Original Article

Development in the Surgical Treatment of Acute Appendicitis: A Single-center Experience

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Abstract

Purpose: Laparoscopy has become the treatment of choice for acute appendicitis. The aim of the study was to compare open (OA) and laparoscopic (LA) approaches in all forms of acute appendicitis. **Methodology:** Two hundred and ninety-two children underwent appendectomy (238 LA/54 OA). 3/238 patients required conversion. LA surgical technique has been modified by closing also the distal stump of appendix (DSC) before removing it. **Results:** Early experience**:** 130 appendectomy, 44 by OA (34%), and 86 by LA (66%). The mean operative time was similar for both techniques. Complicated appendicitis (CA) was observed in 14 patients (11%). 10 patients treated with OA (10/14 = 71%) and 4 with LA (4/14 = 29%). Complications occurred mainly in the LA group without statistical significance. **Late Experience:** One hundred and sixty-two appendectomy, 10 OA (6.17%), and 152 LA (93.8%). Thirty-eight children (23.4%) had CA. The mean operative time was lower in LA group without reaching statistical significance. Total complication rate (CR) was 7.4%. CR in patients with DSC was null and significantly lower when compared to patients without DSC. **Conclusion:** Our results demonstrated that nearly all cases of appendicitis may be managed by laparoscopy. Ligature of distal appendiceal stump is a trick that may significantly improve outcomes during LA appendectomy.

Keywords: Appendectomy, children, complications, laparoscopy, surgical technique

Introduction

Acute appendicitis is the most common indication for urgent abdominal surgery in children and lifetime incidence may range from 7% to 9%.[1]

Laparoscopic appendectomy (LA) was first described by Semm in 1983.[2] Since then, many studies have shown its advantage over open approach (OA) with better cosmesis, shorter hospital stay, less pain, and recovery.[3,4] However, although the surgical technique of LA appendectomy has been well established, various technical aspects still need to be evaluated and standardized, especially regarding the closure of the appendiceal stump. It is established that inappropriate management of appendiceal stump can lead to serious postoperative complications, such as stercoral fistulas, postoperative peritonitis, and intra-abdominal infection.

Changes to the original procedure and new materials have been introduced over the years and the division of the appendix base can be successfully obtained using a stapler, a clip, or endoloops.[5-7]

The aim of this retrospective study was to compare results in the treatment of acute appendicitis in children by OA and LA with special regard to complicated appendicitis (CA) and technical details, such as closure of distal appendiceal stump.

Methodology

All children, included in this study, were observed by senior author and underwent LA appendectomy for acute appendicitis during the period 2006-2015. We collected information about age, gender, type of presentation (simple or complicated), surgical procedure, complications (only major), and hospital

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stay. The study was approved by the Ethics and Research Commission because the study did not involve significant changes in the standard of care. Furthermore, all patients signed up informed consent terms for treatment and data privacy. Most of patients treated with LA technique during the early experience period were operated by the senior author, while those included in the late experience were done by all staff/residents. The LA grading system of acute appendicitis was used to graduate the disease.[8] The diagnosis of intra-abdominal infections was suspected by clinical signs and demonstrated by ultrasonography, computed tomography (CT) scan, or laparoscopy. Children who underwent surgical procedure without final diagnosis of appendicitis were excluded from the study. The negative appendectomy rate was 7.8% and 9.2% in the early and late experience, respectively. All the children received antibiotics pre-operatively and were operated under general anesthesia. None of children with CA had interval appendectomy even if symptoms were more than 3 days.

LA procedure was performed with three-port technique, a 10 mm umbilical port for camera, one 5 mm port in the right hypogastrium (in the early experience a suprapubic trocar was used instead), and the last 5 mm port in the left iliac fossa [Figure 1]. The initial LA approach was done by Verres needle for umbilical port. However, since 2012, we changed to open access in children with CA (following an episode of intraoperative bowel perforation by Verres needle on a fixed bowel loop in umbilical region). Patients were lying supine in Trendelenburg position, tilted 10°–15° to the left side. Appendix was retrieved and its mesentery was dissected by bipolar forceps or, in most difficult cases, by Ultracision (Harmonic, Ethicon Endosurgery LLC, PR, USA). During the early experience, only two endoloops were placed at the base of appendix, 1-2 mm apart, and the distal appendiceal stump was cutted without closing it. Three years ago, we changed our technique with closure of the distal appendiceal stump (DSC) because a child had abscess formation due to unrecognized intra-abdominal lost of a little fecal mass (coprolite) during removal of appendix. The appendix was removed by the left iliac or umbilical port and, if bulky, with the help of endocatch bag. The OA technique consisted of Rockey–Davis or McBurney incisions, splitting of muscle and fascia, access to peritoneal cavity, and recovery of appendix by blind finger dissection or under direct vision in more complicated cases. Then, the mesoappendix was taken between sutures or electrocautery, and the appendix was ligated and cutted at the basis with or without inversion in the cecum. Intraoperative irrigation and drainage placement were done in all children with CA. Operative time (skin to skin) and hospital stay were evaluated. Surgical site infection was defined by clinical signs of edema, redness around the wound, or purulent discharge until the 30th postoperative day. Operative complications were defined as bleeding, iatrogenic injury, small bowel obstruction, and enteric leak. Postoperative analgesia was by paracetamol or, in resistant cases, intravenous ketorolac.

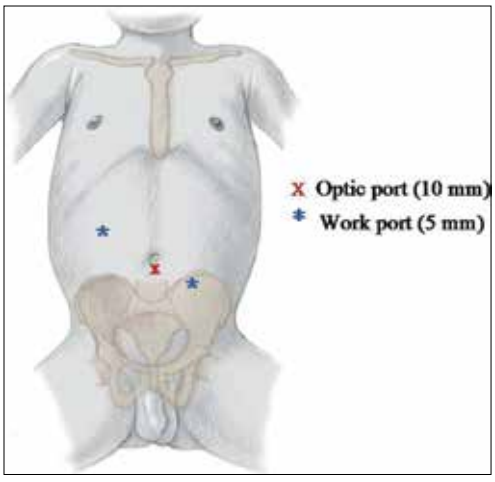

Figure 1: Trocars'position

Postoperative antibiotic treatment consisted of a 5-day course of ceftriaxone in CA or 7–10 days course of combination therapy Piperacillin/Tazobactam (Tazocin®) and Teicoplanin (Targosid®).

Statistical analysis was performed with Statistical Package for the Social Science software (SPSS, Inc., Chicago, IL, USA) and statistical differences between groups were calculated by Fisher's exact test and paired *t*-test. The data were expressed as mean + standard deviation (SD). Statistical significance was when $P < 0.05$.

Results

Early experience

A total of 130 appendectomy procedures (58 females, 72 males; mean age 9.4 ± 2.9 years) were done, 44 by OA (34%) and 86 by LA (66%). Only one patient required conversion from LA to OA. The mean operative time (+SD) was as follows: LA = 68' ±19' versus OA = 62'±17; (P = 0.073). CA was present in 14 patients (11%; mean age 4.4 ± 0.5), 10 treated with OA (10/14 = 71%) and 4 with LA (4/14 = 29%). One intraoperative bladder injury and two postoperative complications (intra-abdominal abscess [IAA]) were observed in the LA group and 1 child in the OA group had wound infection (total CR: 4/130 = 3.1%; partial CR: LA 3/86 = 3.5% and OA 1/44 = 2.3%; $P = 0.059$). The mean hospital stay was 5.7 ± 1.6 days. The hospital stay for LA group was 5 ± 1 days while for OA was 7 ± 2 days [Table 1].

Late experience

A total of 162 appendectomy procedures (102 females, 60 males; mean age 8.7 ± 3.6 years) were analyzed. Of these, 10 were OA (6.17%) and 152 LA (93.8%). Fifty-five patients were treated with DSC and 97 without closure of distal stump (WDSC). There was CA in 38 children (23.4%; mean age 7.5 ± 3.2 years), 4 underwent OA for multiple IAA and 34 LA. In the last group, there were 19 WDSC and 15 DSC. Only 2 patients required conversion (2/152 = 1.31%). The mean operative time was LA = 52 min ± 14 min vs.

OA = 150 min ± 55; (P = 0.01). Total CR was 7.4% (12/162). Partial CR for LA and OA groups was 6.5% (10/152) and 20% (2/10), respectively. The CR was 0% and 12.3% in DSC and WDSC, respectively (DSC 0/55 vs. WDSC 12/97; $P < 0.001$). The mean hospital stay was 6.5 + 2.8 days. The hospital stay for LA group was 6 + 2 days while for OA was 10.2 + 4 days [Table 1].

Comparison between early and late experience

The only intraoperative complications (bladder injury, loss of coprolite, and bowel perforation) were observed in the LA group in both periods. There were no significant differences in the length of hospital stay between early and late experience and type of approach. In Table 2, details about type of intra- or postoperative complications for both groups and number and type of complications divided for groups and subgroups are reported. All patients who developed IAA except the one with unrecognized loss of a coprolite during laparoscopy were treated by percutaneous aspiration or/and drainage.

Table 1: Number of children underwent appendectomy during the early and late experience; number/percentage of open and laparoscopic appendectomy with type of appendicitis (simple/complicated), mean operative time, complication rate, closure of distal appendix stump and mean hospital stay

	Early experience	Late experience
Number of appendectomy (%)	130	162
OA	44 (34)	10 (6.17)
LA	86 (66)	152 (93.8)
SA	116 (89)	124 (76.6)
CA	14 (11)	38 (23.4)
CA treated by OA/LA	10/4	4/34
Mean operative time (min)OA/LA	62±17/68±19	150±55/52±14
Total CR (%)	2,3	7,4
Partial CR for OA/LA (%)	0/3,5	20/6,5
Mean hospital stay in OA/LA (days)	7±2/5±1	10±4/6±2
Appendectomy with/without DSC/WDSC	N/A	15/19
CR in patients DSC/WDSC (%)	N/A	0/12.3

OA: Open appendectomy, LA: Laparoscopic appendectomy, SA: Simple appendectomy, CA: Complicated appendectomy, CR: Complication rate, WDSC: Without distal stump closure

Table 2: Number and type of intra-operative/postoperative complications in children underwent open and laparoscopic appendectomy during the early and late periods

	Early experience	Late experience
	OA/LA	OA/LA
Number of complication (*n*)	1/3	2/10
Intraoperative complication (*n*)	1	0/2
Bladder injury	0/1	0
Bowel injury	0	0/1
Lost of appendicular fecal mass	0	0/1
Postoperative complication	2	2/8
Intra-abdominal abscess (*n*)	0/2	2/8
Wound infection (*n*)	1/0	0

OA: Open appendectomy, LA: Laparoscopic appendectomy

Discussion

The first clear data are that OA approach has become exceptional in the treatment of acute appendicitis (early vs. late experience: 34% vs. 6.3%. P =0.013) being limited to those cases with multiple IAA or where the surgeon does not feel still comfortable with LA. The percentage of cases with CA was significantly higher in the late experience (early vs. late experience: 11% vs. 23.4%. P=0.023). In the late experience group, the operative time was reduced in LA, while it was increased in the OA group (LA, early vs. late experience: 62 min + 19 min vs. 52 min + 14 min, P = 0.031; OA, early vs. late experience: 62 min + 17 vs. 150 min + 55; P = 0.14). In the late experience group, there was an increased CR (total CR, early vs. late experience: 3.1% vs. 7.5%, P = 0.0011; CR: LA, early vs. late experience: 3.5% vs. 6.5%, P = 0.0018 - CR: OA; early vs. late experience: 2.3% vs. 20%, P = 0.08). Subsequently, the late group was divided into two subgroups according to closure of distal appendix, WDSC and DSC. The CR in patients who underwent DSC is significantly better that those WDSC.

LA appendectomy has become the treatment of choice for acute appendicitis all over the developed world. However, controversies remain about the role of LA appendectomy in CA. These include gangrenous or perforated appendicitis and appendicular inflammatory masses. Furthermore, as the number of LA surgeons increases, the percentage of children with complicated acute appendicitis treated by laparoscopy has increased over the last 10 years from 9.9% to 46.6%.[9] The increased rate of IAA in LA appendectomy for CA has been underlined over the years by several authors.[10-12]

Other investigators have reported higher incidence of IAA in LA patients without reaching statistical significance[13,14] and more recently a very large review article showed that the incidence of IAA in patients with CA is increased in the LA group (LA 3.69% vs. OA 2.59%).[10] On the other hand, several authors have faced this finding by showing that LA approach is not associated with an increased risk of IAA[15-18] even in perforated appendicitis.[19] The aim of this manuscript is far from resolving this controversy. We want only to report our experience in the treatment of all cases of simple and complicated acute appendicitis in children over the years, which has progressively switched from open to LA approach. Interestingly, our data show different and unusual results from early and late experience, which has been unexpected. In the early period, we found that 2/3 of cases were approached by LA, but nearly all of them had simple appendicitis. In this series, the senior author was always the first operator or directly supervising less experience surgeons. In the OA group, more surgeons were operating also in CA. The operating

time between LA and OA was similar with an increased rate of complications in LA group, which did not reach statistical significance. Furthermore, the mean hospital stay was similar between the two groups. In the late period, all surgeons including residents were entitled to approach simple and CA. In this series, LA was used in nearly all children with CA. The operating time was significantly lower in the LA groups when compared with OA. This finding was most likely a consequence that OA was reserved only to major complicated cases often with multiple IAA. Interestingly, the total rate of complication was significantly higher in the late period group when compared with that observed in the early period. In the late group, the children who underwent OA had a higher CR compared to LA group. This finding did not reach statistical significance because of few cases treated by OA.

In our opinion, there are several factors which may explain these unexpected findings: (a) Surgical experience: In the late period also less experienced surgeons or residents were performing LA. In fact, it has been demonstrated that surgeon expertise is a major contributing factor in reducing CR.[9,20] (b) The number of cases with CA in the late group was more than doubled in percentage when compared with the early group. It has been clearly demonstrated that complicated appendicitis carry a significant increased risk of developing IAA.[21,22] (c) The highest rate of complication in late group underwent OA is justify by the fact that it includes only children who, at presentation, had proved multiple IAA at CT-scan. The authors have already demonstrated that patients presenting with multiple IAA abscesses are more likely to develop severe complication and poorer prognosis in the postoperative period.[23]

During the late period, an iatrogenic complication (lost a little fecal mass during removal of appendix by LA) which needed a re-exploration for IAA forced us to close also the distal appendiceal stump by applying a third endoloop in addition at 2 endoloops placed at appendix basis. Surprisingly, this little technical modification greatly improved our results with no complication observed since then. Traditionally, the closure of distal stump is not needed in OA and not routinely done in LA. However, some authors have already underlined the importance to close the distal stump before appendix removal.[23,24] In literature, there are few articles dealing with closure of distal appendix when compared to the technique and instruments for closing appendix basis.[25,26] Despite we cannot prove that removal of appendix without closing distal stump carry an increased risk of bacterial contamination, we do believe that squeezing/manipulation of appendix may potentially cause a significant bacterial spread in the abdomen of patients underwent LA appendectomy. We do believe that this event is underestimated by most surgeons, so that a large multicenter prospective study should be designed to better clarify its importance.

Conclusion

We found that complicated appendicitis remains a difficult surgery that can be managed by laparoscopy in most cases. Several factors may influence the rate of complications in those patients including the closure of distal stump of appendix. In our opinion, closure of distal appendiceal stump before appendix removal may avoid further intra-abdominal contamination and then possibly improve results during LA appendectomy. However, a larger number of cases is needed to confirm this initial observation.

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Conflicts of interest

There are no conflicts of interest.

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