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Technical Reports

Infectious Complications After Laparoscopic Appendectomy in Pediatric Patients with Perforated Appendicitis: Is There a Difference in the Outcome Using Irrigation and Suction Versus Suction Only? Results of a Multicentric International Retrospective Study

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Abstract

Background: Analyzing the recent literature, it seems that the use of irrigation increases the incidence of intra-abdominal abscesses (IAAs) and infectious complications in perforated appendicitis. The aim of this study was to compare peritoneal irrigation and suction versus suction only during laparoscopic appendectomy (LA) for perforated appendicitis in children.

Materials and Methods: We retrospectively reviewed the records of 699 patients (460 boys and 239 girls, average age 9.8 years) who underwent LA for complicated appendicitis in six international centers of pediatric surgery over a 5-year period. The appendix was perforated with localized peritonitis in 465 cases and diffuse peritonitis in 234 patients. Irrigation + suction was used in 488 cases (group 1 [G1]), whereas suction only was used in 211 cases (group 2 [G2]).

Results: No significant difference between the two groups was found in regard to average operative time ($P = .23$), average time of resumption of oral diet ($P = .55$), average reprise of gastrointestinal transit ($P = .55$), and average length of hospital stay ($P = .41$). As for postoperative complications, the incidence of IAAs was significantly higher in G2 (41/211; 19.4%) compared with G1 (38/488; 7.7%) ($P = .0000$), whereas no significant difference was found between the two groups in regard to wound infection (G1: $n = 2$ or 0.4%; G2: $n = 4$ or 1.8%; $P = .05$) and small bowel obstruction rates (G1: $n = 8$ or 1.6%; G2: $n = 2$ or 0.9%; $P = .47$).

Conclusions: In contrast with the most recent literature on this topic, our results demonstrated that peritoneal irrigation and suction were associated with a lower rate of postoperative IAA formation compared with the suction-only approach in children with perforated appendicitis. In such cases, peritoneal irrigation and abdominal drainage should be the preferred methods for peritoneal toilette, with no increase in operative time and postoperative morbidity.

Keywords: complicated appendicitis, suction, irrigation, laparoscopy, children

Introduction

Laparoscopic appendectomy (LA) is being progressively accepted as the standard of care for acute appendicitis in the pediatric population.[1,2] Benefits of LA over open treatment include faster recovery, less postoperative pain, reduced wound infections, shorter hospitalization, and earlier return to full daily activities.[3]

Perforated appendicitis is still a cause of significant postoperative morbidity. The main problem is the high incidence

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(3%–20%) of intra-abdominal abscesses (IAAs) following LA in perforated cases.[4,5] The presence of an IAA often requires a second procedure for drainage and frequently necessitates additional general anesthesia for young children.[6]

There are several technical variations that may potentially affect the outcome of LA. One is the need for peritoneal irrigation, which is still debated.[7,8] While the surgical technique of LA is well established, there is little evidence to guide the decision to irrigate or not. The use of irrigation is based on the hypothesis that if the bacterial load is diluted, the patient will have less risk of peritonitis or a less severe postoperative course. Current practice in pediatric surgery appears to be controversial, with many surgeons strongly advocating for irrigation and many advocating against.[9]

In the only prospective randomized trial on this topic to date, peritoneal irrigation was shown to have no advantage over a suction-only approach in a pediatric population.[10]

Analyzing the most recent literature, it seems that in case of perforated appendicitis, the use of irrigation increases the incidence of IAAs and infectious complications.[11,12]

For this reason, we decided to perform a multicentric international study aiming to compare the outcome of LA using peritoneal irrigation and suction versus suction only for peritoneal toilette in children with perforated appendicitis. The main objective of the study was to determine whether irrigation of the peritoneal cavity in children with perforated appendicitis affected the rates of IAA formation as well as wound infections and other postoperative complications.

Materials and Methods

We retrospectively reviewed the records of 708 patients who underwent LA for perforated appendicitis in six international centers of pediatric surgery over a 5-year period.

Eight patients, in whom a conversion to open surgery was necessary, were excluded and a final number of 699 patients were enrolled in the study. There were 460 boys and 239 girls with an average age of 9.8 years (range 6.9–11.8) and an average weight of 45.7 kg (range 26–60). The appendix was perforated with localized peritonitis in 465 cases, while diffuse peritonitis was found in 234 patients.

Operative irrigation + suction was used in 488 cases (group 1 [G1]), whereas suction only was adopted in 211 cases (group 2 [G2]).

The technique used for peritoneal toilette (irrigation and suction versus suction only) was chosen based on the operating surgeon's personal preference.

Preoperatively, all patients underwent a clinical examination and laboratory analysis (white blood cell [WBC] count, C-reactive protein [CRP]) and abdominal ultrasonography (US).

All patients received the same antibiotic therapy protocol (cephalosporin [dosage: 50 mg/kg/die] + metronidazole [dosage: 7.5 mg/kg/8 hours]) for 7 days postoperatively. In case of cephalosporin allergy, ciprofloxacin (dosage: 15 mg/kg/12 hours) was adopted.

Laboratory analysis (WBC count, CRP) was repeated on postoperative days 1, 3, 5, and 7. Intravenous antibiotics were stopped once patients were afebrile for more than 24 hours with normal white cell count.

The primary outcome measurement was incidence of postoperative IAA. Secondary outcomes were wound infections and noninfectious complications (postoperative ileus and small bowel obstruction), length of surgery, length of hospital stay, time of resumption of oral diet, and time of reprise of gastrointestinal transit.

Postoperative complications were assessed according to the Clavien-Dindo classification system.[13] Any patient with clinical features suggestive of a postoperative intra-abdominal collection had abdominal US and, if confirmed, was started on antibiotics or prepared for US-guided or computed tomography (CT)-guided drainage and, in case of failure, for surgical drainage.

In all cases, patients were discharged when they were afebrile, pain was managed by oral analgesics, and oral intake was stable. Upon discharge, all patients were prescribed an antibiotic regimen with amoxicillin/clavulanate (dosage: 80 mg/kg/die divided in three doses via oral administration) for 8–10 days. A high level of patients' compliance to this antibiotic regimen was recorded in our series since all patients completed the prescribed therapy.

This study received the appropriate institutional review board approval.

Statistical analysis was carried out by using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL), version 13.0. Demographic data were compared using Student's *t*-test. The chi-square test or Fisher's exact test was used for analyzing the incidence of complications. Significance was defined as $P < .05$.

Surgical technique

LA was performed using a three-trocar technique, one 5- or 10-mm trocar placed umbilically as a camera port and two 5-mm trocars placed in the left iliac fossa and suprapubically. The mesoappendix was dissected, depending on the surgeon's preference, with either a bipolar tissue sealing system (Ligasure) or using thermal fusion technology (Miseal; Microline).

The appendiceal base was divided using an Endoloop ligature or endostapler, according to the surgeon's preference. In the endoloop group, the loops were placed over the base of the appendix and the appendix was divided between the loops. The use of one or two proximal loops and one distal loop was the standard method. In the endostapler group, a 12-mm trocar was placed in the left lower abdomen for the stapler. The endostapler was fired at the base of the appendix with blue cartridges and a 35- or 45-mm blade. In case of perforation or necrosis of the appendiceal base or inflammation of the cecum, the stapler was fired taking a rim of healthy cecum.

The appendix was then extracted using a disposable specimen retrieval bag through the largest port site. All purulent fluid was aspirated, and debris and fibrin clots were removed in all patients. In the irrigation group, the peritoneal cavity was repeatedly washed with warm 0.9% NaCl solution without antibiotics until the aspirated fluid was clear; the solution was aspirated. An average volume of irrigation of 1000 mL (range 500–2500 mL) was used. In the suction group, neither peritoneal cavity irrigation nor drainage was used and the surgery was completed with suction alone.

At the end of surgery, a drain was placed into the pelvis and/or right pericolic region and exited the abdomen through a trocar's orifice.

Skin incisions were routinely closed with separate resorbable sutures.

Results

The analysis of patients' demographics revealed that there was no significant difference between G1 and G2 in regard to patients' average age at surgery (G1: 10.2 years [range 6.9–12.6]; G2: 10.9 years [range 8.5–14.3]; $P = .20$), preoperative average WBC count (G1: 15,100/mm^3; G2: 14,850/mm^3; $P = .41$), and preoperative average CRP (G1: 12.8 mg/dL; G2: 12.5 mg/dL; $P = .41$).

No intraoperative complication was recorded. There was no significant difference between the two groups in regard to average operative time (G1: 65.5 minutes; G2: 60.6 minutes; $P = .23$), average time of resumption of oral diet (G1: 53 hours; G2: 58 hours; $P = .55$), average reprise of gastrointestinal transit (G1: 3 days; G2: 4 days; $P = .55$), average length of hospital stay (G1: 6.5 days; G2: 7 days; $P = .41$), and average duration of antibiotic therapy (G1: 6.5 days; G2: 7 days; $P = .41$).

As for postoperative complications, the incidence of IAA was significantly higher in G2 (41/211; 19.4%) compared with G1 (38/488; 7.7%) ($P = .0000$), whereas no significant difference was found between the two groups in regard to wound infection (G1: $n = 2$ or 0.4%; G2: $n = 4$ or 1.8%; $P = .05$) and adhesion-related small bowel obstruction rates (G1: $n = 8$ or 1.6%; G2: $n = 2$ or 0.9%; $P = .47$).

In regard to management of postoperative complications, wound infections were treated with antibiotic therapy in all patients of both groups (II Clavien). Small bowel obstructions were managed by nasojejunal tube decompression in all cases (II Clavien) except six cases of G1 who required surgical intervention for adhesiolysis (IIIb Clavien). IAAs were all managed with antibiotic therapy and/or US-guided or CT-guided drainage (II Clavien) except in 10 patients (9 G1 patients and 1 G2 patient) who required, after failure of an attempt with imaging-guided drainage, surgical drainage under general anesthesia (IIIb Clavien).

The reoperation rate was higher in G1 ($n = 15$ or 3.0%) compared with G2 ($n = 1$ or 0.5%), but this difference was not statistically significant ($P = .16$).

Patients' demographics and outcome parameters are reported in Table 1.

Discussion

Acute appendicitis is increasingly treated laparoscopically because of several reported advantages compared with the open approach, including faster recovery, less pain, and fewer wound infection rates.[1–3,14]

Complicated appendicitis is still associated with a high morbidity rate; previous studies have suggested that there is an increased risk for postoperative complications, such as IAA formation and small bowel obstruction, in perforated appendicitis, both in children and adults.[4–6]

Table 1. Patients' Demographics and Outcome Parameters in Group 1 and Group 2

	G1 (irrigation + suction) n = *488*	*G2 (suction only)* n = *211*	*Statistical analysis,* P
Patients' demographics			
Number of boys	340	120	
Number of girls	148	91	
Average age (years)	10.2	10.9	.20
Average weight (kg)	48.8	42.6	.20
Perforated appendicitis with localized peritonitis (*n*)	352	113	.50
Diffuse peritonitis (*n*)	136	98	.47
Preoperative average WBC count (/mm^3)	15.100	14.850	.41
Preoperative CRP (mg/dL)	12.8	12.5	.41
Operative outcome			
Average operative time (minutes)	65.5	60.6	.20
Intraoperative complications (*n*)	0	0	
Average time of resumption of oral diet (hours)	53	58	.55
Average analgesic requirement (hours)	48	56	.55
Average resumption of gastrointestinal (GI) transit (days)	3.8	4.3	.7
Average length of hospital stay (days)	6.5	7	.41
Average duration of antibiotic therapy (days)	6.5	7	.41
Postoperative complications			
Intra-abdominal abscess (IAA)	38 (7.7%)	41 (19.4%)	.0000
Wound infection	2 (0.4%)	4 (1.8%)	.05
Small bowel obstruction	8 (1.6%)	2 (0.9%)	.47
Others	0	0	
Reoperation	15 (3.0%)	1 (0.5%)	.16
Clavien-Dindo grading			
Grade I	0	0	
Grade II	33 (68.8%)	46 (97.8%)	
Grade III	15 (31.2%)	1 (2.1%)	
Grade IV	0	0	
Grade V	0	0	

CRP, C-reactive protein; G1, group 1; G2, group 2; WBC, white blood cell.

The most frequent and devastating complications after LA are of an infectious origin, mainly formation of IAA.[4–6] IAA causes significant morbidity, prolonging hospital stay, increasing cost, and often requiring repeat intervention. Various studies have quoted the rates of IAA of 1%–4% for nonperforated appendicitis compared with 10%–24% for perforated cases.[15]

There are several technical variations that may potentially affect the outcome of LA in perforated appendicitis. One is the necessity for peritoneal irrigation that is still under debate.[7,8] While the surgical technique of LA is well established, there is little evidence to guide the decision to irrigate or not.[9,10] Analyzing the most recent literature, it seems that in case of perforated appendicitis, the use of irrigation increases the incidence of IAAs and infectious complications.[10,11]

Proponents of the suction-only approach argue that the process of irrigation could cause contamination in clean areas of the peritoneal cavity, especially in instances of perforated appendicitis with localized abscess/free pus.[16]

In an article published in 2013, St. Peter outlined several reasons why irrigation may not work and may be harmful: (i) bacteria adhere to the peritoneal mesothelial cells and the micro-organism load on the peritoneum is not decreased by irrigation; (ii) irrigation may cause diffuse or remote inoculation, and washing can spread the contamination; and (iii) irrigation may dilute mediators of phagocytosis (opsonic proteins and immunoglobulins).[12]

Other authors have reported that peritoneal irrigation and drainage, which are still used by many surgeons for perforated appendicitis, do not contribute to a decrease in postoperative complications.[16,17] In addition, some studies reported a higher rate of postoperative complications in patients treated with irrigation and suction compared with suction only, with an increase in operative time.[10,11]

In contrast with the last articles published on this topic, the results of our international multicentric study demonstrated that the use of peritoneal irrigation can positively influence the outcome of LA in perforated appendicitis. It was associated with a lower incidence of postoperative IAA formation compared with the suction-only approach. The incidence of wound infections and other noninfectious complications, including adhesion-related small bowel obstruction, was not significantly different between the two groups. In addition, in our series, the use of peritoneal irrigation did not cause an increase in the operative time, as reported in previous studies.[16,18] In our series, the technique used for peritoneal toilette (irrigation and suction versus suction only) was chosen based on the operating surgeon's personal preference.

All patients of both groups received the same antibiotic therapy protocol (cephalosporin + metronidazole) for 7 days postoperatively. Upon discharge, all patients were prescribed an antibiotic regimen with amoxicillin/clavulanate (dosage: 80 mg/kg/die divided in three doses per os) for 8–10 days. A high level of patients' compliance to this antibiotic regimen was recorded in our series since all patients completed the prescribed therapy.

Another debated point is about the optimal amount of fluid to be used for irrigation and whether irrigation should be performed using only saline solutions or solutions with antibiotics or antiseptics such as povidone-iodine.[8,19,20] In our experience, we always used only warm 0.9% NaCl solution without antibiotics or antiseptics to irrigate the peritoneal cavity.

In regard to the volume of irrigation, we adopted an average volume of irrigation of 1000 mL, with a minimum volume of 500 mL and a maximum volume of 2500 mL. The common strategy was abundant lavage of the whole peritoneal cavity until the aspirated fluid was clear with meticulous suction of all fluids, in particular at the level of Douglas space and subhepatic, subphrenic, and right parieto-colic spaces.

Another important trick is to use a low pressure in irrigation to avoid displacement and dislodgement of pus in the entire abdominal cavity.

In regard to abdominal drainage, some authors argued that keeping the drain tube in the peritoneal cavity for a long period is associated with a higher risk of foreign body reactions or infections and may increase hospital stay because of discharge coming through the drain.[21,22]

We preferred to leave an abdominal drainage through one of the trocars' orifices for at least 24–48 hours following surgery in all patients. In our experience, the use of abdominal drainage was not associated with an increase in postoperative morbidity and length of hospital stay.

It is also debated if it is preferable to leave one or two drainages in the abdominal cavity; however, in our experience, we found no difference between the use of one and two drains and we usually prefer to leave only one drainage.

In conclusion, in contrast with the most recent literature published on this topic, our results demonstrated that the use of peritoneal irrigation and suction positively influenced the postoperative outcome and was associated with a lower rate of postoperative IAA formation compared with the suction-only approach in children who underwent LA for perforated appendicitis.

In such cases, peritoneal irrigation and abdominal drainage should be the preferred methods for peritoneal toilette, with no increase in operative time and postoperative morbidity.

Disclosure Statement

No competing financial interests exist.

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