APPENDICITIS CLINICAL PATHWAY

EXECUTIVE SUMMARY

Physician Owner(s): Dr. Zebulon Timmons

Primary Objective

Approximately one-third of all appendectomies at Children's Hospital & Medical Center are perforated (NSQIP definition). In 2018, we saw an increase in surgical site infections (SSI), *Streptococcus anginosus*, and readmissions for perforated appendicitis. In 2021-2022, Children's experienced increased variability in use of imaging in children for whom appendicitis was a concern, as well as an increased length of hospital stay.

The purpose of the Appendicitis Pathway is to standardize care and to decrease complications. The current departments that manage care for appendectomy and perforated appendectomy patients: Emergency Department, General Surgery and Operating Room, Inpatient, Outpatient Surgery Clinic, and Radiology. The intention of this pathway is to standardize patient evaluation for perforated appendicitis, expedite appropriate antibiotic treatments, reduce SSI rates, reduce return visits, and reduce return to the OR.

Emergency Department Recommendations

Inclusion Criteria

- Children 4 to 21 with clinical suspicion of appendicitis

Exclusion Criteria

*Acute appendicitis can occur in **any** of the following excluded populations, but likely require different considerations in evaluation.*

- Children <4 years
- Toxic appearance
- Hemodynamic instability
- Previous appendectomy
- Pregnancy
- History of IBD
- Trauma patients
- CT done at outside hospital
- Ongoing treatment for malignancy
- History of organ transplant
- Severe developmental delay

SCORING TOOLS

- Only 50-70% of patients with appendicitis are correctly diagnosed at initial assessment because there is no definitive sign, symptom, or laboratory value. The implementation and evolution of scoring systems have increased diagnostic accuracy from 58% to 71%.[31]
- The Pediatric Appendicitis Score (PAS) is a scoring system for children 3 years to 18 years and generates a risk score based on eight statistically significant variables. Variables include findings from the patient's history, physical, and laboratory results.[31]

- PAS serves as a clinical decision support tool to guide a clinician in determining whether to observe or operate.[31]
- PAS has been validated in multicenter studies; one study showed a sensitivity of 1, specificity of 0.92, positive predictive value of 0.96, and negative predictive value of 0.99.[31]

LABORATORY EVALUATION

- WBC <11,000 unlikely to be appendicitis in non- visualized and non-diagnostic ultrasounds with NPV 95% and 96% respectively. [10]
- A left shift with normal WBC is seen in early appendicitis.[39]

DIAGNOSTIC IMAGING

- Ultrasound (US) has emerged as the preferential first-line modality for imaging in suspected appendicitis.[12]
- Despite its advantages,[12] US by itself has limitations in diagnosing appendicitis[28], with the rate of equivocal examinations in some studies approaching 50%. [29, 30, 34, 36]

  Category 0-4 definitions for ultrasound reads to guide diagnosis and initiation of antibiotic therapy:

  Category 0: Examination nondiagnostic/poor visualization due to habitus. Further imaging is to be based on full clinical evaluation.
  Category 1: Appendix seen and normal.
  Category 2: Appendix not seen or not fully seen, but no specific secondary signs of appendicitis.
  Category 3: Appendix not seen or not fully seen but concerning RLQ findings/inflammation. Additional imaging may be beneficial.
  Category 4: Positive exam for appendicitis.

- Several scoring systems, including the pediatric appendicitis score (PAS),[31] can help the clinician with diagnosis, but also do not perform well in isolation at diagnosing appendicitis. [4-5, 11, 14-15, 23-24, 32]
- An intravenous contrast-enhanced computed tomography (CT) scan has historically been utilized in children with equivocal screening US results.[18]
- Due to rising awareness of a potential CT-related risk of radiation-induced malignancies in children, [7, 27, 38] there has been a decrease in the CT rate over the past decade.[3]
- Magnetic Resonance Imaging (MRI) has emerged as an accurate second-line modality to US with good diagnostic accuracy and quick protocols that do not require sedation.[13]
- Children's will trial utilizing the same scoring system for MRI Appendicitis exams as it currently uses for US studies (see above) to help guide decision-making.
- There has also been evidence that serial exams and repeat US can help avoid many CT scans and their associated radiation.[33]
- **In summary, when appendicitis is suspected an US should be obtained and when equivocal an MRI and/or serial exam should be employed to avoid CT whenever**

possible.

ANTIMICROBIAL THERAPY

- Otherwise, healthy children without cephalosporin allergy AND without suspicion for perforation, abscess or phlegmon should be started on cefoxitin. Cefoxitin covers MSSA, *Streptococcus anginosus*, enteric gram negatives and some anaerobic bacteria. It does not cover *Pseudomonas aeruginosa*; however, regimens without pseudomonal coverage have been shown equally efficacious in pediatric appendicitis as regimens with anti-pseudomonal drugs[8,19, 26] including patients with complicated appendicitis.[17, 21-22]
- Otherwise, healthy children without suspicion of perforation, abscess or phlegmon but who have cephalosporin allergies should be started on levofloxacin plus metronidazole.[35]
- In patients with suspicion for or confirmation of perforation, abscess or phlegmon, therapy should be initiated with piperacillin/tazobactam. In recent years, perforated appendicitis has been increasingly complicated by late abscesses due to *Streptococcus anginosus*, which piperacillin/tazobactam covers. For patients with penicillin allergy, consider levofloxacin plus metronidazole or ceftriaxone plus metronidazole.
- Immunocompromised patients or patients with concern for sepsis or severe disease should be started on piperacillin/tazobactam unless CNS disease cannot be excluded, in which case they should be started on cefepime + metronidazole. Infectious Disease consultation is recommended.
- The optimal time for administration of preoperative doses is within 60 minutes before surgical incision to reduce the rate of surgical site infection (SSIs) based on the Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery.[6]
- Surgical Site infections were significant lower when preoperative antibiotics were given between 16-60 minutes before incision compared to 0-15 minutes and 121-180 minutes prior to incision. SSI risk was higher for patients receiving infusions 61-120 minutes before incision (confidence interval 0.98-5.61).[6]
- Ideally, an antimicrobial agent for surgical prophylaxis should (1) prevent SSI, (2) prevent SSI-related morbidity and mortality, (3) reduce the duration and cost of health care (when the costs associated with the management of SSI are considered, the cost-effectiveness of prophylaxis becomes evident)[1,2], (4) produce no adverse effects, and (5) have no adverse consequences for the microbial flora of the patient or the hospital.[37] To achieve these goals, an antimicrobial agent should be (1) active against the pathogens most likely to contaminate the surgical site, (2) given in an appropriate dosage and at a time that ensures adequate serum and tissue concentrations during the period of potential contamination, (3) safe, and (4) administered for the shortest effective period to minimize adverse effects, the development of resistance, and costs.[16, 20, 25]

Metrics

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1. Increase proportion of patients who receive IV Antibiotics prior to Pre-op dose (antibiotics given 0-60mins prior to incision count as bundle dose; doses received 60+ mins prior to incision count as prior to Pre-op dose) by 10% from baseline by September 2023. – Outcome Metric
    a. Denominator = all appendicitis patients with appendectomy procedure listed on OR schedule
2. Decrease proportion of total appendicitis patients who undergo an Abdominal CT during evaluation in the CHMC ED by 10% from baseline by September 2023. – Outcome Metric
    a. Denominator = any patient with RLQ US or MR appendicitis WO contrast ordered in CHMC ED
3. Increase utilization of ED Appendicitis order set for evaluation of patients diagnosed with appendicitis to 50% by September 2023. – Process Metric
    a. Denominator = any patient with RLQ US or MR appendicitis WO contrast ordered in CHMC ED
4. Monitor ED LOS (minutes) from triage to disposition. – Balancing Metric
    a. Denominator = any patient with RLQ US or MR appendicitis WO contrast ordered in CHMC ED

Rationale

Appendicitis is the most common surgical emergency in pediatrics. Despite the frequency with which it is seen, appendicitis can still be elusive, as it presents in a myriad of different ways. The diagnostic uncertainty which comes with appendicitis has led to variability in care across different institutions and often between providers at a single site.

The purpose of a clinical pathway for appendicitis is to reduce these inconsistent approaches. It will allow for focused care based on the extensive available evidence on how to appropriately diagnose and manage this condition. Following the best available evidence will lead to:

1. A reduction in unnecessary imaging, especially modalities that expose patients to ionizing radiation.
2. Better timing of antibiotic administration as well as more focused antibiotic coverage with a focus on stewardship.
3. Reduced confusion for families, staff, and providers as we are all involved are following the same plan.

A clinical pathway like this is often borne out of compromise, so some who have practiced differently in the past may be guided towards different practices that will require education and monitoring for compliance. We will also have to monitor patient outcomes to remain confident that these interventions continue to be the best choice for our specific patient population.

Team Members

Champion: Zebulon Timmons, M.D. (Emergency Department Division Chief)

Members:

- Jennifer Wang, D.O. (Emergency Department Medical Director)
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- Abby Vipond, MSN, APRN, FNP-C, (Clinical Effectiveness)
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Evidence

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