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Feasibility of a Nonoperative Management Strategy for Uncomplicated Acute Appendicitis in Children

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Abstract

Background—Urgent operation has been considered the only appropriate management of acute appendicitis in children for decades. The purpose of this study was to investigate the feasibility of non-operative management of uncomplicated acute appendicitis in children.

Study Design—A prospective non-randomized clinical trial of children with uncomplicated acute appendicitis comparing non-operative management to urgent appendectomy was performed. The primary outcome is the 30-day success rate of non-operative management. Secondary outcomes include comparisons of disability days, missed school days, hospital length of stay (LOS), and measures of quality of life and healthcare satisfaction.

Results—Seventy-seven patients were enrolled during October 2012–October 2013; 30 chose non-operative management and 47 chose surgery. There were no significant differences in demographic or clinical characteristics. The immediate and 30-day success rates of non-operative management were 93% (n=28/30) and 90% (n=27/30). There was no evidence of progression of appendicitis to rupture at the time of surgery in the three patients that failed non-operative management. Compared to the surgery group, the non-operative group had fewer disability days (3 vs. 17 days, p<0.0001), returned to school more quickly (3 vs. 5 days, p=0.008), and exhibited higher quality of life scores in both the child (93 vs. 88, p=0.01) and the parent (96 vs. 90, p=0.03), but incurred a longer LOS (38 vs. 20 hours, p<0.0001).

Conclusions—Non-operative management of uncomplicated acute appendicitis in children is feasible with a high 30-day success rate and short-term benefits including a quicker recovery and

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improved quality of life scores. Additional follow-up will allow for determination of a longer-term success rate, safety, and cost-effectiveness.

Keywords

Appendicitis; children; pediatric; appendectomy; non-operative management

Introduction

Traditionally, children presenting with appendicitis are referred for urgent appendectomy. Recent improvements in both the quality and availability of diagnostic imaging now allow for better pre-operative characterization of appendicitis including the severity of inflammation, size of the appendix, and presence of extra-luminal inflammation, phlegmon, or abscess (1–3). These advances permit pre-operative stratification of appendicitis severity, which can be used to direct care. For example, complicated cases of appendicitis with abscesses are now commonly identified and managed non-operatively with catheter drainage and antibiotics (4–6). These imaging advances, in conjunction with the availability of broad spectrum oral antibiotics, may allow for the identification of a subset of patients with uncomplicated appendicitis that can be successfully treated with antibiotics alone.

Several recent European randomized controlled trials suggest that therapy with antibiotics alone is a safe treatment option for appendicitis (7–11). However, these studies primarily enrolled adults. Data in pediatric appendicitis is promising, but limited to one international retrospective study of only 16 patients, which reported an 81% one-year success rate of non-operative management in children with non-perforated appendicitis (7).

Although appendectomy is curative, it exposes children to the risks of anesthesia and surgery. In addition, it is associated with missed school, activity restriction, and alteration of daily life for the child and family. Given an option to avoid surgery, many families may choose non-operative management. The objective of this study was to determine the feasibility of a non-operative management strategy for uncomplicated acute appendicitis in children.

Methods

Study Design

This is an ongoing prospective non-randomized clinical trial comparing non-operative management to urgent appendectomy in children with acute appendicitis. Patients presenting to our hospital meeting the following criteria were eligible for enrollment: age 7 to 17 years, 48 hours of abdominal pain, white blood cell count < 18,000, radiographic evidence based on final radiologic interpretation of non-ruptured acute appendicitis on either ultrasound (US) or computed tomography (CT) with an appendiceal diameter $\leq$ 1.1 cm without phlegmon, abscess, or fecalith, and evaluation by a surgeon confirming clinical suspicion of acute appendicitis. Exclusion criteria include a positive pregnancy test, diffuse peritonitis on clinical exam, or a history of chronic intermittent abdominal pain. Families of eligible patients are counseled on each treatment option and then allowed to choose either non-

operative management (non-operative group) or routine surgical management (surgery group). In order to minimize selection bias, all children meeting the inclusion criteria were evaluated by one of three trained physicians to establish eligibility and perform trial enrollment. This report presents our planned 30-day analysis to assess the feasibility of a non-operative management strategy for uncomplicated appendicitis in children. A subsequent analysis to evaluate success rate, safety, and cost-effectiveness at 1 year follow-up is planned.

Treatment Arms

Non-operative management consists of hospital admission with a minimum of 24 hours of intravenous antibiotics (piperacillin-tazobactam or ciprofloxacin/metronidazole if penicillin allergic) and observation. Pain medicine is administered as needed. Diet is advanced after a minimum of 12 hours nil per os (NPO) and only when clinical improvement (decreased pain or tenderness) is recognized. Patients are switched to oral antibiotics (amoxicillin-clavulanate or ciprofloxacin/metronidazole if penicillin allergic) when they are tolerating a regular diet. At least one dose of oral medication is administered in the hospital to ensure tolerance. Oral antibiotics are prescribed to complete a total course of 10 days (including the duration of intravenous antibiotics). Evidence of clinical worsening such as increased pain or progressive systemic signs of sepsis, or failure to demonstrate any clinical improvement (decreased tenderness, resolution of fever, decreased pain, or resolution of nausea or emesis) within 24 hours of antibiotics is deemed a failure of non-operative management and prompts conversion to surgical therapy with a laparoscopic appendectomy. Any patient managed non-operatively that returns after discharge with abdominal pain and has a clinical evaluation consistent with appendicitis undergoes urgent laparoscopic appendectomy. Phone or in person follow-up is conducted at 2–5 days, 10–14 days, and 30 days after discharge.

Surgical management consists of hospital admission with initiation of intravenous antibiotics and urgent laparoscopic appendectomy within 12 hours of admission. Postoperatively, antibiotics are discontinued, diet is advanced and patients are usually discharged within 24 hours. Phone or in-person follow-up is conducted at 30 days.

Outcomes

The primary outcome is the success rate of non-operative management, defined as the percent of patients treated non-operatively who do not undergo an appendectomy. Two analyses of this outcome are planned: the first at 30 days to assess feasibility and initial safety and the second at 1 year to determine success rate, safety, and cost-effectiveness. Secondary outcomes include: hospital length of stay, disability days (reported as days to return to normal activity for the child and as days to return to normal schedule for the parent), missed school days, and quality of life measures at 30 days. Days to return to normal activity was defined as the child returning to all of their activities including participation in gym, recess, sports, and other after school activities. Days to return to normal schedule was defined as the parent resuming their normal full schedule at work and/or home. The Quality of Life measure examined in this study was the score on the PedsQL™ survey, developed by Dr. James W. Varni (12–17). The PedsQL™ Quality of Life Inventory: Child and Parent Report questionnaire were given to the subject and parent

at the 30-day follow-up (12–17). In addition, the PedsQL™ Healthcare Satisfaction Generic Module: Parent Report was completed by the parent at 30 days (18).

Statistical Analysis

Sample size was calculated on the success rate of non-operative management at 30 days. Based on an expected success rate of 88% at 30 days, 28 patients treated non-operatively are needed to have a 95% confidence interval with a lower limit of 70%, based on the exact binomial distribution (19,20). This lower limit of 70% was chosen because this was considered a clinically acceptable success rate to offer non-operative management to patients. In order to allow for dropout of a small number of patients, we planned to enroll 30 patients into the non-operative treatment arm. Assuming 40% of eligible patients would choose non-operative management, a total of 75 patients would need to be enrolled to obtain the needed number of patients choosing non-operative management.

Continuous variables were described with means and standard deviations or medians and interquartile ranges (IQR) and compared between treatment groups using t-tests or Mann-Whitney U tests. Categorical variables were described using frequencies and percentages and compared between treatment groups using chi-squared tests or Fisher exact tests. Quality of life and healthcare satisfaction scores in the 30-day period after hospitalization were compared between treatment groups using the Mann-Whitney U test. All tests were 2-sided and $p < 0.05$ was considered statistically significant. SAS version 9.3 (SAS Institute Inc., Cary, NC) was used for all statistical analyses.

This study was approved by our Institutional Review Board and was registered with clinicaltrials.gov. All participants provided written informed consent.

Results

Characteristic of Study Groups

Seventy-seven patients were enrolled with 30 patients choosing non-operative management and 47 choosing surgery (Figure 1). There were no significant differences in demographic characteristics, duration of pain, presenting symptoms, method of diagnosis or white blood cell counts (Table 1). Within the surgery group, pathology demonstrated complicated appendicitis in 13% ($n=6$ with 2 gangrenous and 4 perforated) and no appendicitis in 4% ($n=2$ with 1 normal and 1 with granulomas).

Primary Outcome: 30-day Success Rate of Non-Operative Management

The immediate and 30-day success rates of non-operative management were 93% ($N=28/30$; 95% CI: 78 – 99) and 90% ($N=27/30$; 95% CI: 79 – 100). Of the three failures, two patients underwent laparoscopic appendectomy during the initial admission because of insufficient clinical improvement. Pathology revealed acute appendicitis in one and appendicitis secondary to a carcinoid tumor in the other. The third patient presented with recurrent abdominal pain 1 day after being discharged, had imaging consistent with early appendicitis, and underwent laparoscopic appendectomy; however pathology showed a normal appendix with reactive lymph nodes. No patients who failed non-operative management within 30

days exhibited progression of their appendicitis to rupture or gangrene at the time of appendectomy.

Secondary Outcomes: Comparison of 30 day Outcomes between groups

Table 2 displays 30-day outcome comparisons between the groups. Patients choosing non-operative management had a significantly shorter time to return to normal activities and fewer missed school days. Compared to the surgery group, hospital length of stay was significantly longer in the non-operative group (median (IQR): 38 hours (31–42) vs. 20 (16–34), $p < 0.0001$). Post-operative Emergency Department (ED) visits in the non-operative group were for complaints of abdominal pain; in the surgery group, ED visits were related to wound complications.

Quality of life and healthcare satisfaction scores at 30-day follow-up are shown in Table 3. Compared to patients in the surgery group, quality of life scores of both the child and parent were significantly higher in patients managed non-operatively. Parental satisfaction with care was equally high in both groups at 30-day follow-up.

Discussion

This study is the first prospective trial of a non-operative management strategy for acute appendicitis in the United States and is the first in children internationally. Our results suggest that non-operative management of acute appendicitis in children is feasible with immediate and 30-day success rates of 93% and 90%. Patients managed non-operatively had a more rapid return to normal activities, fewer missed school days, and higher quality of life scores at 30 days post-hospitalization. In addition, in patients who failed non-operative management, either initially or delayed, there was no progression to rupture at the time of appendectomy.

Non-operative management of appendicitis has recently emerged as a viable treatment alternative to surgery and is being increasingly utilized in adults (4,7–11,19,21–30). There have been several randomized controlled studies comparing appendectomy to antibiotics in adult patients with appendicitis (7–11). A meta-analysis of these studies demonstrated that non-operative management had a pooled success rate of 63% at 1 year with significantly lower risks of complications and no difference in the risk of developing complicated appendicitis (30). This meta-analysis concluded that non-operative management of appendicitis is a safe initial treatment. Several hospitals in Europe have adopted it as their initial therapy with appendectomy reserved for medical failure (10). However, these results may not be generalizable to children because these studies did not include children and they had variable inclusion criteria. Many of these studies enrolled all patients with appendicitis regardless of length of symptoms, imaging findings or suspicion of more advanced or complicated disease. Clinical factors associated with a higher likelihood of failure of non-operative management include the presence of a fecalith or fluid collection on imaging and an appendiceal diameter >1.1 cm (4,28). Therefore, to minimize the risk of harm in our study, we excluded patients with these characteristics. Our 30-day success rate of 90% is higher than those reported in most of the adult studies. However, it is similar to the 30-day success rate of 88% reported in the one adult trial that specifically attempted to enroll

patients with uncomplicated appendicitis (19). In addition, our 30-day results are consistent with the initial success rate of 94% reported by Abes et al. in their retrospective study of non-operative management in children with non-perforated appendicitis (7).

Importantly, the recent adult trials of non-operative management of appendicitis did not demonstrate an increased risk of developing perforated appendicitis in patients managed non-operatively (30). Our early results are consistent with the results reported in the adult trials. Within the surgery group in our study, six patients had complicated appendicitis at the time of appendectomy with four having perforated appendicitis. However, no patient who failed non-operative management within 30 days had progression of his/her appendicitis to complicated appendicitis at the time of appendectomy. In addition, in the patient with a carcinoid tumor, symptoms did not improve with antibiotics alone and she underwent appendectomy within 24 hours of admission. This rare case highlights the importance of in-hospital monitoring for clinical improvement as part of a non-operative treatment strategy. During the initial hospitalization, the lack of improvement of this patient's symptoms was promptly recognized and an appendectomy was performed without disease progression.

The effects of medical interventions on patient centered outcomes, such as disability days, quality of life and healthcare satisfaction, are being assessed more frequently in pediatric clinical trials (31–33). Incorporation of these measures as either primary or secondary outcomes contributes to the larger body of knowledge pertaining to the impact of medical interventions on childhood adjustment (34). In our study, patients managed non-operatively had fewer disability days with less missed school days and a more rapid return to normal activities including organized events and sports. In fact, most children managed non-operatively returned to both school and extra-curricular activities within 1 day after hospital discharge. Compared to appendectomy, non-operative management of appendicitis was less disruptive to the lives of the patients and their families. The importance of this quicker resumption of normal activities to the patient and their families was reflected in the higher quality of life scores reported by both the children and parents 30 days after hospitalization. Based on studies of healthy children and children with acute and chronic health conditions, the minimal clinically important differences (MCID) in PedsQL scores are 4.4 on the child report and 4.5 on the parent report (35–37). These MCIDs represent the smallest differences in scores that patients perceive to be beneficial and that would mandate a change in the patient's management (38). In our study, patients who chose non-operative management had higher PedsQL scores that were both statistically and clinically significant.

Several intra-abdominal infections, previously treated with urgent operations, are now successfully managed with initial antibiotic therapy alone. For example, diverticulitis has evolved into a medically managed disease with surgery reserved for cases in which medical therapy fails (39–41). In addition, similar transitions to primarily medical management have occurred with intra-abdominal abscesses from Crohn's disease and acute suppurative salpingitis (42, 43). Over the last 20 years, appendicitis has also evolved to incorporate alternative treatment strategies based on severity of illness. Patients with perforated appendicitis with abscesses are now often managed non-operatively with radiographic guided catheter drainage of intra-abdominal abscesses and prolonged antibiotics (4–6). Investigators are now also reconsidering the need for an interval appendectomy in these

severe cases (21,23,25,44). Our current study attempts to further explore the medical options in the management of appendicitis. Although appendectomy is curative, peri-operative complications occur in 8.7–11.1% of patients and recovery from an uncomplicated appendectomy may require children to miss up to a week of school and their caregiver to potentially miss equal amounts of work (26). A successful non-operative treatment strategy for early appendicitis can markedly decrease the number of appendectomies performed, thereby limiting the number of children and families exposed to the risks and stress associated with surgery.

We chose to perform a non-randomized prospective clinical trial based upon patient choice because we believe that the success of each treatment option partially depends on which outcomes are most important to the patient and their family. For example, although initial non-operative management of early appendicitis may be safe for most patients, appendectomy may be a better treatment option for patients who live in remote areas or for families who are so fearful of a recurrence that they are likely to return to the emergency department every time their child develops abdominal pain. For these patients, the risk of post-operative complications may be perceived as minor compared to the benefit of a curative appendectomy. In contrast, for families who are averse to surgery, initial non-operative therapy may be the least stressful and most appealing choice because it may eliminate the need for an operation and its inherent risks while expediting a quicker return to activities. For these reasons, we opted to allow eligible patients and their families to choose between surgery and non-operative management rather than randomize patients to one of the two treatment groups.

One potential limitation of performing a patient choice trial is the possibility for selection bias. In clinical practice, both the surgeon's opinions and specific patient characteristics may affect which treatments are chosen. These represent two potential sources of bias in a patient choice trial. With surgeon bias, the opinions of the consulting surgeon on each treatment may influence the patient and family to choose a particular treatment option. Although, it is not possible to entirely control for this bias outside of a randomized controlled trial (RCT) design, we attempted to minimize selection bias introduced by the medical team by using a standardized scripted consenting process with only a few trained physicians performing trial enrollment. The second possibility for bias is that a specific patient characteristic (e.g. gender) may affect the treatment choice. To assess for bias based on underlying patient characteristics, we compared the groups for differences in important demographic and clinical variables (Table 1) and did not identify any significant differences. It should also be noted that compared to an RCT, the patient choice trial may allow for enrollment of a more diverse group of "research subjects" who more accurately reflect the overall patient population. One potential reason patients/families refuse to participate in an RCT is because they cannot choose the treatment; by offering choice and not randomizing to a treatment, these families may be more inclined to participate in the study. This potential advantage of the patient choice design is supported by the high percentage of eligible patients that agreed to enroll in our study.

This study of a non-operative management strategy for uncomplicated acute appendicitis demonstrates a high early success rate and improved patient centered outcomes in patients

managed non-operatively. These results support non-operative management of appendicitis as a viable treatment option for children with acute appendicitis. Additional enrollment and follow-up will allow us to determine success rate, safety, and cost-effectiveness at 1 year and throughout childhood.

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References

1. Terasawa T, Blackmore CC, Bent S, Kohlwes RJ. Systematic review: computed tomography and ultrasonography to detect acute appendicitis in adults and adolescents. *Ann Intern Med.* 2004; 141:537–546. [PubMed: 15466771]
2. Kessler N, Cyteval C, Gallix B, et al. Appendicitis: evaluation of sensitivity, specificity, and predictive values of US, Doppler US, and laboratory findings. *Radiology.* 2004; 230:472–478. [PubMed: 14688403]
3. Pinto F, Pinto A, Russo A, et al. Accuracy of ultrasonography in the diagnosis of acute appendicitis in adult patients: review of the literature. *Crit Ultrasound J.* 2013; 5:S2. [PubMed: 23902717]
4. Ein SH, Langer JC, Daneman A. Nonoperative management of pediatric ruptured appendix with inflammatory mass or abscess: presence of an appendicolith predicts recurrent appendicitis. *J Pediatr Surg.* 2005; 40:1612–1615. [PubMed: 16226993]
5. Ein SH, Wales P, Langer JC, Daneman A. Is there a role for routine abdominal imaging in predicting postoperative intraabdominal abscess formation after appendectomy for pediatric ruptured appendix? *Pediatr Surg Int.* 2008; 24:307–309. [PubMed: 18188573]
6. Fraser JD, Aguayo P, Leys CM, et al. A complete course of intravenous antibiotics vs a combination of intravenous and oral antibiotics for perforated appendicitis in children: a prospective, randomized trial. *J Pediatr Surg.* 2010; 45:1198–1202. [PubMed: 20620320]
7. Abes M, Petik B, Kazil S. Nonoperative treatment of acute appendicitis in children. *J Pediatr Surg.* 2007; 42:1439–1442. [PubMed: 17706511]
8. Eriksson S, Granstrom L. Randomized Controlled Trial of Appendectomy Versus Antibiotic-Therapy for Acute Appendicitis. *Brit J Surg.* 1995; 82:166–169. [PubMed: 7749676]
9. Hansson J, Korner U, Khorram-Manesh A, et al. Randomized clinical trial of antibiotic therapy versus appendectomy as primary treatment of acute appendicitis in unselected patients. *Brit J Surg.* 2009; 96:473–481. [PubMed: 19358184]
10. Hansson J, Korner U, Ludwigs K, et al. Antibiotics as First-line Therapy for Acute Appendicitis: Evidence for a Change in Clinical Practice. *World J Surg.* 2012; 36:2028–2036. [PubMed: 22569747]
11. Styrud J, Eriksson S, Nilsson I, et al. Appendectomy versus antibiotic treatment in acute appendicitis. a prospective multicenter randomized controlled trial. *World J Surg.* 2006; 30:1033–1037. [PubMed: 16736333]
12. Varni JW, Seid M, Rode CA. The PedsQL™: Measurement model for the pediatric quality of life inventory. *Med Care.* 1999; 37:126–139. [PubMed: 10024117]
13. Varni JW, Seid M, Kurtin PS. The PedsQL™ 4.0: Reliability and validity of the Pediatric Quality of Life Inventory™ Version 4.0 Generic Core Scales in healthy and patient populations. *Med Care.* 2001; 39:800–812. [PubMed: 11468499]
14. Varni JW, Seid M, Knight TS, et al. The PedsQL™ 4.0 Generic Core Scales: Sensitivity, responsiveness, and impact on clinical decision-making. *J Behav Med.* 2002; 25:175–193. [PubMed: 11977437]
15. Varni JW, Burwinkle TM, Seid M, Skarr DI. The PedsQL™ 4.0 as a pediatric population health measure: Feasibility, reliability, and validity. *Ambul Pediatr.* 2003; 3:329–341. [PubMed: 14616041]

16. Chan KS, Mangione-Smith R, Burwinkle TM, et al. The PedsQL™: Reliability and validity of the Short-Form Generic Core Scales and Asthma Module. *Med Care*. 2005; 43:256–265. [PubMed: 15725982]
17. Varni JW, Limbers CA. The PedsQL™ 4.0 Generic Core Scales Young Adult Version: Feasibility, reliability and validity in a university student population. *J Health Psychol*. 2009; 14:611–622. [PubMed: 19383661]
18. Varni JW, Burwinkle TM, Dickinson P, et al. Evaluation of the built environment at a Children's Convalescent Hospital: Development of the Pediatric Quality of Life Inventory™ Parent and Staff Satisfaction Measures for pediatric health care facilities. *J Dev Behav Pediatr*. 2004; 25:10–20. [PubMed: 14767351]
19. Vons C, Barry C, Maitre S, et al. Amoxicillin plus clavulanic acid versus appendicectomy for treatment of acute uncomplicated appendicitis: an open-label, non-inferiority, randomised controlled trial. *Lancet*. 2011; 377:1573–1579. [PubMed: 21550483]
20. Newcombe RG. Two-sided confidence intervals for the single proportion: comparison of seven methods. *Stat Med*. 1998; 17:857–872. [PubMed: 9595616]
21. Ein SH, Shandling B. Is interval appendectomy necessary after rupture of an appendiceal mass? *J Pediatr Surg*. 1996; 31:849–850. [PubMed: 8783121]
22. Harrison PW. Appendicitis and the antibiotics. *Am J Surg*. 1953; 85:160–163. [PubMed: 13016882]
23. Hoffmann J, Lindhard A, Jensen HE. Appendix mass: conservative management without interval appendectomy. *Am J Surg*. 1984; 148:379–382. [PubMed: 6476230]
24. Mason RJ. Surgery for appendicitis: is it necessary? *Surg Infect (Larchmt)*. 2008; 9:481–488. [PubMed: 18687030]
25. Puapong D, Lee SL, Haigh PI, et al. Routine interval appendectomy in children is not indicated. *J Pediatr Surg*. 2007; 42:1500–1503. [PubMed: 17848238]
26. Wilms IM, de Hoog DE, de Visser DC, Janzing HM. Appendectomy versus antibiotic treatment for acute appendicitis. *Cochrane Database Syst Rev*. 2011 CD008359.
27. Malik AA, Bari SU. Conservative management of acute appendicitis. *J Gastrointest Surg*. 2009; 13:966–970. [PubMed: 19277796]
28. Shindoh J, Niwa H, Kawai K, et al. Predictive factors for negative outcomes in initial non-operative management of suspected appendicitis. *J Gastrointest Surg*. 2010; 14:309–314. [PubMed: 19936849]
29. Turhan AN, Kapan S, Kutukcu E, et al. Comparison of operative and non operative management of acute appendicitis. *Ulus Travma Acil Cerrahi Derg*. 2009; 15:459–462. [PubMed: 19779986]
30. Varadhan KK, Neal KR, Lobo DN. Safety and efficacy of antibiotics compared with appendicectomy for treatment of uncomplicated acute appendicitis: meta-analysis of randomised controlled trials. *BMJ*. 2012; 344:e2156. [PubMed: 22491789]
31. Eiser C, Morse R. A review of measures of quality of life for children with chronic illness. *Arch Dis Child*. 2001; 84:205–211. [PubMed: 11207164]
32. Trama A, Dieci M. Quality of life in clinical trials for children. *Eur J Clin Pharmacol*. 2011 May; 67(Suppl 1):41–47. [PubMed: 21104074]
33. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Med Care*. 2001 Aug; 39(8):800–812. [PubMed: 11468499]
34. Spieth LE, Harris CV. Assessment of health-related quality of life in children and adolescents: an integrative review. *J Pediatr Psychol*. 1996; 21(2):175–193. [PubMed: 8920152]
35. Varni JW, Burwinkle TM, Seid M. The PedsQL as a pediatric patient-reported outcome: reliability and validity of the PedsQL Measurement Model in 25,000 children. *Expert Rev Pharmacoeconomics Outcomes Res*. 2005; 5(6):705–719.
36. Varni JW, Burwinkle TM, Seid M, Skarr D. The PedsQL 4.0 as a pediatric population health measure: Feasibility, reliability, and validity. *Ambul. Pediatr*. 2003; 3:329–341. [PubMed: 14616041]

37. Wyrwich, Tierney W, wolinsky F. Using standard error of measurement to identify important changes on the Asthma Quality of Life Questionnaire. *Qual Life res.* 2002; 11:1–7. [PubMed: 12003051]
38. Jaeschke R, Singer J, Guyatt GH. Measurement of health status: Ascertaining the minimally clinically important difference. *Control Clin Trials.* 1989; 10:407–415. [PubMed: 2691207]
39. Salem L, Anaya DA, Flum DR. Temporal changes in the management of diverticulitis. *J Surg Res.* 2005; 124(2):318–323. [PubMed: 15820264]
40. Chapman J, Davies M, Wolff B, et al. Complicated diverticulitis: is it time to rethink the rules? *Ann Surg.* 2005; 242:576–581. [PubMed: 16192818]
41. McCafferty MH, Roth L, Jorden J. Current management of diverticulitis. *Am Surg.* 2008; 74:1041–1049. [PubMed: 19062658]
42. Rypens F, Dubois J, Garel L. The place of interventional radiology in Crohn disease in children. *Pediatr Radiol.* 2007; 37:1093–1095. [PubMed: 17899061]
43. Krivak TC, Cooksey C, Propst AM. Tubo-ovarian abscess: diagnosis, medical and surgical management. *Compr Ther.* 2004; 30:93–100. [PubMed: 15566104]
44. Gillick J, Mohanan N, Das L, Puri P. Laparoscopic appendectomy after conservative management of appendix mass. *Pediatr Surg Int.* 2008; 24:299–301. [PubMed: 18197408]

Figure 1.
Study Flow Diagram.

Table 1

Demographic and Clinical Characteristics

	Nonoperative management (n=30)	Surgery (n=47)	p Value
Age, y, median (interquartile range)	10 (9, 15)	12 (10, 14)	0.46
Male, n (%)	18 (60.0)	35 (74.5)	0.18
Race, n (%)			
White	22 (73.3)	39 (83.0)	0.13
Black	3 (10.0)	7 (14.9)	
Hispanic	3 (10.0)	1 (2.1)	
Other	2 (6.7)	0 (0.0)	
Insurance status, n (%)			
Private	22 (73.3)	33 (70.2)	1.00
Medicaid	8 (26.7)	13 (27.7)	
No Insurance	0 (0.0)	1 (2.1)	
Duration of abdominal pain, h., median (interquartile range)	13 (8, 24)	14 (9, 24)	0.52
Fever, median (interquartile range)	8 (26.7)	8 (17.0)	0.31
Vomiting, median (interquartile range)	16 (53.3)	19 (40.4)	0.27
Diarrhea, median (interquartile range)	4 (13.3)	2 (4.3)	0.20
Ultrasound, median (interquartile range)	28 (93.3)	37 (78.7)	0.11
CT scan, median (interquartile range)	9 (30.0)	12 (25.5)	0.67
White blood cell count, 1000 cells/mcL, median (interquartile range)	12.6 (8.5, 14.3)	13.1 (10.2, 14.6)	0.33

Table 2

Comparison of Outcomes at 30-day Follow-Up

	Nonoperative management (n=28)	Surgery (n=38)	p Value
Length of stay, h	38.0 (31.0, 42.0)	20.0 (16.0, 34.0)	<0.0001
Days to return to normal activities	3.0 (2.5, 6.5)	16.5 (9.0, 21.0)	<0.0001
Days of school missed	3.0 (2.0, 5.0)	5.0 (3.0, 6.0)	0.008
Days for guardian to return to normal schedule	2.0 (1.0, 3.0)	3.0 (1.0, 5.0)	0.12
Fevers	2 (7.1)	4 (10.5)	1.00
Abdominal pain	6 (21.4)	12 (31.6)	0.36
Nausea	1 (3.6)	3 (7.9)	0.63
Vomiting	3 (10.7)	3 (7.9)	0.69
Patients with an ED visit at 30 d	2 (7.14)	4 (10.5)	1.00

Data are presented as medians and interquartile ranges for continuous variables.

Table 3

Quality of Life and Healthcare Satisfaction between Non-Operative and Operative Groups

	30 d after Hospitalization		
	Nonoperative management (n=28)	Surgery (n=38)	p Value
Child QOL questionnaire	93.0 (87.0, 96.7)	87.5 (81.5, 93.5)	0.011
Parent proxy for child QOL questionnaire	95.7 (90.8, 98.9)	89.7 (82.6, 95.7)	0.026
Parent healthcare satisfaction	99.0 (95.8, 100.0)	99.0(95.9, 100.0)	0.721

Data are presented as medians and interquartile ranges.

QOL, quality of life.