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# USG To Decide Non-Operative Management for Appendicitis in Children: A Systematic Review

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**ABSTRACT**

***Learning Objective:*** The purpose of this review is to see which condition of appendicitis in children through ultrasonography that applicable to performing Non-Operative Management. ***Background:*** Appendicitis is a common gastrointestinal disease affecting approximately 1 per 1000 populations each year in the Western world, with the highest incidence between the ages of 10 and 19 years. Appendectomy surgery is the standard treatment for appendicitis patients. However, in recent times many studies have studied the non-surgical management of appendicitis patients. Several studies have even demonstrated the efficacy and safety of non-surgical treatment in appendicitis patients. Therefore, researchers are interested in conducting a review to see what kind of condition of appendicitis in children through ultrasonography can be performed in non-operative management. ***Methods:*** Systematic searches of PUBMED, ScienceDirect, and Cochrane Library from 2018 until 2022 that studied ultrasound or ultrasonography at Non-Operative Management for Appendicitis in Children were conducted according to PRISMA guidelines. ***Imaging Findings:*** Nine articles were selected from two non-randomized clinical trials, two randomized-clinical trials, one prospective cohorts, and four retrospective analyses. The success rate of Non-Operative Management Acute Appendicitis in Children ranged from 70% - 86,6%. Ultrasound findings varied about inflammatory signs even about fecalith and also vary about the diameter of the appendix. The ranged appendix diameter from 4.2 – 11 mm on ultrasound findings. ***Conclusion:*** Ultrasound is an important option to consider in determining the non-surgical management of children appendicitis patients.

***Keywords:*** ultrasound; ultrasonography; appendicitis; non-operative management; children

## INTRODUCTION

Appendicitis is a common gastrointestinal disease affecting approximately 1 per 1000 populations each year in the Western world, with the highest incidence between the ages of 10 and 19 years. In the United States, more than 70,000 children are hospitalized each year for acute appendicitis, about 11.4% of pediatric emergency department admissions. Acute appendicitis is the most common cause of emergency surgery in the pediatric population. Appendicitis is the most common disease process requiring urgent surgery in pediatric patients. It is one of the most common reasons for pediatric hospital admissions, being responsible for 60,000-80,000 admissions annually in the US. It is estimated that the lifetime risk of developing appendicitis is 7% in girls and 9% in boys, with a lifetime risk of appendectomy of 23.1% for women and 12.0% for men [1–6].

Diagnosing appendicitis in children is a challenge for medical personnel. Pediatric patients may present with atypical and nonspecific symptoms and pediatric patients mostly cannot tell their symptoms. With imaging, assessment systems, and a wider range of treatment possibilities, appendicitis contemporary therapy is becoming more sophisticated and precise. Ultrasonography (USG) is reliable in identifying abnormal appendix, especially in thin patients like children. However, it is operator dependent and excludes the more problematic appendicitis. Universal imaging of patients with Computed Tomography (CT), besides being resource-consuming, is not without health risks. It is estimated that the routine use of Computed Tomography (CT) avoids 12 unnecessary appendectomies. Given the concerns regarding ionizing radiation-based imaging in children, the National Cancer Institute and the American Pediatric Surgical Association recommend the use of non-radiation-based imaging such as Ultrasonography (USG) whenever possible. Ultrasound is preferred as the imaging method of the first choice. Ultrasonographic findings correlate well with the pathological classification of appendicitis; The submucosal layer is irregular in phlegmonous appendicitis and is lost in gangrenous appendicitis where blood flow to the inflamed appendix is reduced when gangrene changes occur [7–10].

Appendectomy surgery is the standard treatment for appendicitis patients. Not a few parents of patients are anxious or even refuse when their children have to be operated on.

However, in recent times many studies have studied the non-surgical management of appendicitis patients. Several studies have even demonstrated the efficacy and safety of non-surgical treatment in appendicitis patients. Therefore, researchers are interested to see the condition of pediatric appendicitis that is still possible to do non-operative management through ultrasound from several studies.

**OBJECTIVE**

The purpose of this review is to see the condition of pediatric appendicitis that is still possible to do non-operative management through ultrasound from several studies.

**METHODS**

We took all kinds of studies related to ultrasound and nonoperative management of appendicitis in pediatric patients. This study investigated the ultrasound imaging features and the possibility for nonoperative management of pediatric appendicitis patients. Studies with mixed populations of children and adults were excluded.

We searched PubMed database, ScienceDirect database, and Cochrane database on September 21, 2022. We included studies that were published between 2018 and 2022. Only studies with available full text in English were considered. The MESH terms appendicitis, children, pediatri, ultrasound imaging were used in combination wih AND, OR, and NOT. The investigated outcomes were defined as follows: ultrasound features, non-operative management appendicitis, length of stay at hospital, duration of therapy, recurrence, mortality, treatment cost, and patient/parents satisfaction. We identified 220 studies that were scanned for inclusion and exclusion criteria, the process is shown in figure 1. PRISMA flow chart.

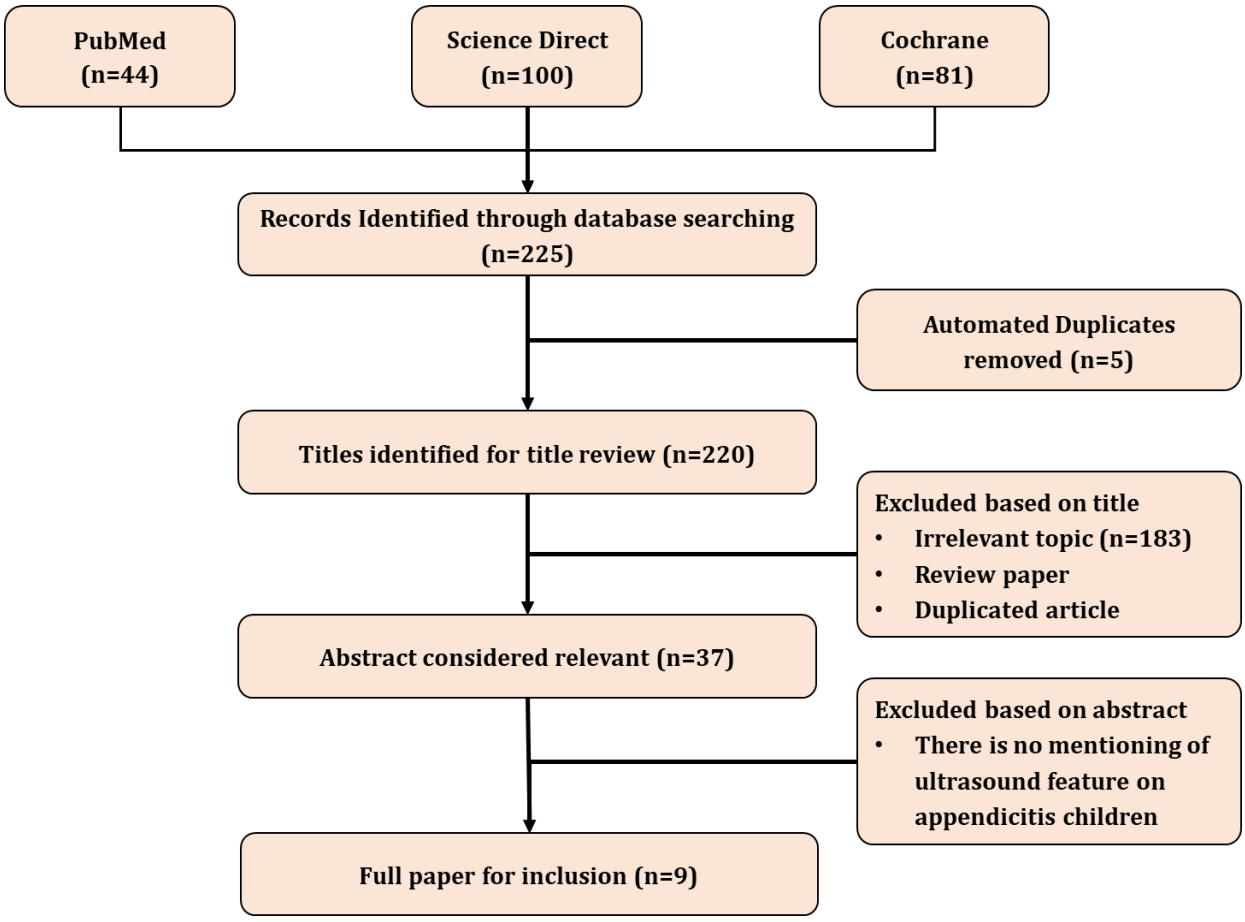


**FIGURE 1:** PRISMA flow chart.

**RESULT**

Nine articles were selected from two non-randomized clinical trials, two randomized-clinical trials, one prospective cohorts, and four retrospective analyses. The studies are summarizing in Table 1.

**TABLE 1:** Study summary: Ultrasound (USG) for determining non-operative management of appendicitis in children.

| Study | Year of Publication | Study Design | Sample (n) | Ultrasound features | Therapy | Outcome |
|---|---|---|---|---|---|---|
| Sajjad et al. [6] | 2021 | RCT | 180 | No abscess formation, complex peri appendiceal fluid, or appendicolith | Intravenous meropenem (10 mg/kg/dose intravenous infusion 8 hourly) and metronidazole (20 mg/kg/day intravenous divided doses 8 hourly) for at least 48 hours. Once the child started tolerating oral intake and clinically improved, the treatment was changed to oral ciprofloxacin (10 mg/kg/dose twice daily) and metronidazole (20 mg/kg/day two divided doses) for another 8 days. | Success rate 84% |
| Perez Otero et al.[11] | 2022 | RCT | 245 | appendix diameter < 11 mm, and radiographic absence of perforation or abscess on ultrasound | Antibiotics-alone (intravenous piperacillin /tazobactam for 24–48 h followed by 10 days of oral ciprofloxacin and metronida- zole). Antibiotics were transitioned from intravenous to oral when the following clinical criteria were met: improvement in symptoms and physical exam findings, afebrile for at least 24 h, and WBC level returned to normal and/or CRP decreased by at least 15%. | 90% adjusted 1-year success rate |
| Minneci et al.[12] | 2019 | NRCT | na | hyperemia, ≤ 1.1 cm in diameter, compressible or non-compressible, no abscess, no fecalith, no phlegmon | Non-operative management consists of hospital admission for observation with a minimum of 24 h of IV antibiotics (piperacillin-tazo-bactam or ciprofloxacin/metronidazole if penicillin allergic). Pain medication are administered as needed. Diet is advanced after a minimum of 12 h 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 tolerate a regular diet. At least one dose of oral antibiotics is administered in the hospital to ensure tolerance. | Success rate 77% |

| Study | Year of Publication | Study Design | Sample (n) | Ultrasound features | Therapy | Outcome |
|---|---|---|---|---|---|---|
| Steiner et al.[13] | 2018 | NRCT | 362 | were short duration of symptoms (< 36 h); Samuel score ≥ 7; US appendicular diameter > 6 mm < 10 mm, or CT visualization of an enlarged appendix measuring ≥ 7 mm in diameter in addition to inflammatory signs including hyperemia in the wall or peri appendiceal fat stranding | Intravenous (IV) ceftriaxone (50 mg/kg/day) and metronidazole (30 mg/kg/day) with continued oral feeding. In the presence of amelioration of clinical signs and symptoms, surgery was delayed and IV antibiotics were administered for 3–4 days. Once asymptomatic (e.g., temperature stabilization < 37.5 °C, without abdominal tenderness), the surgery was canceled and the children were discharged home on oral amoxicillin and clavulanic acid (50 mg/kg/day) for additional 5–7 days. | success rate 85,3% |
| Steiner et al. [14] | 2022 | Cohort | 646 | diameter <7,8 mm | Intravenous (IV) ceftriax- one (50 mg/kg/day) and metronidazole (30 mg/kg/day) with con- tinued oral feeding. In the presence of amelioration of clinical signs and symptoms, surgery was delayed and IV antibiotics were given for 3–4 days. Once asymptomatic (e.g., temperature stabilization < 37.5 °C, without abdominal tenderness), the surgery was can- celed and the children were discharged home on oral amoxicillin and clavulanic acid (50 mg/kg/day) for an additional 5–7 days. | Success rate 79% |
| Wang et al.[8] | 2021 | Retrospective | 182 | diameter 8,4 mm | antibiotic | Success rate 75% |
| Uzunlu and Genisol.[9] | 2022 | Retrospective | 54 | average appendiceal diameter was between 5.6 ± 1.4 and 5.7 ± 1.5mmdepending on the reviewer and 34%–39% of normal appendixes were larger than 6 mm | The IV antibiotic protocol was ampicillin-sulbactam (150 mg/kg/day, divided into four doses), gentamicin (5 mg/kg/day, divided into two doses), and clindamycin (40 mg/kg/day, divided into four doses). All cases were evaluated by a physical examination at 12-hour intervals. For the patients who responded to antibiotic treatment after 24 hours, oral feeding was initiated. IV antibiotic duration was five days in all cases at the hospital, and all patients were discharged from the clinic with an oral antibiotic regimen (amoxicillin/clavulanic acid and metronidazole). Total antibiotic duration (IV and oral) lasted for 10 days. | Initial success rate 100% |

| Study | Year of Publication | Study Design | Sample (n) | Ultrasound features | Therapy | Outcome |
|---|---|---|---|---|---|---|
| Wijayanayaka et al.[7] | 2018 | Retrospective | 327 | 7.76 ± 1.4 (6-11) , The main criterion of non-operative management of acute appendicitis was no signs of fecaliths in the appendix lumen; | antibiotic | 70 % |
| Abbo et al.[16] | 2018 | Retrospective | 166 | 7.85 +- 1.6 mm, with inflamed fat | For 2 days (six doses). Clinical assessment during the 2 days' hospitalization was conducted twice a day. At the end of the intravenous treatment, clinical and biological (leukocyte count and C-reactive protein [CRP]) tests were used to confirm the discharge. Antibiotic treatment was prolonged for 5 days per mouth | success rate 86.6% |

## CONCLUSION

Ten articles were selected from two non-randomized clinical trials, two randomized-clinical trials, two prospective cohorts, and four retrospective analyses. The success rate of Non-Operative Management Acute Appendicitis in Children ranged from 70% - 86,6%. Ultrasound findings varied about inflammatory signs even about fecalith and also vary about the diameter of the appendix. The ranged appendix diameter from 4.2 – 11 mm on ultrasound findings. The results of this study discuss that non-surgical management of pediatric appendicitis patients can be considered in medical practice. Ultrasound is an important option to consider in determining the non-surgical management of children appendicitis patients.

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