



# Laparoscopic appendectomy: Effectiveness in children with generalized and advanced generalized peritonitis cases

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## ABSTRACT

Laparoscopic appendectomy is one of the most common surgical procedures in treating pediatric appendicitis. This study aimed to investigate the efficacy of laparoscopic surgery in cases complicated with advanced generalized peritonitis in the pediatric population. The study retrospectively reviewed 55 cases of children who underwent laparoscopic appendectomies. The cases were classified as uncomplicated, complicated, or advanced generalized peritonitis. Laboratory results, diagnostic algorithms, surgical techniques, and complications were investigated. Twenty-four of the cases were boys and 31 were girls. Mean age was  $11.3 \pm 3$  years. Twenty of the cases (36%) were uncomplicated and 35 (64%) were complicated. Nine of the complicated cases presented advanced generalized peritonitis and were additionally classified as "another special group". Mean leukocyte count and C-reactive protein levels were measured respectively as  $22.49 \pm 12 \times 10^9/L$  and  $120.5 \pm 99$  mg/L in complicated cases and as  $17.06 \pm 10 \times 10^9$  and  $52.37 \pm 69$  mg/L in uncomplicated cases. All advanced generalized peritonitis cases had presented to the hospital with intestinal obstruction and had diffuse abdominal rigidity on physical exam. None of the cases had any complications in the intraoperative or early postoperative period. Infection complications (namely, intra-abdominal abscesses and surgical site infections) were observed in four cases (7%) in the postoperative period. Mean length of hospital stay was  $5.62 \pm 2.6$  days and  $3.95 \pm 1$  days in complicated and uncomplicated cases, respectively. Mean length of stay in advanced generalized peritonitis cases was  $8.33 \pm 2$  days. It was observed that laparoscopic appendectomy might be the first choice of treatment option in cases complicated with advanced generalized peritonitis.

**Keywords:** Appendectomy, laparoscopy, child, postoperative complications, complicated appendicitis, advanced generalized appendicitis

## INTRODUCTION

Acute appendicitis is the most common abdominal surgical pathology in children (1,2). Appendectomy is the basic therapeutic approach for acute appendicitis. Appendectomy is performed by applying conventional methods like open surgery or with less invasive laparoscopic surgery. Treatment of complicated appendicitis (e.g., gangrenous, perforated, appendiceal abscesses, plastron appendicitis, and etc.) differs according to clinical experience, the severity of illness and preference of the surgeon. Laparoscopic appendectomy has important advantages, but its applicability and safety for complicated appendicitis has been questioned in pediatric cases (3-6). This study aimed to evaluate the efficacy of laparoscopic surgery in complicated appendicitis cases in children, with a particular emphasis on missed perforated appendicitis presenting with advanced generalized peritonitis.

## MATERIALS and METHODS

Between April 2016 and September 2020, 55 acute appendicitis cases were treated laparoscopically at our clinic. Laparoscopic surgery was our first choice of treatment in all complicated cases, including those with advanced generalized peritonitis, and surgical procedure was performed by a single surgeon in all cases. Ethics approval for this study was obtained from the Pamukkale University Ethics Committee (E-60116787-020-14389).

## Diagnosis of Acute Appendicitis

The diagnosis of acute appendicitis was based on clinical history, physical examination, laboratory results, and radiological evaluation. Cases pre-defined as appendicitis were subsequently scanned by routine radiological examinations. Abdominal

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radiography and abdominal ultrasonography (US) were the initial radiologic evaluations. In US findings, an appendix diameter of longer than six millimeters, an uncompressible appendix, and echogenicity of tissue around the appendix confirmed acute appendicitis. Computed abdominal tomography (CT) was applied to late-admitted and obese patients and to those in whom US failed to confirm appendicitis.

### Surgical Procedure

Laparoscopic appendectomy was performed using a standard three-port technique. A 10-millimeter 30° port for the camera was used for abdominal exposure, placed transumbilically using the open technique. After carbon dioxide insufflation (maximum pressure: 10-12 mmHg), an additional two working ports were inserted from the suprapubic and left lower quadrants. The mesoappendix was sectioned using a surgical energy device and hook cautery. An intracorporeal suturing technique with 1-0 silk or vicryl suture material secured the base of the appendix, and appendectomy was performed. Removal of appendix specimens was accomplished through the first port site without any retrieval bags. The peritoneal cavity was irrigated and aspirated with saline solution and dried.

### Definition of Advanced Generalized Peritonitis Cases Due to Missed Perforated Appendicitis

The patients classified as advanced generalized peritonitis cases were admitted to our clinic in the late onset period (i.e., more than three days) of the illness, and their diagnosis was determined according to intraoperative findings. The diagnosis of some cases was not clearly obtained in the preoperative period. The intra-abdominal cavity could not be observed during the insertion of the transumbilical port due to immense amount of inflammation. In order to insert the transumbilical port, a minimal intra-abdominal space was created with an assisted gauze technique similar to retroperitoneoscopic laparoscopic surgery. Meanwhile, bolus purulent fluid drainage was observed. Vision of the surgical site was restricted by pseudomembranes and edematous bowels, and there was an insufficient cavity in the abdomen for laparoscopic exploration.

Usual laparoscopic procedures could be converted to open; however, minimally invasive surgery was preferred. Dense purulent fluid and pseudomembranes in the abdomen were removed using optical blunt dissection to provide free space in the left lower quadrant for the insertion of a five-millimeter port trocar. This trocar was placed by employing open technique. Afterwards, the inside of the abdomen was irrigated with a warm saline solution and then aspirated. A free space was created in the suprapubic area for a secondary working port. Dense inflammation, purulent fluid, and pseudomembranes were observed in all quadrants of the abdomen. The appendix was visualized by blunt dissection and all of them were in a perforated fashion. These cases were determined as a distinct group: Advanced generalized peritonitis cases due to missed perforated appendicitis. (complementary video)

### Statistical Analysis

Statistics were presented as weighed means with standard deviations (after the “±” symbol). Differences between dependent groups were calculated using the paired samples t-test, and p-values less than 0.05 were considered significant.

### RESULTS

Twenty-four (44%) of the cases were males, and thirty-one (56%) were females. Female-to-male ratio was 1.29. Mean hospital admission time for all patients was  $1.98 \pm 1.4$  days (range= 1-7 days). Mean admission time for 35 complicated cases was  $2.37 \pm 1.6$  days (range= 1-7 days) and  $1.30 \pm 0.7$  days (range= 1-3 days) for 20 uncomplicated cases. Admission time in complicated cases was significantly longer ( $p= 0.002$ ). Mean leukocyte count (WBC) and C-reactive protein levels were  $20.51 \pm 11.17 \times 10^9/L$  and  $96.56 \pm 94.8$  mg/L, respectively. Mean WBC and CRP levels were  $22.49 \pm 12 \times 10^9/L$ ,  $120.5 \pm 99$  mg/L in complicated cases and  $17.06 \pm 10 \times 10^9/L$  and  $52.37 \pm 69$  mg/L in uncomplicated cases, respectively. WBC and CRP levels were significantly higher in complicated cases ( $p < 0.05$ ). Small bowel obstruction was observed in all advanced generalized peritonitis cases and in five complicated cases. Intestinal obstruction was not observed in uncomplicated cases (Table 1).

**Table 1.** General characteristics of uncomplicated and complicated cases

	Uncomplicated n= 20	Complicated n= 35	p
Symptom duration (day)	$1.30 \pm 0.7$	$2.37 \pm 1.6$	0.000*
WBC $\times 10^9/L$	$17.06 \pm 10.8$	$22.49 \pm 12$	0.085
CRP mg/L	$52.3 \pm 69$	$120.5 \pm 99$	0.004*
Ileus sign (x-ray) n (%)	0	14 (40)	0.001*
LOS (day)	$3.9 \pm 1$	$5.4 \pm 2$	0.004*
Complication n (%)	2 (8.6)	2 (5.7)	0.062

LOS: Length of hospital stay, WOS: White blood cell, CRP: C-reactive protein.  
\* $p < 0.05$  is significant.

Ultrasonography was performed in 49 of the cases, the appendix was visualized in 32 cases (65%), all of which presented acute appendicitis. Mean appendix diameter was  $9.47 \pm 2$  mm (range= 6-15 mm). No cases presented additional abdominal pathologies (e.g., tuba-ovarian pathology). Intravenous contrast-enhanced CT imaging was applied in 42 cases. The appendix could not be identified in five cases due to the perforated structure. In 37 cases the appendix was identified, it appeared inflamed, enlarged, periappendiceal fat stranding was observed, and mean appendix diameter was  $11 \pm 2$  mm (range= 7-20 mm). During laparoscopic exploration, 35 cases were classified as complicated-24 due to perforation, and 11 due to gangrene. Nine (37%) of the missed perforated appendicitis cases were classified as advanced generalized peritonitis cases (Table 2). All cases were treated with broad-spectrum antibiotics. With a mean admission time of  $5.01 \pm 2.3$  days, hospitalization for these complicated cases was significantly longer ( $p < 0.05$ ). Mean hospitalization time of advanced generalized peritonitis cases was  $8.33 \pm 2$  days. All patients were discharged with an oral antibiotic regimen of amoxicillin with clavulanic acid and metronidazole. Mean follow-up period was 43 months (range= 10-117 months); none of the patients experienced intraoperative complications, and only four patients had minor complications in the postoperative period. Three of these cases experi-

enced surgical site infection (transumbilical port insertion site), and the other developed intra-abdominal abscess 15 days after the operation. This case was managed conservatively by antibiotic therapy.

## DISCUSSION

Complicated appendicitis cases, especially those presenting with generalized peritonitis, can be further complicated and endangered by traditional surgical methods. These complications may be minor complications such as surgical site infection, intra-abdominal abscess, and etc., but may also be serious complications such as small bowel obstruction, solid organ injury and vascular injury. Many authors do not propose laparoscopic appendectomy to mitigate risk in already complicated cases (7). Miyano et al. are the first to report that laparoscopic appendectomy could be safely performed in pediatric cases of appendicitis accompanied with generalized peritonitis (8). However, lack of research featuring cases in which inflammation is so severe to prevent a clear view of the abdominal cavity motivated us to study such advanced peritonitis cases. Up until now, there has been lack of reports of cases of advanced generalized peritonitis treated with minimally invasive surgery.

In cases of complicated appendicitis not suitable for conservative treatment, two treatment options exist: open appendec-

**Table 2.** Summary of diagnosis and treatment of nine advanced peritonitis cases

Age (year)	Symptom duration (day)	WBC $\times 10^9/L$	CRP mg/L	SBO	Radiologic evaluation	Antibiotic course	LOS day	Complication
4	5	13.56	185.4	+	US: Unvisualized appendix CT: Appendix diameter 11.5 mm	Cefoperazone Gentamicin metronidazole	9	⊖
4	4	7.28	265.4	+	CT: Appendix diameter 16.5 mm	Ceftriaxone Metronidazole	7	⊖
4	4	20.64	98.6	+	US-CT: Unvisualized appendix	Ampicilline/Sulbactam Gentamicin metronidazole	6	⊖
7	7	22.00	32.5	+	US: Unvisualized appendix	Cefoperazone Gentamicin metronidazole	8	⊖
10	3	18.34	133.7	+	US-CT: Unvisualized appendix	Ampicilline/Sulbactam Gentamicin metronidazole	6	⊖
11	7	15.43	315.8	+	US: Unvisualized appendix CT: Appendix diameter: 9 mm	Meropenem Ornidazole	15	⊖
12	3	27.85	96.4	+	US: Unvisualized appendix CT: Appendix diameter: 13 mm	Ampicilline/Sulbactam Gentamicin metronidazole	7	⊖
16	5	17.82	371.1	+	US: Appendix diameter:7 mm CT: Appendix diameter:9 mm	Meropenem Teikoplanin metronidazole Fluconazole	10	⊖
16	4	35.69	219.0	+	US: Appendix diameter:5.7 mm CT: Appendix diameter:13 mm	Cefoperazone Gentamicin metronidazole	7	⊖

LOS: Length of hospital stay, SBO: Small bowel obstruction, US: Ultrasonography, CT: Computed tomography.

tomy and laparoscopic appendectomy. The main limiting factors of laparoscopic appendectomy for complicated cases in children are severe adhesions in the abdomen and an intra-abdominal cavity that is smaller than that of the adults. Poor visibility, limited dissection field, and severe post-operative complications have led many researchers to pursue safer and more efficacious ways of treating complicated pediatric appendicitis. Some studies (9-11) suggest open appendectomy instead of laparoscopic surgery in complicated cases while others now recommend laparoscopic appendectomy (6,12-14).

It is well known that laparoscopic surgery reduces the length of hospital stays, dependence on pain medication, and many other complications. Incidence of complications has been reported to be as high as 41% in patients undergoing laparoscopic appendectomy for complicated appendicitis (15). Laparoscopic procedure was performed in all complicated appendicitis cases in this study. Only four cases (7%) developed infectious complications. Three cases experienced surgical site infections and one developed an intra-abdominal abscess. None of the cases developed serious complications. We administered some precautionary treatments to reduce possible complications in generalized perforated appendicitis cases. These included employing the open port insertion technique, meticulous dissection, complete eradication of purulent fluid, and the removal of pseudomembranes. None of the patients in this study suffered post-operative small bowel obstruction, and only in one case was there an intra-abdominal abscess. These results suggest that laparoscopic appendectomy could be applied in all patients with complicated cases concomitant advanced generalized peritonitis.

In some complicated appendicitis cases, laparoscopic surgery might be converted to open surgery during the procedure due to poor visualization, severe inflammation, edematous bowels, and inability to perform dissection. Kyung Hye et al. have reported a conversion rate of 10% due to severe inflammation and ileus (16). In our study, severe inflammation and small bowel obstruction did not affect our decision when converting to open surgery in complicated cases.

Hospitalization periods in complicated cases were longer, especially in nine advanced generalized peritonitis cases. Although laparoscopic appendectomies do tend to shorten hospital stays; extended antibiotic duration and the presence of nine advanced peritonitis cases resulted in prolonged hospital stays in this study. It is our opinion, however, that intravenous antibiotics reduce the incidence of intra-abdominal abscesses and hospital readmissions.

One of the most important advantages of laparoscopic appendectomy is that post-operative small bowel obstruction is

rarely seen. In the literature, the incidence of small bowel obstruction is 8% in complicated appendicitis while meta-analysis findings are 3.5% (8,17). Although more than half (63%) of the present study's cases were complicated and nine were generalized peritonitis, post-operative small bowel obstruction was not observed during the 43-month follow-up period. These findings are encouraging when considering the applicability of laparoscopic appendectomy in complicated pediatric cases. Surgeries are performed by many different surgeons in many clinics. The limitations of the present study include its retrospectivity and the fact that the surgeries were performed by a single surgeon experienced in minimally invasive surgery.

## CONCLUSION

We propose that laparoscopic appendectomy can be performed safely in children's appendicitis cases, especially in complicated and advanced generalized appendicitis cases, even where children have small intra-abdominal cavity and inflammation amount to the whole abdomen.

**Ethics Committee Approval:** This study was approved by Pamukkale University Non-Invasive Clinical Research Ethics Committee (No: E-60116787-020-14389, Date: 02.02.2021).

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### OLGU SERİSİ-ÖZET

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## Laparoskopik apendektomi: Çocuklarda yaygın peritonitli apandisit olgularında etkinliği

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### ÖZET

Laparoskopik apendektomi, çocukluk çağında en yaygın uygulanan cerrahi prosedürlerden biridir. Bu çalışmanın amacı; pediyatrik olgularda ileri yaygın peritonit ile komplike olan olgularda laparoskopik cerrahinin etkinliğini araştırmaktır. Çalışmada, laparoskopik apendektomi yapılan 55 çocuk vakası retrospektif olarak gözden geçirildi. Olgular komplike olmayan, komplike veya ileri yaygın peritonit olarak sınıflandırıldı. Laboratuvar sonuçları, tanı algoritmaları, cerrahi teknikler ve komplikasyonlar araştırıldı. Olguların 24'ü erkek, 31'i kızdı. Ortalama yaş  $11,3 \pm 3$  yıl idi. Olguların 20'si (%36) komplike değildi ve otuz beşi (%64) komplike idi. Komplike vakaların dokuzu ileri yaygın peritonitti, bu nedenle bunlar ek olarak "başka bir özel grup" olarak sınıflandırıldı. Ortalama lökosit sayısı ve C-reaktif protein seviyeleri komplike vakalarda sırasıyla  $22,49 \pm 12 \times 10^9/L$  ve  $120,5 \pm 99$  mg/L, komplike olmayan vakalarda  $17,06 \pm 10 \times 10^9/L$  ve  $52,37 \pm 69$  mg/L idi. vakalar. İlerlemiş yaygın peritonit olgularının tamamı hastaneye bağırsak tıkanıklığı ile başvurmuştu ve bu nedenle fizik muayenede yaygın karın rijiditesi vardı. Olguların hiçbirinde intraoperatif veya erken postoperatif dönemde herhangi bir komplikasyon gelişmedi. Postoperatif dönemde dört olguda (%7) enfeksiyon komplikasyonları (karın içi apseler ve cerrahi alan enfeksiyonları) gözlemlendi. Ortalama hastanede kalış süresi komplike ve komplike olmayan olgularda sırasıyla  $5,62 \pm 2,6$  gün ve  $3,95 \pm 1$  gündü. Yaygın peritonit olgularında ortalama yatış süresi  $8,33 \pm 2$  gündü. Yaygın peritonit ile komplike vakalarda laparoskopik apendektominin ilk tedavi seçeneği olabileceğini gözlemledik.

**Anahtar Kelimeler:** Apendektomi, laparoskopi, çocuk, postoperative komplikasyon, komplike apandisit, yaygın peritonit

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