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Research Article

Appendicitis in Childhood: What has Been Changed in the Last Few Decades in Central-Europe?

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Abstract

Introduction: The evolution of managing pediatric appendicitis, including its surgical approaches, is described. With time, pediatric surgeons have started to use more accurate diagnostic and surgical tools. This retrospective study aimed to analyze the efficacy of the progress of managing appendicitis in children at a leading Central European pediatric institute.

Methods: Appendectomies in this study were performed in two periods: from 1976-1985 (group A, n=1293) and from 2011-2020 (group B, n=1182). Pre-, intraoperative diagnoses and postoperative complications were analyzed according to the histological results. Both main groups were divided into two subgroups based on the histological findings: complicated (perforated) and uncomplicated (non-inflamed, simplex, catarrhal, phlegmonous, and gangrenous). Groups and subgroups were analyzed separately. Patients older than 15 years and with other comorbidities were excluded from the study. Histological results and postoperative complications of the groups and subgroups were statistically analyzed using Chi^2- and Fischer's exact tests.

Results: The proportion of non-inflamed or simplex appendicitis cases in groups A and B was 37.6% and 11.9%, respectively ($p<0.0001$). Regarding the postoperative complications, solely the late complication rate was higher in group B compared to group A ($p<0.0001$).

Discussion: Due to better diagnostic methods, fewer non-inflamed cases are considered nowadays. To understand the higher rate of late postoperative complications observed in recent years, further prospective studies are needed.

Keywords: Appendicitis; Pediatric; Open appendectomy; Laparoscopic appendectomy; Complication

Introduction

The evolution of managing pediatric appendicitis, including its surgical approaches, is well described. With time, pediatric surgeons have started to use more accurate diagnostic and surgical tools. The symptoms of acute appendicitis and the methodology of traditional Open Appendectomy (OA) are also documented [1]. In the 1970s, the diagnosis was mainly based on physical examination, observation, and basic laboratory tests (white blood cell count, neutrophil ratio, erythrocyte sedimentation rate), which were used at the authors' institute as well [2]. Nowadays, a wide range of modern imaging techniques (Ultrasound, CT, MRI) and laboratory tests can be performed (C-reactive protein/CRP, procalcitonin/PCT), in order to help us to clarify the diagnosis in this frequently seen disease. In the case of the traditional open technique, the skin incision was modified by Elliot and Lanz [3]. The Laparoscopic

Appendectomy (LA) was introduced in 1983 by Kurt Semm, a German gynecologist [4]. The minimally invasive surgery forges ahead in our times. The first pediatric LA series was published in 1992 by Gilchrist. In 2005 more than half of appendectomies were performed via LA in the United States [4,5]. It has been demonstrated that LA can also be done safely in children [6]. The most common advantage of LA is the shorter hospital stay and short learning curve in surgical training [7-9]. The present study aimed to analyze the improvement of appendicitis management in children at a leading Central European pediatric institute. Furthermore, the authors would like to examine the difference in non-inflamed or simplex (false negative) operated cases and in postoperative complications between two eras.

Methods

Patients with acute appendicitis were enrolled in a retrospective observational cohort study, which was performed during two periods between 1976-1985 (group A) and between 2011-2020 (group B) at the authors' institute. Medical data were collected retrospectively from both paper and the digital-based medical records in both groups. Patients between 0-15 years were included. Patients older than 15 years, those with insufficient medical data, or any other comorbidities (e.g. oncological diseases) were excluded.

Patients were subgrouped according to their age (patients between 0-6 years-Y/younger subgroup, and 7-14 years-O/older subgroup) and by their histological results as uncomplicated (UCAA-negative, simplex, catarrhal, phlegmonous and gangrenous appendicitis) and Complicated Acute Appendicitis (CAA-perforated appendicitis). The non-inflamed or negative and 'simplex (false positive) cases' were also analyzed separately within the subgroups. Complications were divided into early (e.g., wound healing problems, intra-abdominal abscess, paralytic ileus) and late complications (e.g., wound healing problems, ileus/reoperation). In group A, all the surgeries were done via laparotomy (OA). In group B, the surgical techniques were both OA (including laparoscopic converted to an open appendectomy) and LA. The histological results and complications were analyzed by Fischer's exact and Chi^2-tests. The value of $p<0.05$ was considered a statistically significant alteration.

Results

Altogether, 2475 appendectomy cases were included (in group A n=1293, in group B n=1182) in the study. Number and the age proportion (younger and older children) of the observed patients in both groups are detailed in Table 1. The majority of the patients were older than 6 years of age in both groups and the proportion of operations performed on 0–6-year-old children was significantly higher in group A (20.4%) than in group B (14.0%) ($p<0.0001$). In the UCAA subgroup more patients were operated in group B than in group A, especially in older patients ($p<0.0001$). There were more negative or simplex appendicitis cases operated in group A than in group B. The latter difference is significant in all subgroups ($p<0.0001$). A difference was found in the proportion of CAA cases in the older age subgroup (O, 7-14yrs): more CAA cases were observed in group A ($p<0.0001$). In younger patients the ratio of CAA cases was higher than in older patients (group A: 29.5% vs 18.3%, group B: 28.3% vs 11.2%) (Table 1 & Figure 1). Pathologies behind negative and simplex appendicitis cases are detailed in Table 2.

Table 1: Number of patients that underwent appendectomy according to age groups and severity of appendicitis.

	Age Groups	A Group (1976-85)	B Group (2011-20)	p
all	0-6 years (Y)	264 (20.4%)	166 (14.0%)	<0.0001
	7-14 years (O)	1029 (79.6%)	1016 (86.0%)	<0.0001
	all	1293	1182	
UCAA	0-6years (Y)	70.5% (186/264)	71.7% (119/166)	0.7841
	7-14years (O)	81.7% (841/1029)	88.8% (902/1016)	<0.0001
	all	79.4% (1027/1293)	86.4% (1021/1182)	<0.0001
negative, simplex appendix cases				
	0-6years (Y)	42.4% (112/264)	16.9% (28/166)	<0.0001
	7-14years (O)	36.4% (375/1029)	11.1% (113/1016)	<0.0001
	all	37.6% (487/1293)	11.9% (141/1182)	<0.0001
CAA	0-6years (Y)	29.5% (78/264)	28.3% (47/166)	0.7841
	7-14years (O)	18.3% (188/1029)	11.2% (114/1016)	<0.0001
	all	20.6% (266/1293)	13.6% (161/1182)	<0.0001

Table 2: Observed pathologies in negative or simplex appendicitis cases.

	Group A (1976-1985)	Group B (2011-2020)
Mesenteric lymphadenitis	217/487	-
Enterocolitis	19/487	2/141
Henoch-Schönlein's purpura	4/487	-
Kidney stone	4/487	-

Meckel's diverticula	5/487	6/141
Intussusception	5/487	-
Pneumococcus peritonitis	28/487	-
Ovarian pathology (cyst, adnexitis)	4/487	3/141
Pancreatitis	1/487	-
IBD	1/487	2/141
Helminthiasis	-	2/141
Wandering kidney	-	1/141

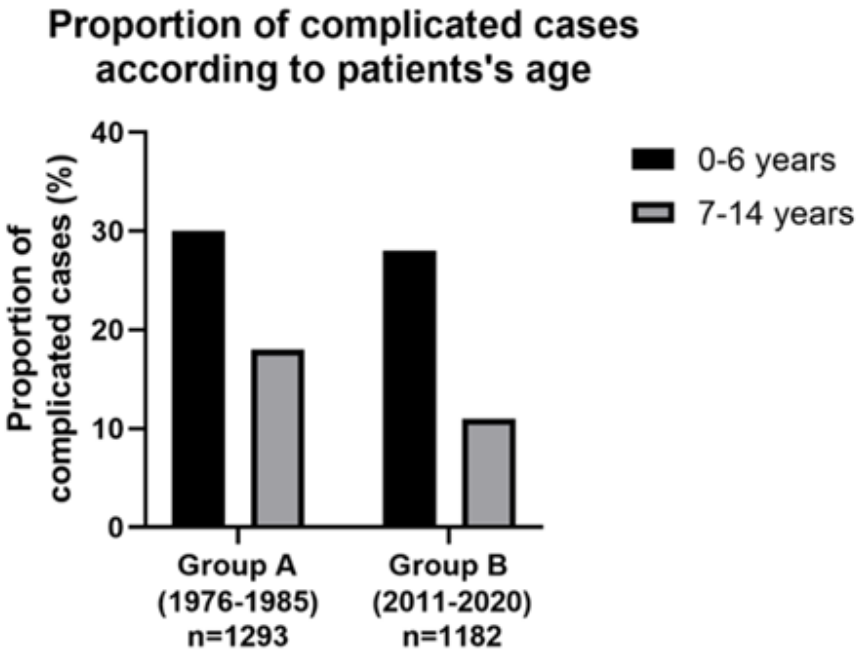

Figure 1: Proportion of complicated cases according to the patients' age.

On the one hand, there was no difference between groups A and B regarding early complications (p=0.2472). On the other, higher rates of late (p<0.0001) and "all" complications (p=0.0105) were observed in group B. However, if we exclude LA cases and examine solely OA cases in both groups, the rate of late complications remains significantly higher in group B both in UCAA and CAA subgroups (Table 3 & Figure 2).

Table 3: Complication rates according to chosen operative technique.

	Complication	A Group (1976-1985)	B Group (2011-2020)	p
All appendectomies A group: OAC B group: OA and LA	Early	5.4% (70/1293)	6.5% (77/1182)	0.2472
	Late	0.6% (8/1293)	3.9% (46/1182)	<0.0001
	All	6.0% (78/1293)	8.7% (103/1182)	0.0105
OA	Early	5.4% (70/1293)	6.9% (49/714)	0.1882
	Late	0.6% (8/1293)	4.9% (35/714)	<0.0001
	All	6.0% (78/1293)	9.8% (70/714)	0.002
OA, UCAA	Early	2.5% (26/1027)	3.7% (22/598)	0.1877
	Late	0.1% (1/1027)	3.9% (23/598)	<0.0001
	All	2.6% (27/1027)	6.4% (38/598)	0.0002
OA, CAA	Early	16.5% (44/222)	23.27% (27/116)	0.1197
	Late	2.6% (7/266)	10.3% (12/116)	0.0033
	All	19.2% (51/266)	38.6% (32/116)	0.0667

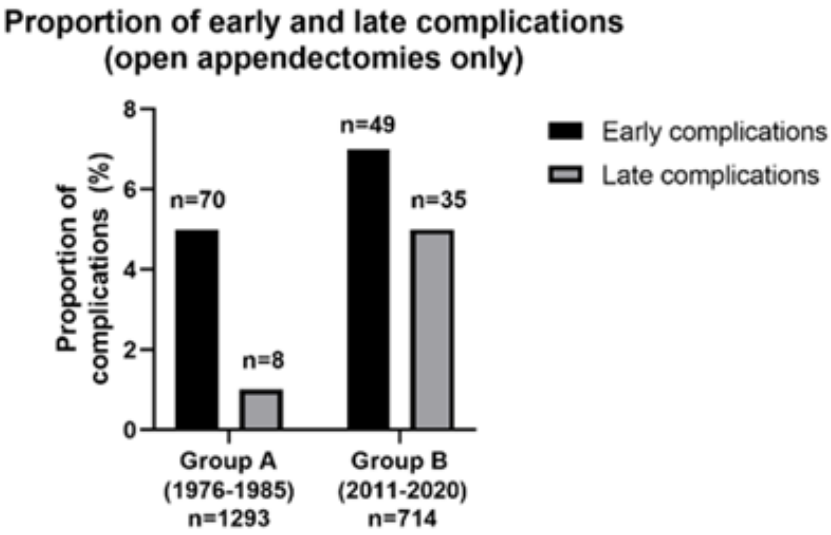

Figure 2: Proportion of early and late complications (open appendectomies only).

Discussion

A retrospective observational cohort study was enrolled: 2475 pediatric appendectomy cases were observed in two eras (1976-1985 and 2011-2020). The proportion of patients in younger and older age groups and postoperative complications were analyzed according to appendicitis severity. This retrospective study suggests that modern diagnostic possibilities might be the reason for a lower negative or simplex appendectomy rate in our time. A previous study by Boenigk H et al. [10] found similar results. In that study three periods were observed (1974-1985, 1986-1996, 1997-2000) at a general surgical department, where the negative appendectomy rate showed a decreasing trend [10]. In a Swedish study on 56 774 pediatric patients, the number of all, negative and perforated appendicitis cases decreased between 1987-2009 [11]. We found that the frequency of CAA cases is slightly lower nowadays, however, this did not reach the statistically significant level. Anderson et al. [12] also found a decrease in perforated appendicitis between 1995 and 2009 [12]. On the contrary, in 1984, Ricci et al. [13] found an increased appendix perforation rate in contrast with their previous data in 1944 (0%), 1964 (13.6%), and 1984 (31.5%) [13]. Our study demonstrated higher CAA rates in younger patients, which is a well-known fact in pre-school age [14]. An earlier study performed from the authors' institute, proved during the laparoscopic appendectomy learning curve, there was no difference in complication rates between OA and LA patients [8,9].

The limitation of our study is the short follow-up time. In the past century, patients with complications are obliged to return to their primary care center where they were operated; therefore, nearly all complications were detected in group A. Nowadays, patients with complications need to return to the primary care center only in the first month after the operation. Later, they are free to choose any other facilities that make longer follow-up difficult.

Conclusion

The authors hypothesized that in the past three decades, the management of pediatric appendicitis is completely changed. Earlier, the younger patients (especially those under six years of age) were operated mainly because of the suspicion of appendicitis. Due to the better diagnostic options available today, fewer young patients perforate, and fewer surgeries are performed on negative appendixes under the age of six. The reason why the late complication rates (ileus, reoperation, wound healing problem) are still high remains unknown. The cause could be the higher multi resistant bacterial infection. In order to answer this question, further prospective studies are needed.

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Balázs Fadgyas], [Gábor István Garai], [Georgina Monostori], [Sándor Sárközy], [Ferenc Csitáry], [Dorottya Őri]. The first draft of the manuscript was written by [Balázs Fadgyas], [Péter Vajda] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics approval

This is an observational study. The Heim Pál National Pediatric Institute Research Ethics Committee has confirmed that no ethical approval is required.

Consent to participate

Written informed consent was obtained from the parents.

Consent to publish

The manuscript does not contain any individual person's data in any form.

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