

# Laparoscopic Appendectomy in Children: A Favorable Alternative in Simple and Complicated Appendicitis

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**Background/Purpose:** The laparoscopic treatment of pediatric appendicitis remains controversial, particularly in complicated cases (gangrene and perforation). This study evaluates outcomes of open (OA) and laparoscopic appendectomy (LA).

**Methods:** The 391 cases of pediatric appendectomy performed between January 1998 and January 2001 were reviewed for age, sex, weight, type and length of intervention, operative description, antimicrobial therapy, analgesia, complications, length of hospitalization, and histopathology.

**Results:** A total of 126 patients were operated on by laparoscopy, 262 by laparotomy, and there were 3 conversions (LA + OA). LA patients were older (11.9 v 9.6 years;  $P < .001$ ) and more frequently girls (57.1% v 38.2%;  $P = .0004$ ). LA took longer to perform (45.7 v 40.6 minutes;  $P = .0014$ ). Operatively, 24.6% of LAs were described as complicated com-

pared with 22.5% in OA. Narcotic use was equivalent in both groups (1.16 v 1.29 days;  $P = .434$ ), as was the incidence of complications, either operative (1.6% v 0.4%;  $P = .20$ ) or postoperative (10.3% v 8.02%;  $P = .32$ ). Hospitalization was shorter in LA (2.38 v 2.94 days;  $P = .0131$ ). Histopathology was negative in 21.4% of LAs compared with 13% of OAs ( $P = .032$ ).

**Conclusions:** Laparoscopic appendectomy does not increase the incidence of complications, even with gangrenous or perforated appendicitis. The length of intervention is prolonged by 5 minutes on average. This technique allows for a shorter hospitalization.

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APPENDICITIS remains the most common intraabdominal surgical pathology in childhood. Conventional management involves open appendectomy (OA), a simple operation that carries minimal morbidity. Although laparoscopic appendectomy (LA) has been described for 20 years,<sup>1</sup> pediatric surgeons have shown some reluctance to accept its routine use because of perceived lack of significant benefit. Moreover, the safety of LA in complicated appendicitis still remains debated. The goal of this study was to review the results of laparoscopic versus open appendectomy in the treatment of both simple and complicated appendicitis in children in an attempt to assess the value of LA for pediatric patients, particularly in cases of gangrene and perforation.

## MATERIALS AND METHODS

The records of all patients aged 0 to 16 years who underwent appendectomy at the Centre Hospitalier de l'Université Laval between January 1998 and January 2001 were reviewed. In addition to demographic data, particular attention was given to surgical technique, description of the appendix, extraappendicular findings, length of intervention (LOI), complications, antimicrobial therapy, analgesia, length of stay (LOS), and histopathologic correlation. Incidental appendectomies performed in the context of malrotation repair or bowel resection were excluded.

The choice of surgical approach was left to the attending surgeon. All appendectomies were performed by surgical residents under appro-

appropriate supervision. Nasogastric tubes, bladder catheterization, and abdominal drains were not used routinely. Antibiotics were started before the intervention. Appendices were classified operatively by the surgeon as normal, acute, gangrenous, or perforated.

The open technique was performed through a modified Rockey-Davis incision. In the laparoscopic technique, a trocar sheath was inserted bluntly through the umbilicus after a small incision, without the use of the Veress needle. Two other trocars were inserted under direct vision. Two technical variants described in the literature<sup>2-5</sup> were used according to the surgeon's preference. In the "IN" technique, the mesoappendix and base were ligated by endoscopic suture, staples, or clips, and drawn out either through the trocar, directly through the incision, or by endoscopic bag. In the "OUT" technique, after laparoscopic ligation of the mesoappendix, the appendix was drawn out through the trocar and resected after extraabdominal base ligation. Intraoperative local anesthetics were not used in either LA or OA.

Postoperative management was identical in both groups: early ambulation, early enteral feeding, and opiate analgesia as needed. Antibiotic choice was left to the surgeon. There was no predetermined length of antimicrobial therapy; criteria for cessation included a normal

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abdominal examination in an afebrile patient with a normal leukocyte count. Enteral antibiotics were not prescribed routinely on discharge.

**RESULTS**

Of the 391 cases of pediatric appendectomy reviewed, 262 were performed by OA and 126 by LA. Of the latter, 74 (59%) were done by the “OUT” technique and 52 (41%) by the “IN” technique. The appendix was exteriorized through the trocar sheath in 74 (58.7%) the cases, by endoscopic bag in 16 (12.7%) cases, and directly through the incision in 36 (28.5%) cases. There were 3 conversions (LA + OA), which were excluded from analysis, representing a conversion rate of 2.3%. Two occurred in the first year, early in the learning curve, and corresponded to ruptured appendicular disease, and one was for a technical difficulty. In both populations, the patients’ ages ranged from 2 to 16 years. The mean age of the laparoscopic group was 11.9 years versus 9.6 for the open group ( $P < .001$ ). There were 72 (57.1%) female patients in the LA population, compared with 100 (38.2%) in the OA group ( $P = .0004$ ). Patients’ weight was above 45 kg in 74 (58.7%) LA patients and in 81 (30.9%) OA patients ( $P < .0001$ ).

Mean operating time was  $45.7 \pm 14.9$  minutes for LA and  $40.6 \pm 14.7$  minutes for OA ( $P = .0014$ ). During surgery, 18 (14.3%) LA appendix and 20 (7.6%) OA appendices were gangrenous. Perforation was noted in 13 (10.3%) LA cases and 39 (14.9%) OA cases. Therefore, the combined ratio of complicated appendicitis was 24.6% in the LA group and 22.5% in the OA group (Table 1). Eleven extraappendicular findings were described, all within the LA population (Table 2). Six (54.3%) occurred in patients whose final pathologic report was negative. Three operative complications were reported (Table 3): 2 (1.6%) in LA, and 1 (0.4%) in OA ( $P = .20$ ).

Postoperative antibiotic therapy lasted on average  $1.90 \pm 2.83$  day in LA cases and  $2.38 \pm 2.74$  days in OA cases ( $P = .108$ ). LA patients required opiate analgesia (parenteral or enteral) 1.16 days on average compared with 1.29 days in the OA group ( $P = .434$ ). There were 35 postoperative complications, 13 (10.3%) reported in LA and 22 (8.02%) in OA ( $P = .32$ ; Table 4). Eleven complications required surgical reintervention, 2 in LA patients and 9 in OA patients ( $P = .19$ ). LA patients were

**Table 2. Extra-Appendicular Findings at Laparoscopy**

Finding	Frequency
Ovarian cyst	5
Meckel’s diverticulum	1
Torsion of the appendix epiploicae	1
Adhesions	1
Intestinal rotation anomaly	1
Hydatid cyst	1
Abnormal gynaecological bleeding	1
Total	11

hospitalized  $2.38 \pm 1.76$  days on average, whereas OA patients stayed  $2.94 \pm 2.63$  days ( $P = .0131$ ).

The pathologic report was negative in 27 (21.4%) LA cases and 34 (13%) OA cases ( $P = .032$ ). The subgroup of LA patients with negative appendectomy had an LOI of 48.2 minutes, an LOS of 2.7 days and required narcotics for 1.33 days on average. Of these 27 cases, 16 (60.1%) corresponded to patients with either atypical symptoms, pain for more than 48 hours, or inconclusive radiologic findings.

**DISCUSSION**

Laparoscopy initially was perfected by gynecologists. However, it became an integral part of general surgery in the mid-1980s, because it proved to be superior in the treatment of symptomatic cholelithiasis. Since then, surgeons have come up with an increasing number of procedures that can be performed by minimally invasive techniques. As such, laparoscopic appendectomy was described in 1983 by Semm.<sup>1</sup> The first report of LA in children goes back to 1991, when Ure et al<sup>2</sup> presented a small prospective series of 43 patients, concluding that it was a safe procedure. This was followed by 3 major European studies confirming the feasibility of LA in pediatric surgery on a routine basis. Valla et al<sup>3</sup> published a review of 465 laparoscopic cases; however, their study had no control group. Varlet et al<sup>4</sup> presented a comparative study of 403 cases (200 LA v 203 OA), from which cases of complicated appendicitis were excluded. El Ghoneimi et al<sup>5</sup> compiled a series of 1,379 LAs, once again without any OA control. These and other proponents of the laparoscopic approach for appendicular disease noted many advantages: better exposure of the abdominal cavity,<sup>3,4,6</sup> efficient lavage of the peritoneal space,<sup>3-5</sup> improved cosmesis,<sup>3,7,8</sup> decreased rate of misdiagnosis,<sup>5</sup> better pain control,<sup>4,8-10</sup> shorter hospitalization,<sup>5,6,8,11</sup> and earlier return to normal activities.<sup>5,6,8,9</sup>

**Table 1. Operative Description of Appendices**

	LA	OA
Normal	9 (7.1%)	7 (2.7%)
Simple acute	86 (68.3%)	196 (74.8%)
Gangrenous	18 (14.3%)	20 (7.6%)
Perforated	13 (10.3%)	39 (14.9%)

NOTE. Combined  $P$  value: .020.

**Table 3. Operative Complications**

LA	OA
Benign arrhythmia (1)	Superficial bowel laceration (1)
Appendix fragmentation (1)	

**Table 4. Postoperative Complications**

Complication	LA	LA (Reintervention)	OA	OA (Reintervention)
Intraabdominal abscess	2	1	6	3
Wound infection	3		6	4
Umbilical granuloma	2	1	0	
Seroma	1		0	
Partial small bowel obstruction	0		2	2
Pancreatitis	1		0	
Morphine allergy	0		1	
Pneumonia	0		1	
Gastroenteritis	0		2	
Urinary retention	1		0	
<i>C difficile</i> infection	3		4	
Total ( $P = .32$ )	13 (10.3%)		22 (8.02%)	
Surgical reintervention ( $P = .19$ )		2		9

However, many pediatric surgeons remain sceptical as to the routine use of laparoscopy in the treatment of acute appendicitis. First, OA is a simple and efficient procedure that produces excellent results. Second, reservations are brought up as to the incidence of operative complications; reports have been published describing worrisome vascular injuries, most commonly to the iliac artery.<sup>12,13</sup> One investigator also notes a significantly greater incidence of operative complications in LA, ranging from stump release and uncontrollable bleeding, to visceral perforation.<sup>4</sup> Moreover, there does not seem to be a clear consensus as to the safety of LA in cases of gangrene and perforation. Many investigators systematically exclude these cases from eligibility to LA. In fact, only 3 pediatric studies seriously address this issue. The first notes a very low incidence of intraabdominal abscesses, but does not substantiate the argument with a control OA group.<sup>5</sup> The second notes a 3-fold higher rate of intraabdominal abscesses in children treated by LA but is limited by the small size of the series (56 patients).<sup>14</sup> A last report concludes that as the learning curve progresses, intraabdominal abscess rates of both techniques tend to equalize.<sup>8</sup> Adult surgical literature is as confusing; decreased complications,<sup>15</sup> increased complications,<sup>16,17</sup> and lack of difference<sup>9</sup> all have been reported. Tang et al<sup>17</sup> even conclude that although LA is superior to OA in gangrenous appendicitis, the advantages are lost in cases of perforated appendicular disease.

These results show that LA can be integrated safely into the daily practice of pediatric surgery with equivalent complication rates. Operative complications are equally low in both techniques. In the case of LA, it compares favorably with what is reported in the literature,<sup>4,5</sup> as does the rate of conversion (2.3%).<sup>14,15,18</sup> The absence of significant operative complications could be attributed to the fact that in all of the LA cases, trocars were placed under direct guidance, following a mini-incision in the umbilicus, thus eliminating blind insertion

and use of the Veress needle. As for postoperative complications, there is no statistically significant difference in the incidence of intraabdominal abscesses or wound infections, the 2 most common concerns of opponents of LA. Ten complications probably are not related to the choice of technique (1 morphine allergy, 2 cases of gastroenteritis, and 7 *Clostridium difficile* infections). For the remaining, this lack of difference persists, even in cases of gangrene and perforation. The rate of surgical reinterventions also is equivalent in both techniques. We did not observe a difference in the incidence of infectious complications related to the method of appendix exteriorization. Finally, there was no difference in the incidence of complications between the "IN" and "OUT" variants of LA.

In the context of cost containment and operating room (OR) time availability, LOI has always been a major worry in LA. In his series, Varlet et al<sup>4</sup> reported an average LOI of 40 minutes; however, he excluded cases of complicated appendicitis. Others report LOIs ranging from 71 minutes in older studies<sup>6</sup> to 55 minutes in more recent ones.<sup>7</sup> As surgeons and OR staff become familiar with the minimally invasive technique, differences in LOI will become clinically insignificant as is the case in this study and in a recent publication.<sup>8</sup>

Contrary to what is reported generally in the adult literature, we did not see a significant difference in the postoperative use of opiate analgesia in children operated on by LA, even when patients are grouped according to weight. This seems to be in accordance with what authors of other pediatric studies report.<sup>7,19</sup>

In accordance with the majority of papers published,<sup>3,5,6,8,20</sup> hospitalization was significantly shorter when the patient was treated by LA, which substantiates the hypothesis that laparoscopy allows for faster return of normal organic functions. This has an impact not only in terms of hospital costs but also in terms of familial organization around the sick child.

Analysis of pathologic reports shows a higher rate of negative appendectomies within the LA group. Interestingly, absence of appendicular disease in these patients was not associated to a shorter LOI (48.2 minutes), LOS (2.7 days), or duration of narcotic use (1.33 day). Hence, the higher rate of negative appendectomies in our LA population does not seem to affect mean surgical time, and cannot explain the shorter LOH observed in our patients treated by laparoscopy. Furthermore, 60.1% of these cases occurred in patients with either atypical symptoms, pain for over 48 hours, or equivocal radiologic findings. At the same time, 6 of the 11 extra-appendicular findings were in patients whose pathologic report turned out to be negative. These observations emphasize one of the main advantages of LA: the ability

to perform a confirmatory diagnostic maneuver before the therapeutic act.

Although confined to the retrospective nature of its data, these findings show that laparoscopic appendectomy is a safe and effective alternative in acute pediatric appendicitis. Both operative and postoperative complications are not increased, no matter how advanced the disease is. This technique allows for a complete visualization of the abdominal cavity, enabling diagnosis and treatment of other abdominal pathologies. The length of intervention is prolonged by 5 minutes on average, a difference that will probably decrease as surgeons and OR staff become more familiar with the technique. Finally, patients spend less time in hospital, thus, reducing the burden of this common disease.

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