CHAPTER 3

The impact of disease severity, age and surgical approach on the outcome of acute appendicitis in children

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Pediatr Surg Int 2015;31:339-345

Abstract

Background

Although a national guideline has been implemented, the optimal approach for appendectomy in children remains subject of debate in the Netherlands. Opponents of laparoscopy raise their concerns regarding its use in complex appendicitis as it is reported to be associated with an increased incidence of intra-abdominal abscesses. The aim of this study was to evaluate the outcome of surgical approaches in both simple and complex appendicitis in paediatric patients.

Methods

A 10-year retrospective cohort study was performed (2001-2010) in paediatric patients treated for suspected acute appendicitis. Patients were divided into either simple or complex appendicitis and into different age groups. Primary outcome parameters were complication rate (intra-abdominal abscess (IAA), superficial surgical site infection (SSI) and readmission) and hospital stay.

Results

In total, 878 patients have been treated (median age 12, range 0-17 years). Two-thirds of the patients younger than 6 years had complex appendicitis, compared to one quarter in the group aged 13-18. In the complex appendicitis group, LA was associated with more IAA and early readmissions. In the simple appendicitis group, the complication rate was comparable between the two approaches. Significantly more IAAs were seen after LA in the youngest age group.

Conclusion

This study demonstrates the unfavourable outcome of LA in the youngest age group and in patients with complex appendicitis. Therefore we advise to treat these patients with an open approach.

Introduction

Surgical approaches for acute appendicitis in children remain controversial. Appendectomy, either through an open (OA) or laparoscopic approach (LA), is performed in a semi-urgent setting. Annually, 16,000 patients undergo an appendectomy in the Netherlands, due to suspicion of acute appendicitis, of whom 5,500 younger than 20 years old.[1]

In 2010, a national guideline for acute appendicitis was published in the Netherlands, but clear recommendations regarding the optimal surgical approach in children could not be made. Current studies show that LA is safe in children, as it does not seem to affect the incidence of intra-abdominal abscesses (IAA), reduces superficial surgical site infections (SSI) and is associated with shorter hospital stay in the overall group.[2-4] However in adult literature, it was noted in a large review that the chance of developing an IAA was increased nearly twofold after LA.[5] This finding could not be confirmed by other reviews.[6-7] Evidence on this subject in children is scarce. There is however one review which has also reported a higher incidence of IAA after LA in children with complex appendicitis.[8] In addition a large retrospective study by Jen et al reporting on 95,000 children with both simple and complex appendicitis showed more postoperative abscess drainages in children undergoing LA for both simple and complex appendicitis.[9] This is in contrast to a study by Vahdad et al where no differences in IAA after LA and OA were seen in perforated appendicitis.[10] The latter study did report significant more complications after conversion to open appendectomy. This group was analyzed separately and no intention to treat analysis was done. Thus, equivocal results have been published concerning the complication rate of LA and OA in specific patient groups.

The aim of this study is to investigate the surgical outcome in terms of IAA, SSI and unplanned early readmissions after LA and OA in paediatric patients with simple or complex appendicitis in different age groups.

Material and methods

All paediatric patients (age 0-17 years), who underwent an open or laparoscopic appendectomy for the suspicion of acute appendicitis between January 2001 and December 2010, were eligible for inclusion. The 10-year study period was divided in early (2001-2005) and late period (2006-2010). Retrospective patient selection was done using ICD-9 codes for appendicitis and appendectomy. This study was conducted in two tertiary referral centres and one general hospital. Excluded were patients who were not operated on, those who underwent an interval appendectomy, or those who underwent an appendectomy for other reasons than acute appendicitis. In addition patients with a negative appendectomy (appendix sana) or those who underwent another open approach (than the grid iron incision) were also excluded from analysis. Approval for this study was obtained from the Institutional Ethics Committee at VU university medical centre.

Data were collected independently by two authors, using a standardizsed data extraction form with potential predictors as well as outcome variables. After inclusion, patients were divided into two patient groups. These were constructed based on the definite diagnostic categories of simple appendicitis and complex appendicitis.

Simple appendicitis was defined as:

- A perioperative diagnosis made by the surgeon based on signs of a phlegmonous appendix without signs of perforation, purulent fluid, contained phlegmon or IAA. No additional postoperative antibiotics (exception: indication for perioperative spillage) were given.
- Histopathologic confirmation of the diagnosis of appendicitis.

Complex appendicitis was defined as:

- A perioperative diagnosis made by the surgeon based on signs of a gangrenous appendix with or without perforation, intra-abdominal abscess, periappendicular contained phlegmon or purulent free fluid and the need for additional postoperative antibiotics directly after appendectomy (with the exception of the indication spillage perioperative), or
- Histopathologic findings of extensive necrotic tissue in the outer layer of the appendix or signs of perforation.

The technique of appendectomy (LA or OA) depended on the surgeon's preference. Patients were operated by (paediatric) surgeons or by surgical trainees under direct supervision of the previous mentioned. Although no uniform protocol was used for each type (for instance

both staplers and endoloops were used in the LA group), all patients received standard preoperative care including the administration of antibiotic prophylaxis. Criteria for hospital discharge after appendectomy were: absence of fever, return to normal bowel function, signs of normal wound healing, and normal diet. Age groups were created based on the following educational levels: preschool (0-5 years), elementary school (6-12 years) and high school (13-17 years).

Primary outcome parameters were complication rate (in terms of incidence of intra-abdominal abscess (IAA), superficial surgical site infection (SSI), and unplanned early readmissions) and length of hospital stay. An IAA was defined as a fluid collection seen on radiological examination, which required in hospital treatment such as (radiological) drainage, antibiotics or reoperation. SSI was defined using the CDC definition for SSI.[11]
Early unplanned readmission was defined as emergency readmission within 30 days from discharge from hospital. Reasons for readmission were related to postoperative complication. Length of hospital stay was measured in days, beginning at the time of presentation and ending at time of discharge.

Statistical analysis
The principle of intention-to treat analysis was followed. Therefore converted LA was analysed in the LA group. Incidence of IAA, SSI and unplanned early readmission was compared among the different groups using univariate and multivariate analysis techniques. Using t test we compared hospital stay. Statistical significance was defined as a *P*-value <0.05. Missing data were left out of the analysis. All statistical analyses were performed using the statistical software package SPSS, version 18.0 (SPSS, Inc., Chicago, IL, USA).

Results

In total 878 paediatric patients were treated for an acute appendicitis of whom 598 (68.1%) were categorised as simple appendicitis. It was noted that significantly more patients in the complex appendicitis group were of preschool age, namely 64% compared to 34% and 24% in the 6-12 and 13-18 year olds respectively. The laparoscopic approach was the preferred approach in the simple appendicitis group (Table I and II). Median age at time of surgery was 12 years (range 0-17 years), 61 were in the youngest group, 469 in the middle and 348 in the oldest age group. The majority of the patients were male.

Table 1. Univariate analysis of baseline characteristics for simple and complex appendicitis

	Simple (n=598)	Complex (n=280)	*P*
Baseline characteristics			
Sex			
♂	60.4% (361/598)	59.6% (167/280)	ns
♀	39.6% (237/598)	40.4% (113/280)	
Age (years)			
0-5	36.1% (22/61)	63.9% (39/61)	<0.001
6-12	66.5% (312/469)	33.5% (157/469)	
0-5	36.1% (22/61)	63.9% (39/61)	<0.001
13-18	75.9% (264/348)	24.1% (84/348)	
6-12	66.5% (312/469)	33.5% (157/469)	0.004
13-18	75.9% (264/348)	24.1% (84/348)	
Location			
General	59.0% (353/598)	35.7% (100/280)	<0.001
Tertiary referral	41.0% (245/598)	64.3% (180/280)	
Type of operation			
LA	55.7% (333/598)	43.6% (122/280)	0.001
OA	44.3% (265/598)	56.4% (158/280)	
Conversion			
Yes	2.8% (17/598)	15.4% (43/280)	<0.001
No	97.2% (581/598)	84.6% (237/280)	

Results are displayed as % (N/Total N)

Disease severity: simple versus complex appendicitis

In Table III the outcome after surgery in each patient group is categorised according to OA and LA. In the simple appendicitis group no difference was seen in terms of IAA, SSI or early readmission, although hospital stay was significantly longer in the OA approach (P<0.001). In the complex appendicitis group however significantly more IAA (17.2% versus 7.0%) and more early readmission (16.7% versus 6.5%) were seen after the LA approach (P = 0.008 and P = 0.007 respectively). No difference in hospital stay was noted.

Age: different age groups

In Table IIIa the outcome after surgery for each age group is displayed according to the approaches for the overall group. In the youngest age group, significantly more IAA was seen after LA despite the complexity of appendicitis (31.3% versus 8.9%; P = 0.03).

When taken the complexity into account, it was noted that in patient with simple appendicitis, no differences in complication rate were seen between OA and LA in different age groups. The older age groups had a shorter hospital stay after LA (Table IIIb). With respect to the complex appendicitis group, no statistical differences in IAA was seen in the youngest age group although the incidence of IAA was as high as 37.5% after LA compared to 9.7% after

OA (*P*= 0.052). In the 6-12 years old children, significantly more IAA after LA were seen (*P* = 0.004). No differences in hospital stay and SSI were seen. Early readmission was seen significantly more after LA in the youngest age group (Table IIIc).

Table 2. Univariate analysis of baseline characteristics for different age groups

	0 - 5 years (n=61)	6 - 12 years (n=469)	13 – 17 years (n=348)	*P*
Baseline characteristics				
Sex				
♂	57.4% (35/61)	62.0% (291/469)	58.0% (202/348)	ns
♀	42.6% (26/61)	38.0% (178/469)	42.0% (146/348)	
Location				
General	21.3% (13/61)	51.6% (242/469)	56.9% (198/348)	<0.001
Tertiary referral	78.7% (48/61)	48.4% (227/469)	43.1% (150/348)	
Type of operation				
LA	26.2% (16/61)	49.0% (230/469)	60.1% (209/348)	<0.001
OA	73.8% (45/61)	51.0% (239/469)	39.9% (139/348)	
Type of appendix				
Simple	36.1%(22/61)	66.5% (312/469)	75.9% (264/348)	<0.001
Complex	63.9% (39/61)	33.5% (157/469)	24.1% (84/348)	
Conversion				
Yes	9.8% (6/61)	6.0% (28/469)	7.5% (26/348)	ns
No	90.2% (55/61)	94.0% (441/469)	92.5% (322/348)	

Results are displayed as % (N/Total N)

Table 3. Surgical outcome after OA and LA in simple and complex appendicitis

	Simple			Complex		
	OA	**LA**	***P***	**OA**	**LA**	***P***
Hospital stay (in days)*	2.7	2.0	<0.001	7.1	6.3	ns
IAA	2.6% (7/265)	1.8% (6/333)	ns	7.0% (11/158)	17.2% (21/122)	0.008
SSI	3.4% (9/265)	1.5% (5/333)	ns	8.2% (13/158)	4.1% (5/122)	ns
Early readmission	3.4% (9/265)	2.4% (8/333)	ns	6.5% (10/155)	16.7% (20/120)	0.007

Results are displayed as % (N/Total N), unless stated otherwise.
* Results are displayed as mean

Table 3a. Surgical outcome after OA and LA in different age groups

	0 - 5 years			6 – 12 years			13 – 17 years		
	OA	**LA**	***P***	**OA**	**LA**	***P***	**OA**	**LA**	***P***
Hospital stay (in days)*	8.5	6.5	ns	4.0	3.2	0.005	3.6	2.8	0.011
IAA	8.9% (4/45)	31.3% (5/16)	0.030	4.2% (10/239)	6.5% (15/230)	ns	2.9% (4/139)	3.3% (7/209)	ns
SSI	17.8% (8/45)	12.5% (2/16)	ns	4.2% (10/239)	1.7% (4/230)	ns	2.9% (4/139)	1.9% (4/209)	ns
Early readmission	14.0% (6/43)	33.3% (5/15)	ns	4.6% (11/238)	5.7% (13/230)	ns	1.4% (2/139)	4.8% (10/208)	ns

Results are displayed as % (N/Total N), unless stated otherwise.
* Results are displayed as mean

Table 3b. Surgical outcome after OA and LA in different age groups in simple appendicitis

	0 - 5 years			6 – 12 years			13 – 17 years		
	OA	**LA**	***P***	**OA**	**LA**	***P***	**OA**	**LA**	***P***
Hospital stay (in days)*	4.5	3.6	ns	2.7	2.0	0.003	2.5	1.9	0.003
IAA	7.1% (1/14)	25.0% (2/8)	ns	4.1% (6/147)	1.8% (3/165)	ns	0.0% (0/104)	0.6% (1/160)	ns
SSI	21.4% (3/14)	12.5% (1/8)	ns	2.7% (4/147)	1.2% (2/165)	ns	1.9% (2/104)	1.3% (2/160)	ns
Early readmission	14.3% (2/14)	12.5% (1/8)	ns	4.1% (6/147)	2.4% (4/165)	ns	1.0% (1/104)	1.9% (3/160)	ns

Results are displayed as % (N/Total N), unless stated otherwise.
* Results are displayed as mean

Table 3c. Surgical outcome after OA and LA in different age groups in complex appendicitis

	0 - 5 years			6 – 12 years			13 – 17 years		
	OA	**LA**	***P***	**OA**	**LA**	***P***	**OA**	**LA**	***P***
Hospital stay (in days)*	10.3	9.4	ns	6.0	6.3	ns	6.8	5.8	ns
IAA	9.7% (3/31)	37.5% (3/8)	0.052	4.3% (4/92)	18.5% (12/65)	0.004	11.4% (4/35)	12.2% (6/49)	ns
SSI	16.1% (5/31)	12.5% (1/8)	ns	6.5% (6/92)	3.1% (2/65)	ns	5.7% (2/35)	4.1% (2/49)	ns
Early readmission	13.8% (4/29)	57.1% (4/7)	0.013	5.5% (5/91)	13.8% (9/65)	ns	2.9% (1/35)	14.6% (7/48)	ns

Results are displayed as % (N/Total N), unless stated otherwise.
* Results are displayed as mean

Trends

A trend was seen in the use of the laparoscopic approach over the past years; in 2001 LA was performed in 12.9% and in 2010 this was 94.0% of all appendectomies (figure Ia). Hospital stay in days during the study period for LA and OA are shown in figure II. The outcome between early and late study period are shown in table IVab. In the simple appendicitis group operated by OA no differences were seen in hospital stay and complications. Patients suffering from a simple appendicitis operated by LA had a longer hospital stay when they were operated in the early period. No differences were seen in rate of complication. In the complex group operated by OA or LA no differences were seen in hospital stay. In the open group patients had significant more IAA after OA in the early period. No differences were seen in complication rate in the LA group between the two study periods.

Table 4a. Surgical outcome after OA and LA in early and late time period in simple appendicitis

	Simple					
	OA			**LA**		
	Early	**Late**	***P***	**Early**	**Late**	***P***
Hospital stay (in days)*	2.8	2.3	ns	2.8	1.7	0.004
IAA	2.9% (6/205)	1.7% (1/60)	ns	3.3% (3/91)	1.2% (3/242)	ns
SSI	2.4% (5/205)	6.7% (4/60)	ns	3.3% (3/91)	0.8% (2/242)	ns
Early readmission	2.9% (6/205)	5.0% (3/60)	ns	1.1% (1/91)	2.9% (7/242)	ns

Results are displayed as % (N/Total N), unless stated otherwise.
* Results are displayed as mean

Table 4b. Surgical outcome after OA and LA in early and late time period in complex appendicitis

	Complex					
	OA			**LA**		
	Early	**Late**	***P***	**Early**	**Late**	***P***
Hospital stay (in days)*	7.0	7.1	ns	6.1	6.3	ns
IAA	3.6% (4/111)	14.9% (7/47)	0.011	17.5% (7/40)	17.1% (14/82)	ns
SSI	6.3% (7/111)	12.8% (6/47)	ns	7.5% (3/40)	2.4% (2/82)	ns
Early readmission	6.4% (7/109)	6.5% (3/46)	ns	15% (6/40)	17.5% (14/80)	ns

Results are displayed as % (N/Total N), unless stated otherwise.
* Results are displayed as mean

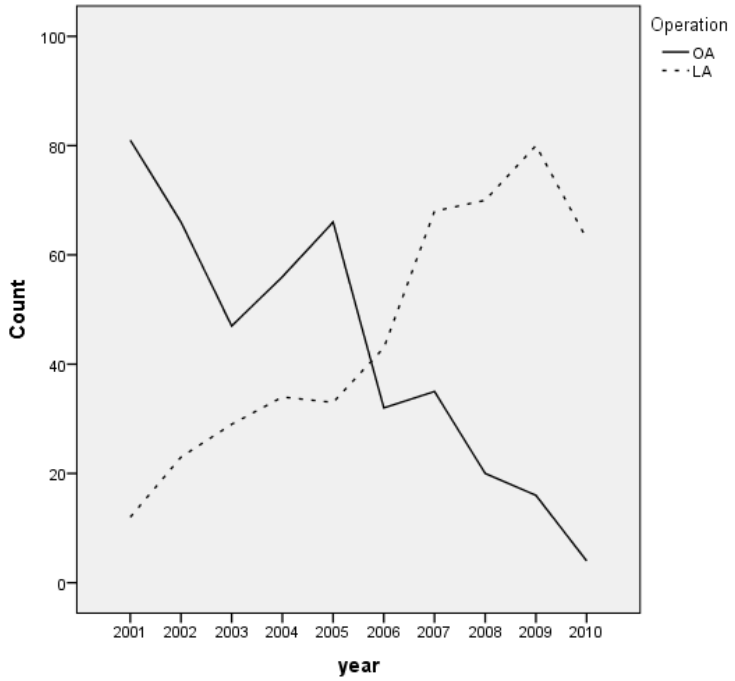

Figure 1. Trend in operation technique

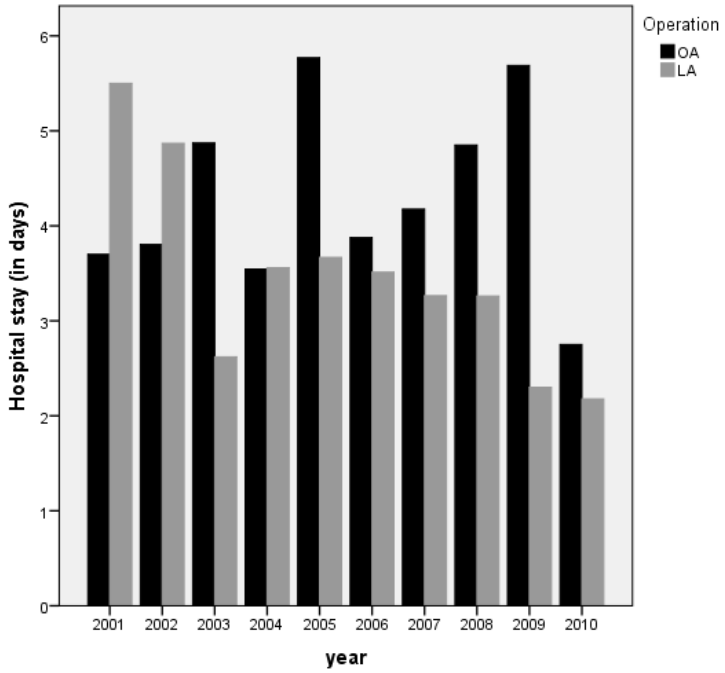

Figure 2. Mean hospital stay in days for different operation techniques

Discussion

In recent years, LA has become an established procedure in case of acute appendicitis in the paediatric population.[12] It appears that most surgeons prefer to perform LA in children with appendicitis nowadays.[13] The discussion about its advantages remains a hot topic both in adults and children. This study contributes to the ongoing discussion as it evaluates the surgical outcome of each technique for specific patient groups within the paediatric population.

We found an increased incidence of IAA after LA for children with complex appendicitis, especially those younger than 12 years of age. Therefore preoperative distinction between simple and complex appendicitis is crucial to determine the optimal surgical approach. In our opinion, LA should be reconsidered in patients with a preoperative diagnosis of complex appendicitis.

Opponents of the laparoscopic approach highlight the reported higher incidence of IAA after LA. It is well known that patients with complex appendicitis are at risk of developing complications after laparoscopy. In a recent review, it was reported that this risk was increased by twofold in the adult population with no specific comments made regarding the severity of appendicitis, although others could not confirm this finding.[5-7] In children, a recent review identified a higher incidence of IAA after LA in children with complex appendicitis.[8] Explanations for the increased risk of IAA after LA are threefold. Firstly, the insufflation of carbon dioxide can lead to spread of purulent fluid throughout the abdomen making it a more generalised abdominal problem. Secondly, the dissection of the appendix is performed intra-abdominally with the potential risk of contamination. Thirdly, suction after irrigation of purulent fluids may contribute to spreading of microorganisms in the abdominal cavity. In 2012, a randomised controlled study in children by St Peter et al showed no advantages of irrigation over suction alone during LA in case of perforated appendicitis.[14] Our study supports the findings from Markar et al and we want to highlight the importance of correct preoperative distinction between simple and complex appendicitis as this influences the preferred surgical approach in our centres.[8] To predict complex appendicitis preoperatively, some studies have developed a scoring system, of which none have been externally validated.[18-19] Most of these are not applicable in Europe as in most European countries, computed tomography is not routinely used in diagnosing (or distinguishing between simple and complex) appendicitis in children.[20]

Results from LA and OA in specific age groups have not been reported previously to our knowledge. Stilling et al showed that in the youngest age group (0-5 years) significantly more complications occurred after LA than in older children.[15] However, no comparison was made between different operation techniques (LA and OA) and between different types

of appendicitis. In our study we showed that younger children had no benefit from shorter hospital stay after LA compared to the older children. In contrast to this benefit, younger children suffered more from an IAA after LA. Like the present study, previous studies did demonstrate that younger children are more likely to suffer from complex appendicitis.[16-17]

The disadvantage of OA was mainly the development of SSI. Even though the incidence after OA was higher than after LA, there was no significant difference between the two techniques. This is in contrast to recent literature.[5] The higher incidence of SSI after OA is explained by the fact that the dissection is made through the open wound whereas in case of LA the principle of abdominal wall protection (i.e. endobag or removal through the trocar) is followed.

There are some limitations to our study. First the retrospective nature of this study may have led to information and selection bias. In addition several important data such as BMI was missing which might also influence the outcome after surgery. Second the fact that this study encompasses a 10-year time period in which most surgeons went through their learning curve for LA. Therefore the higher incidence of IAA might be a reflection of the learning curve of laparoscopic appendectomy during this time rather than due to the severity of appendicitis. Additionally, during this long study period, several new insights have led to adjustment of several technical aspects of LA, which might be of influence on the IAA rate. Against this argument pleads that in our analyses we could not show a differences in IAA after LA between the early and late study period. Third, no uniform protocol was used for the choice for laparoscopic or open approach. In addition, we know that the development of paediatric laparoscopy has been trailing behind that of adults by a good few years. Fourth, the fact that in the Netherlands children are operated by both general and pediatric surgeons or residents with consultant supervision. Current literature in children originates mostly from specialist pediatric surgical services. Even though one can interprete this as a possible bias it should be noted that our incidence of IAA is comparable to the current literature. Finally, the definitions of simple and complex appendicitis are still subject of debate. One could discuss the heterogeneity of our complex appendicitis group. We have chosen to define simple and complex appendicitis based on surgical and histological reports, as supported by previous studies.[18-19-21-22]

We want to point out that despite all the flaws associated with retrospective studies and long period studies, this is the data available to use nowadays. Therefore our recommendations are based on this data. Well-designed prospective studies need to be conducted to test the hypothesis based on retrospective data.

In conclusion, laparoscopic appendectomy for complex appendicitis was associated with a higher incidence of IAA, particularly in the youngest age groups. The laparoscopic approach in simple appendicitis has the advantage of a shorter hospital stay. Preoperative distinction between simple and complex appendicitis is crucial and therefore more research is necessary to find characteristics that distinguish between these two types preoperatively. We recommend to perform a laparoscopic appendectomy for simple appendicitis whereas patients with complex appendicitis and younger children should undergo an open appendectomy. We emphasize the importance of conducting a randomised controlled trial in specific patient groups in order to settle the long lasting debate of the optimal treatment strategy for acute appendicitis in children.

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