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ORIGINAL ARTICLE

Antibiotic treatment of post-appendectomy abscesses in children, regardless of size: a twelve years' experience

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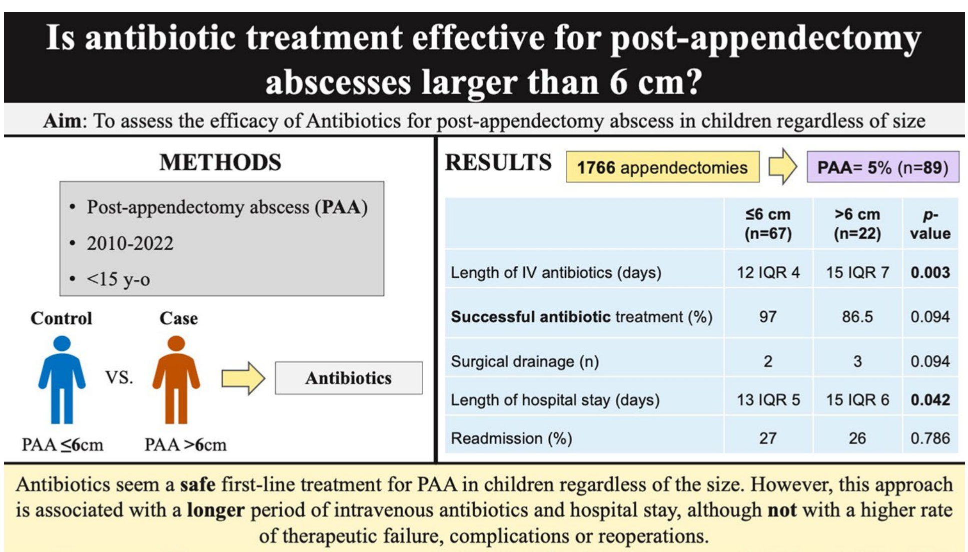
Abstract

Intra-abdominal abscesses are a common issue after appendectomy. Antibiotics have shown efficacy in treating smaller abscesses, while larger ones have traditionally been treated with drainage. This study assesses the efficacy of antibiotics for post-appendectomy intra-abdominal abscess (PAA) in children regardless of size. Case–control study of children with PAA admitted at our hospital from 2010 to 2022. The efficacy of antibiotics was compared between abscesses less and more than 6 cm in diameter. The Institutional Review Board has approved this study. A total of 1766 appendectomies were performed from 2010 to 2022 with an incidence of PAA of 5% (n = 89): age 9.3 IQR 5.8, 63% male (n = 56). Sixty-seven patients presented with a ≤ 6 cm abscess (controls) and 22 children had a > 6 cm PAA (cases). Length of intravenous antibiotics were higher in cases (15 IQR 7 days) than controls (12 IQR 4 days), $p = 0.003$. The efficacy of antibiotics in controls was 97% whereas 86.4% in cases ($p = 0.094$), reoperation was needed in 2/67 controls and 3/22 cases, with no differences in complications or readmission. The length of stay was longer in cases (15 IQR 6 days) than controls (13 IQR 5 days), $p = 0.042$. Antibiotics seem a safe treatment for PAA in children regardless of the size. However, this approach is associated with a longer period of intravenous antibiotics and hospital stay, although not with a higher rate of therapeutic failure, complications or reoperations.

Graphical abstract



Keywords Appendicitis · Abdominal abscess · Antibiotic · Postoperative complications · Children

Extended author information available on the last page of the article

Introduction

Although appendectomy is considered a low-risk procedure, post-operative complications such as abdominal abscesses still occur in up to 20% of patients [1, 2]. These complications can lead to significant morbidity and even mortality if left untreated. Treatment options for these complications have evolved over the years, with current evidence recommending the use of antibiotics for abscesses measuring less than 3–6 cm in diameter [3]. However, larger abscesses have traditionally been managed by drainage, either via percutaneous or surgical methods. Nevertheless, some authors have shown that antibiotics can also be effective for larger post-appendectomy intra-abdominal abscesses (PAA) [4–6]. Since 2010, our department has implemented a protocol for non-invasive treatment of PAA with antibiotics, regardless of the size (Fig. 1). The aim of this study is to provide an overview of our experience and results, on the antibiotic treatment of post-appendectomy abscesses in children since the implementation of this protocol.

Methods

A retrospective case–control study was conducted at a pediatric hospital to investigate the efficacy of antibiotics in children with post-appendectomy abscesses. The study population comprised all children under the age of 15 years who underwent appendectomy at our institution between January 2010 and December 2022 and subsequently developed a post-appendectomy intra-abdominal abscess. PAA was defined as a radiologically confirmed accumulation of purulent fluid in a walled-off space within the abdominal cavity after open, laparoscopic or transumbilical video-assisted appendectomy, accompanied by clinical signs of infection. Patients with abscesses less or equal to 6 cm in size were included as controls (group A), while those with abscesses greater than 6 cm were classified as cases (group B). In the case of multiple abscesses, the larger one was used to enroll patients as control or case. Data were collected from the inpatient and outpatient medical records, including demographic information, operative registries, imaging findings and treatment outcomes.

Descriptive statistics were employed to summarize the data. Children who had abdominal wall abscesses, unorganized free peritoneal fluid or incomplete medical records were excluded from the analysis. Continuous variables were presented as means with standard deviations (±) or medians with interquartile range (IQR), while categorical

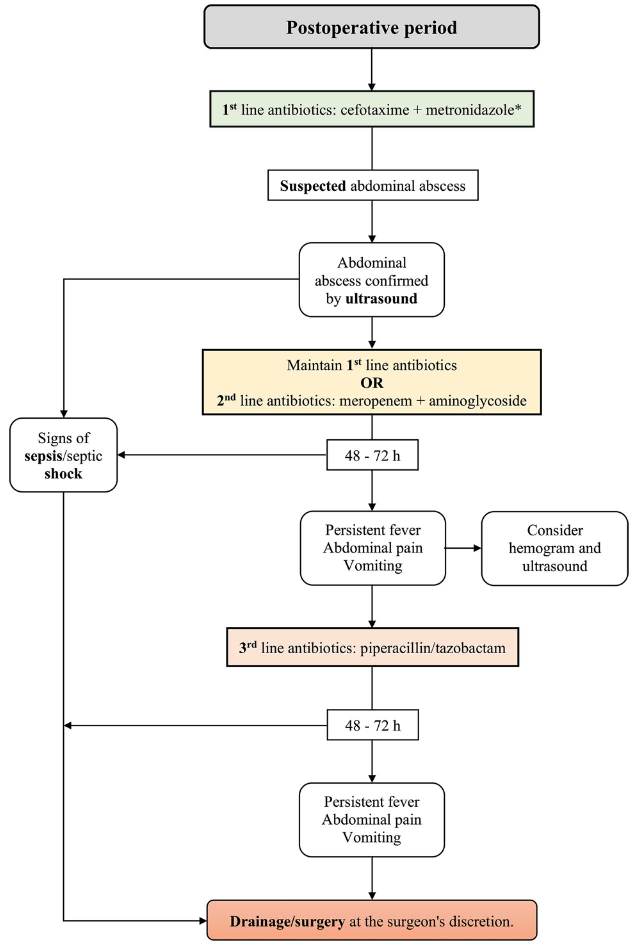


Fig. 1 Non-invasive treatment protocol for postoperative intra-abdominal abscess. *In the immediate postoperative period, all patients received cefotaxime + metronidazole for varying durations depending on the type of appendicitis and clinical condition, unless contraindicated due to allergy

variables were reported as frequencies and percentages. The normality of variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. For normally distributed continuous variables, independent samples t-test was applied, while non-normally distributed data were analyzed using Mann–Whitney's U test. The categorical variables were analyzed by the chi-square test or Fisher's test if the former was not applicable. All statistical calculations were performed with a two-tailed test and statistical significance was established at p value < 0.05 (alpha 5%). Patient data were anonymized and collected using Microsoft® Excel (Version 16.66.1) and analyzed with the Statistical Package for the Social Sciences (IBM Corp., Armonk, NY).

Written informed consent was obtained from the parents or legal guardians of all study participants. This study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional review board (No.

3318-0000200). This paper adhered to The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies [7].

Results

We analyzed 1766 appendectomies that were performed at a tertiary pediatric hospital from January 2010 to December 2022. Of those, 89 patients (5%) developed postoperative abscesses. The diagnosis was made by ultrasound in all patients, and none of them underwent computed tomography (CT) or magnetic resonance imaging (MRI) for the initial diagnosis of PAA. The abscesses were classified into two groups based on their diameter: ≤ 6 cm (n = 67) and > 6 cm (n = 22).There were no significant differences in age between the control group (9.1 ± 3.4 years) and the cases group (12.1 IQR 5.1 years; $p = 0.075$), sex (female 34.3% in group A vs. female 45.5% in group B; $p = 0.349$), or weight (controls 33.5 ± 14 kg vs. cases 40.7 ± 16.8 kg; $p = 0.052$). Additionally, there were no differences in the surgical approach between the groups. The most common surgical approach was the video-assisted transumbilical technique (71.6% in the control group vs. 72.7% in the cases group), followed by laparoscopy (6% in group A vs. 0% in group B), laparotomy (9% in controls vs. 9.1% in cases), and only nine patients in the control group required conversion to laparotomy (13.4%), compared to four children in the case group (18.2%); $p = 0.666$. The types of appendicitis in the control vs. case groups were as follows: phlegmonous (4.5% vs. 4.5%), gangrenous (4.5% vs. 0%), perforated (20.9% vs. 9.1%), appendicular mass (9% vs. 13.6%), localized peritonitis (34.3% vs. 27.3%), and generalized peritonitis (26.9% vs. 45.5%). There were no differences between the groups ($p = 0.454$), although there were more patients with generalized peritonitis in the group of abscesses larger than 6 cm (n = 10/22).

The abscesses were diagnosed on postoperative day 6 (IQR 4) in the control group and 7.5 (IQR 2.3) days in the case group ($p = 0.284$). The abscesses had a median diameter of 4 (IQR 2) cm in group A, compared to 7.15 (IQR 2.5) cm in group B ($p = < 0.0001$). They were found to be more common in the right inferior quadrant (control group 55.2%, case group 31.8%), pelvis (control group 17.9%, case group 31.8%), and hypogastrium (control group 13.4%, case group 27.3%), with no significant differences in localization between the two groups ($p = 0.180$). Multiple abscesses were more frequent in the case group, with one collection in 71.6% of patients in group A (n = 48/67) compared to 40.9% in the group B population (n = 9/22), two in 20.9% of group A versus 36.3% in group B, three in 7.5% (group A) and 9.1% (group B), and only in group B were there patients with four abscesses (13.6%, n = 3/22); this was significant ($p = 0.004$). Among patients with a single abscess, one child required surgery (1/57, 1.7%), in patients with two abscesses, 2 children needed surgical intervention (2/22, 9%), between the seven patients with three abscesses, none required intervention, and among the children with four abscesses, two patients required surgery (2/3, 66%).

Regarding diagnostic and follow-up imaging studies, the control group of children required 3 (IQR 2) abdominal ultrasonography scans, compared to 4 (IQR 1) in the case group ($p = 0.007$). No computed tomography (CT) scans were indicated in the control group, whereas in the case group, three CT scans were performed, two of which were in the same patient ($p = 0.013$), due to uncertain findings in the ultrasound resulting from obesity. Magnetic resonance imaging (MRI) was not performed in either group. The number of total imaging studies performed was 3 (IQR 2) in group A, versus 4 (IQR 2) in group B ($p = 0.002$).

In Group A, 11 out of 67 patients (16.4%) showed favorable progress with first-line antibiotics (compared to Group B: 1 out of 22 [4.5%]; $p = 0.069$). Furthermore, 49 out of 67 children (73.1%) required second-line antibiotics (vs. Group B: 14 out of 22 [63.6%]; $p = 0.532$), and 7 out of 67 patients (10.4%) in Group A needed third-line antibiotics (vs. Group B: 7 out of 22 [31.8%]; $p = 0.012$). The total length of intravenous antibiotic therapy was 12 (IQR 4) days in Group A and 15 (IQR 7) days in Group B ($p = 0.003$) with a successful antibiotic response rate of 97% in the control group compared to 86.5% in the case group. In the group A, no percutaneous drainage was required, whereas in the case group, only one was needed for five days, and ultimately, surgical drainage was necessary. In the control group, only two patients required surgical drainage on postoperative day 16, compared with three patients needing open surgical drainage on postoperative days 16, 16, and 17 ($p = 0.094$); Fig. 2 displays the flow diagram of both treatment groups. The length of hospital stay in the control group was 13 (IQR 5) days, and in the case group, it was 15 (IQR 6) days ($p = 0.042$).

Eighteen children in Group A (26.9%) required a new admission due to abdominal abscess-related symptoms within the first 30 days after the operation, compared to five patients (25.8%) in Group B (p = 0.786). None of these cases required surgery. In the 6-month postoperative period, the number of emergency department visits for Group A were one (n = 12/67; 17.9%), two (n = 3/67; 4.5%), and three visits (n = 1/67; 1.5%), while in Group B, they were one (n = 5/22; 22.7%) and two visits (n = 1/22; 4.5%), (p = 0.796). The number of outpatient clinic visits was 1.28 ± 0.51 in the control group and 1.77 ± 0.81 in the case group (p = 0.003), with longer follow-up time in Group B than in Group A (39 IQR 57.5 days vs. 28 IQR 21 days; p = 0.042). The general characteristics and outcomes of both groups are displayed in Table 1.

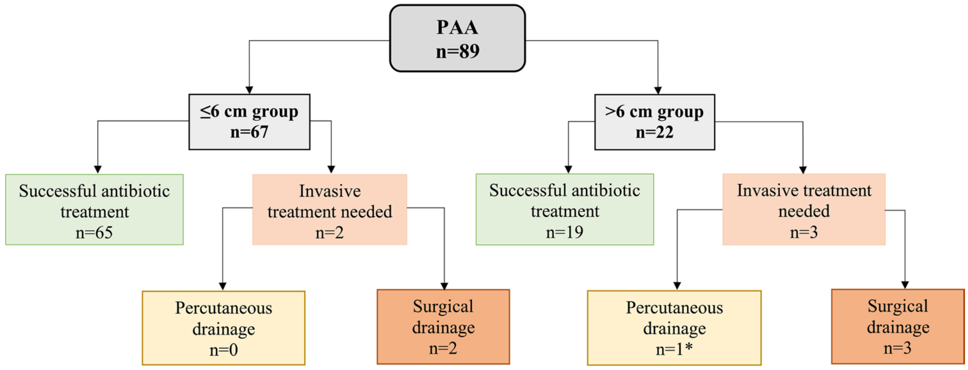


Fig. 2 Flow diagram of the PAA treatment groups. *The patient who required percutaneous drainage later needed surgery for multiple non-communicating abscesses

Table 1 Demographic characteristics and outcomes of the treatment groups

	≤ 6 cm (n = 67)	> 6 cm (n = 22)	*p*-value
Female (%)	34.3	45.5	0.349
Age (years)	9.1 ± 3.4	12.1 IQR 5.1	0.075
Diameter (cm)	4 IQR 2	7.1 IQR 2.5	< 0.0001
Multiple abscesses (%)	28	59	0.004
Number of imaging studies	3 IQR 2	4 IQR 2	0.002
Length of IV antibiotics (days)	12 IQR 4	15 IQR 7	0.003
Percutaneous drainage (n)	0	1	0.079
Successful antibiotic treatment (%)	97	86.5	0.094
Surgical drainage (n)	2	3	0.094
Length of hospital stay (days)	13 IQR 5	15 IQR 6	0.042
Readmission (%)	27	26	0.786
Number of outpatient clinic visits	1.28 ± 0.51	1.77 ± 0.81	0.003
Ambulatory follow-up (days)	28 IQR 21	39 IQR 57	0.042

Discussion

Although previous studies have reported favorable results of non-operative treatment for pediatric patients with PAA, some surgeons are still hesitant to opt for non-invasive treatment due to a lack of high-quality evidence. Additionally, historically, surgeons were trained with the dogma that intra-abdominal pus should be removed from the body. As a result, there is significant heterogeneity in the treatment of PAA. Some authors also suggest that the choice of treatment strategy for PAA depends on the size of the abscess [8]. They propose that only small abscesses (< 3 cm) should be treated non-invasively, while larger abscesses should be drained [9, 10]. In this paper, we describe our experiences with non-invasive treatment using antibiotics for PAA, regardless of abscess size, which yielded good outcomes. Van Amstel et al. found that non-invasive treatment with antibiotics was effective in 100% of unifocal small abscesses (< 3 cm). Focusing on patients with a 3–6 cm PAA, the success rate of antibiotic treatment was 90% compared to 86% for drainage procedures in another teaching hospital that preferred invasive treatment strategies [11]. In our series, the success rate with non-operative treatment was even higher, with antibiotics proving effective in 97% of patients with PAA ≤ 6 cm. Therefore, non-invasive treatment appears to be at least equally successful compared to invasive drainage procedures in this patient group.

Regarding large (> 6 cm) post-appendectomy abscesses, non-invasive treatment strategies have been reported to have a success rate of 67% (n = 2/3), compared to 63% (n = 10/16) in the invasive group [11]; however, nowadays a significant number of authors prefer invasive treatment in this situation [12]. In our cohort, the successful antibiotic response rate was 86.5% in this group of patients, which was not significantly different from the response rate in children with abscesses < 6 cm ($p = 0.094$), and better than that reported by previous authors. Similarly, for the treatment of multiple PAA, most surgeons prefer and recommend invasive drainage procedures, arguing that non-invasive treatment is less suitable and effective [13]. However, we do not fully agree with this statement because in our study, only 4 of 32 patients with multiple PAA required invasive procedures and 87.5% were successfully treated with antibiotics (n = 28/32). Therefore, in our experience, the presence of multiple abscesses is not a contraindication for trying non-operative treatment. Furthermore, drainage of PAA is an invasive procedure associated with morbidity and a longer length of hospital stay compared to non-invasive treatment in some studies. Additionally, it requires general anesthesia [14].

Regarding imaging studies, control patients required a median of 3 (IQR 2) ultrasounds compared to 4 (IQR 1) ultrasounds in cases ($p = 0.007$). In a study of 25 patients, 13 were initially treated with antibiotics, 9 with percutaneous drainage, and 3 underwent surgical drainage. Patients treated with antibiotics underwent a median of 3 ultrasounds per patient compared to 4 ultrasounds per patient in the drainage group [11]. Our results are similar and suggest that patients with larger abscesses will likely have a similar number of imaging studies compared to those treated surgically, but not more. However, in our population, the total number of images performed (including ultrasounds and CT scans) was significantly higher in the larger abscess group compared to smaller ones ($p = 0.002$). Emil et al. described a significantly longer length of hospital stay after invasive treatment (mean of 15.9 ± 5.4 vs. 12.2 ± 4.6 days) [14]. Interestingly, this is similar to the length of stay for the group of abscesses > 6 cm in our study, suggesting no clinical differences in the length of stay between antibiotic and invasive treatment of abscesses larger than 6 cm. However, in our series, patients with larger abscesses had a longer total intravenous antibiotic length of therapy of 15 (IQR 7) days compared to the group with smaller abscesses (12 IQR 4 days).

Treatment with antibiotics has been shown to be equally resolutive as operative treatment, with reported frequencies of persistent or recurrent abscesses ranging from 9% (0–30%) for the antibiotics (non-invasive) group, 50% (0–100%) for the radiological drainage (invasive) group, and 24% (0–33%) for the surgical drainage (invasive) group [15–18]. Our rate of persistent abscesses with antibiotics treatment was lower (3%) for abscesses smaller than 6 cm and slightly higher (13.5%) for larger abscesses, but still better than the invasive treatment rates reported by the aforementioned author. In the study by Emil et al., readmissions were more frequent in the non-invasive treatment group (33% of patients) compared to the drainage group (10%) [14]. The rate of readmission in the antibiotic group in our study was slightly lower than theirs, with 18 patients in group A (27%) requiring readmission in the first 30 postoperative days, compared to 5 children in group B (26%), although with no statistically significant differences ($p = 0.786$) and none of them requiring surgery. The number of emergency department visits in the 6 postoperative months in both groups was similar to that reported in patients who underwent surgical drainage procedures [19].

In our view, antibiotic therapy is a successful approach and should be favored over invasive treatment strategies for patients with PAA, regardless of its size. However, contraindications for this strategy, such as signs of sepsis or septic shock, must be considered. Additionally, it is recommended to frequently re-evaluate the patient's clinical, biochemical, and radiological status; when available, culture and antibiogram, as well as local microbiology, should also be considered in the antibiotic regimen. More research and prospective studies are needed to further explore this topic, taking into account the potential risk of bias associated with this paper's retrospective design and small sample size. Furthermore, it is important to acknowledge a degree of uncertainty in determining the exact dimensions of abscesses. Radiologic assessments, including ultrasound, cannot provide absolute measurements due to their susceptibility to technical and operator factors.

Conclusion

Based on this overview of our experience, we propose that abscesses larger than 6 cm in diameter can be safely and effectively managed with antibiotic therapy. However, such patients may require a longer duration of intravenous antibiotics and may experience an extended hospital stay.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Julio Moreno. The first draft of the manuscript was written by Julio Moreno. Ada Molina and Alberto Pérez commented on previous versions of the manuscript and made critical review. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author, JCMA, upon reasonable request.

Declarations

Conflict of interest None.

Ethical approval This study was approved by the Institutional Research Ethics Committee (SNS-O No. 3318–0000200) and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

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