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ORIGINAL ARTICLE

Efficacy of oral antibiotics in children with post-operative abscess from perforated appendicitis

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Abstract

Background Post-operative intra-abdominal abscess (PIAA) is the most common complication after appendectomy for perforated appendicitis (PA). Typically, intravenous antibiotics by a peripherally inserted venous catheter are utilized to treat the abscess. We sought to evaluate the role of oral antibiotics in this population.

Methods This is a retrospective review conducted of children between January 2005 and September 2015 with a PIAA. Demographics, clinical course, complications, and follow-up were analyzed using descriptive statistics. Comparative analysis was performed on those who were treated with oral vs IV antibiotics after diagnosis of PIAA.

Results 103 children were included. Days of symptoms prior to admission were 3.2 ± 2.3 days with a WBC of 17.9 ± 6.4. Median time to diagnosis of PIAA from appendectomy was 7 days (7, 10). Mean total length of stay was 10 ± 3.4 days. 42% were treated with oral antibiotics ($n = 43$) versus 58% IV antibiotics ($n = 60$) at the time of discharge. We found a significant increase in total length of hospital stay (9.1 vs 10.7, $p = 0.02$) and number of medical encounters required for treatment (3.4 vs 4.4, $p \leq 0.01$) in the IV group.

Conclusions PIAA treatment after appendectomy for PA can be treated with oral antibiotics with equivalent outcomes as IV antibiotic treatment, but with shorter length of hospitalizations and less medical encounters required.

Keywords Perforated · Appendicitis · Pediatric · Intravenous · Oral · Antibiotics

Abbreviations

PA Perforated appendicitis
PIAA Post-operative intra-abdominal abscess

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Background

Post-operative intra-abdominal abscess (PIAA) is the most common complication after appendectomy for perforated appendicitis (PA) [1]. This results in a protracted medical course. Previous studies, from our institution, have centered on comparing various post-operative antibiotic regimens including a complete IV antibiotic course (once daily dosing of ceftriaxone and metronidazole for a minimum of 5 days) vs completing the course with oral antibiotics (for a total of 7 days) in the treatment of PA finding no difference in post-operative abscess rates [2–6]. At our institution, PIAA typically has been treated with IV antibiotics by a peripherally inserted venous catheter to treat the abscess; however, this increases hospital charges and hospital length of stay [1]. Recently, we began to utilize oral antibiotics more frequently for treatment of PIAA after PA. Due to this, we sought to evaluate our overall outcomes, interventions, complications and hospital course in the treatment of post-operative abscess following PA, and evaluate the role of oral antibiotics in this population. We hypothesized patients with

PIAA after PA could be treated with oral antibiotics successfully and with equivalent outcomes to IV antibiotics.

Methods

Following IRB approval, we performed a retrospective review of children, under the age of 18, with a PIAA from January 2005 to September 2015. Patients were included if they received both surgical and antibiotic therapies for the initial treatment of PA at our institution. Perforated appendicitis is defined at our institution as an identifiable hole in the appendix or a fecalith in the abdomen [7]. Patients were excluded if they had an abscess associated with a PA prior to surgery as identified by computed tomography (CT) or were treated initially at another institution. Demographics, laboratory values, type and duration of antibiotics, interventions, imaging, length of stay, complications and hospital costs were all analyzed using descriptive statistics. Patients were compared if they were treated with oral vs IV antibiotics after diagnosis of PIAA. Diagnosis of PIAA was by imaging with associated symptoms such as fevers, elevated white blood cell count, and poor oral intake. Descriptive and comparative statistics were performed including Fisher's exact test, Mann–Whitney U, and chi squared. Statistical analysis was performed using STATA (StataCorp 2017. Stata Statistical Software: Release 15. College, Station, TX: StataCorp LLC) for calculations. Results are reported as means ± standard deviation and medians with interquartile ranges (IQR).

Results

103 patients were diagnosed with a PIAA after treatment of PA over the 10-year study period. Sixty-eight (68%) were male with a mean age of 11 ± 3.6 years at the time of surgery. At the time of index admission for PA, patients had an average of 3.2 days ± 2.3 days of symptoms with a WBC of 18 ± 6.4 mcL. All patients received IV antibiotics for the treatment of PA. There was no difference in the length of inpatient IV antibiotic treatment. Mean WBC at the time of discharge was 12.3 ± 4.7 mcL.

At the time of diagnosis for PIAA, patients had experienced a mean of 3 ± 2 days of symptoms and presented with a mean WBC of 15.5 ± 6.1 mcL. Sixty-eight (60%) were diagnosed with PIAA prior to hospital discharge from their index operation. There was no difference in the groups between those who had their PIAA discovered prior to hospital discharge or as an outpatient. Median time from appendectomy to diagnosis of PIAA was 7 days (7, 10). Forty-seven patients (46%) were treated with antibiotics only (IV or oral). In addition to antibiotics, 40 (39%) were treated with percutaneous drain placement and 16 (15%) were treated with aspiration of the abscess, both being performed by Interventional Radiology. Average total length of hospitalization was 10 ± 3.4 days. (Tables 1, 2).

At the time of discharge, patients were given a course of either oral or IV antibiotics for further treatment of PIAA. Forty three (42%) were prescribed oral antibiotics and 60 (58%) were given IV antibiotics. Comparing the hospital course between the two groups, there was no difference in the number of radiological imaging obtained, number or types of IR procedures performed, total length of drain days if required, or length of outpatient antibiotic duration. However, those who were discharged with IV antibiotics did have a significantly higher number of PICC lines placed, as would be expected. (Table 2). There was no difference in the management of both patient groups during their treatment of PA and after diagnosis of PIAA, regarding days of IV antibiotics while inpatient. There was, however, a significant increase in the number of days of oral antibiotics that were taken after perforated appendicitis for those that were discharged with IV antibiotics for the treatment of PIAA (Table 3). There was no difference in the total number of hospitalizations (1.4 ± 0.5 vs 1.5 ± 0.7, $p = 0.4$) between the IV and oral antibiotic groups. However, the total length of hospitalizations in days (9.1 vs 10.7, $p = 0.02$) and the total number of medical encounters (3.4 vs 4.4, $p = 0.003$) were significantly higher in the group discharged on IV antibiotics, which included ER visits, surgery clinic visits and other clinic visits such as infectious disease or GI. (Table 4).

Oral antibiotics utilized for treatment of PIAA upon discharge was predominately ciprofloxacin and metronidazole at 56% ($n = 24$) with augmentin being the second most common at 35% ($n = 15$). Patients treated with IV antibiotics at discharge for treatment of PIAA most commonly utilized ceftriaxone and metronidazole at 98% ($n = 59$). Post-treatment complications did not differ between treatment groups at discharge regarding the need of additional surgery for small bowel obstruction, wound infections, and *Clostridium difficile* infections. There were no methicillin-resistant *Staphylococcus aureus* infections in either group. (Table 5).

Discussion

After diagnosis of a PIAA, many patients are treated with IV antibiotics through a peripherally inserted venous catheter. Our study demonstrates that oral antibiotics offer equivalent outcomes to IV antibiotics without the morbidity of placement and difficulty of maintenance of a delivery catheter. Patients with a PIAA after PA treated with oral antibiotics also benefit from shorter length of hospitalizations and less medical encounters required. As a result of this study, our institution now treats all patients with PIAA after PA with oral antibiotics on discharge from the hospital.

Table 1 Demographics and admission details

	IV antibiotics ($n=60$)	Oral antibiotics ($n=43$)	p value
Gender:male[a]	35 (58)	33 (77)	0.12[c]
Age at surgery (years)	11 ± 3.8	11.2 ± 3.4	0.78[e]
BMI	22.4 ± 11.0	20.7 ± 5.5	0.35[e]
Admission for perforated appendicitis			
WBC	18.8 ± 6.5	16.7 ± 6.1	0.1[e]
Temperature	38.1 ± 1.0	37.7 ± 0.9	**0.04**[e]
Days of symptoms	3.1 ± 1.6	3.4 ± 3.1	0.52[e]
Time to initial feed (h)[b]	52.3 (39, 76)	44 (32, 53)	**0.03**[d]
Time to full feed (h)[b]	102 (71, 147)	90 (66, 122)	0.18[d]
WBC at discharge	12.8 ± 5.2	11.4 ± 3.5	0.13[e]
Length of stay (days)	9.5 ± 3.5	8.1 ± 4.2	0.07[e]
Admission/diagnosis for intra-abdominal abscess			
Time from surgery to diagnosis (days)[b]	7 (7, 9)	7 (7, 10)	0.87[d]
WBC	15.4 ± 6.2	15.8 ± 6.2	0.75[e]
Temperature	37.5 ± 0.8	37.6 ± 0.9	0.55[e]
Days of symptoms	2.3 ± 1.7	3.6 ± 2.5	**0.002**[e]
Diagnosed while inpatient[a]	42 (70)	26 (60)	0.43[c]
Length of stay if readmitted (days)	3.3 ± 1.6	2.8 ± 1.2	0.09

[a]*N*(%)

[b]Median (interquartile range)

[c]Chi squared

[d]Mann Whitney *U*

[e]Fisher's Exact test

Table 2 Radiology imaging and interventions

	IV antibiotics ($n=60$)	Oral antibiotics ($n=43$)	p value
Total number of CT's	2.4 ± 0.7	2.1 ± 0.9	0.06[b]
Total number of US	0.8 ± 1.2	1.0 ± 1.1	0.39[b]
Number of Radiology Procedures (aspiration/drain placement)	0.7 ± 0.6	0.5 ± 0.9	0.27[b]
Number of PICC lines placed	1.0 ± 0.2	0.1 ± 0.3	**0.0001**[b]
Intervention for IAA[a]			
Antibiotics only	22 (37)	25 (56)	0.08[c]
IR aspiration	10 (16)	5 (12)	0.66[c]
IR drain placement	28 (47)	13 (30)	0.14[c]
Total length of drain (days)	4.2 ± 2.4	4.3 ± 3.4	0.86[b]
Drain removed prior to discharge	25 (89)	12 (92)	0.21[c]
Total days of outpatient antibiotics (IV or po)	12 ± 4.6	13.3 ± 7.4	0.27[b]

[a]*n* (%)

[b]Fisher's Exact test

[c]Chi squared

No single antibiotic regiment has proven to decrease the risk of PIAA in patients with PA [2, 8–13]. The risk of PIAA after PA has remained steady at our institution at 20% [2]. While little progress has been made in decreasing the incidence of PIAA, there is room for improvement in its treatment. It is generally accepted that patients may be treated with oral antibiotics in the setting of appendectomy with perforated appendicitis but their role in the treatment of PIAA is less clear [3, 6, 14, 15]. It has been shown that PIAA can be treated with only IV antibiotics, without the use of a trans-abdominal drain [16]. Up to 20% of these patients with complicated appendicitis may receive a PICC

Table 3 Inpatient Antibiotic Therapy

	IV antibiotics ($n=60$)	Oral antibiotics ($n=43$)	p value
For perforated appendicitis			
Days of IV antibiotics initially	6.7 ± 1.6	6.1 ± 1.9	0.09
Discharged with oral antibiotics after surgery[a]	7 (12%)	1 (2%)	0.17
Number of days of oral antibiotics after surgery	4.9 ± 2.9	3	**0.002**
For IAA while inpatient			
Days of IV antibiotics	3.7 ± 2.2	3.1 ± 2.4	0.19
Total days of IV antibiotics	10.3 ± 2.5	9.2 ± 3.5	0.07

[a]*n* (%)

Table 4 Hospitalizations/medical encounters

	IV antibiotics ($n=60$)	Oral antibiotics ($n=43$)	p value
Total number of hospitalizations	1.4 ± 0.5	1.5 ± 0.7	0.4
Total length of stay for all hospitalizations (days)	10.7 ± 3	9.1 ± 3.7	**0.02**
Total number of medical encounters	4.4 ± 1.0	3.4 ± 1.7	**0.003**

Mean ± standard deviation

Table 5 Complications after IAA

	IV antibiotics ($n=60$)	Oral antibiotics ($n=43$)	p value
Required additional surgery[a]	1 (2%)	1 (2%)	1[b]
Wound infection[a]	2 (3%)	2 (5%)	0.73[b]
C. difficile infection[a]	0	1 (2%)	0.86[b]
MRSA infection[a]	0	0	N/A

[a]*n* (%)

[b]Chi squared

line for treatment of their complicated appendicitis which is associated with many complications, including infectious, thrombotic, and mechanical complications, without proven improvement in patient course [17, 18]. By transitioning away from the treatment of PIAA with IV antibiotics, patients can avoid the morbidity of PICC placement and simplify their post-operative course.

In our study, patients treated with oral antibiotics had shorter length of hospital stay and less medical encounters once discharged. In addition, they had no difference in complications after discharge in comparison with the IV antibiotic treatment group. Decreased length of stay is likely due to the historical comparison with the IV group and patients were more likely to be discharged a little sooner in the more modern cohort. Regardless, the lack of differing outcomes suggests oral antibiotics are an equivalent treatment for PIAA after PA. Since the conclusion of this study, our institution has utilized only oral antibiotics in patients who are discharged with a PIAA after PA plus or minus drainage or aspiration of the abscess itself.

The primary limitation of our study is its retrospective nature and the patients largely represent serial timeframes. While our groups were similar over the 10-year study period, there may be slight differences along this time frame we cannot account for. However, we did not find any statistically significant differences in these two groups at their time of discharge. In addition, our institution utilizes strict discharge criteria for these patients that have remained unchanged. Patients are only discharged home once they are afebrile, tolerating a regular diet, and having bowel function. Another limitation is that we did not examine if patients had generalized peritonitis or other signs of severe appendicitis as part of our data. We did endeavor to only include patients without severe appendicitis, by excluding those with fluid collections or fluid on imaging, but without specifically noting generalized peritonitis it is possible that severity of appendicitis affected our abscess rate. Also, while our groups were similar the oral antibiotics group had a lower temperature and faster start of initial feedings which could suggest that they had a less severe appendicitis.

Conclusion

PIAA treatment after appendectomy for PA can be treated with oral antibiotics with equivalent outcomes as IV antibiotic treatment, but with shorter length of hospitalizations and less medical encounters required.

Author contributions Katrina L. Weaver: concept and design, data collection, data analysis and interpretation, critical revision of article, approval of article. Ashwini Poola: data collection, data analysis and interpretation, critical revision of article, approval of article. Joseph A. Sujka: drafting article, critical revision of article, approval of article. Justin A. Sobrino: drafting article. Katherine W. Gonzalez: data collection, critical revision of article, approval of article. Shawn D. St. Peter:

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Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to disclose.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was waived by our IRB due to the fact that the data collected for this study was retrospective and de-identified.

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