Tech A* 2007;17:371-4.
19. Beldi G, Vorburger SA, Bruegger LE, et al. Analysis of stapling versus endoloops in appendiceal stumpclosure. *Br J Surg* 2006;93:1390-3.
20. Sajid MS, Rimple J, Cheek E, et al. Use of endo-GIA versus endoloop for securing the appendicular stumpin laparoscopic appendicectomy: a systematic review. *Surg Laparosc Endosc Percutan Tech* 2009; 19:11-5.
21. Beldi G, Muggli K, Helbling C, et al. Laparoscopic appendectomy using endoloops: a prospective, randomized clinical trial. *Surg Endosc* 2004;18:749-50.