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Improving imaging strategies in pediatric appendicitis: a quality improvement initiative improving imaging for diagnosing appendicitis



Leah Schoel, BS, Ilan I. Maizlin, MD, MSPH, Tal Koppelman, MD, Chinwendu Onwubiko, MD, PhD, Michelle Shroyer, MPH, Ann Douglas, RN, MSN, and Robert T. Russell, MD, MPH*

Division of Pediatric Surgery, Department of Surgery, University of Alabama at Birmingham, Children's of Alabama, Birmingham, Alabama

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ABSTRACT

Background: Data from the American College of Surgeons National Surgical Quality Improvement Program identified our hospital as an outlier for preoperative computed tomography (CT) use in the diagnosis of acute appendicitis in children. We performed a quality improvement project to reduce this utilization in favor of ultrasound-based diagnoses (ultrasonography [US]) through creation and implementation of an evidence-based appendicitis algorithm.

Methods: Over a 2-y period (1 y preceding and 1 y following institution of the algorithm), the clinical information of all pediatric patients operated on for suspicion of acute appendicitis following imaging studies in our institution was collated. Basic characteristics were compared before and after protocol implementation using the chi-square test for categorical variables and the nonparametric, independent sample test of medians for numerical variables. Imaging modalities used and clinical outcomes were compared using chi-square analysis.

Results: A total of 227 patients (117 preprotocol and 110 postprotocol implementation) were evaluated in our emergency department and operated on for suspicion of acute appendicitis. There were no differences in age, sex, race, or body mass index between the two periods. There were also no differences in length of stay ($P = 0.27$), acute and perforated appendicitis rates ($P = 0.59$), negative appendectomy rates ($P = 0.40$), or postoperative complications ($P = 0.19$). There was a significant reduction in the utilization of CT, from 65.8% to 22.0%, with a concurrent increase in the utilization of US ($P < 0.001$).

Conclusions: With the implementation of a standardized, multidisciplinary algorithm, CT utilization was decreased and concurrently US utilization was increased without sacrificing diagnostic accuracy or patient outcomes.

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* Corresponding author. Division of Pediatric Surgery, Department of Surgery, University of Alabama at Birmingham, Children's of Alabama, 1600 7th Avenue South, Lowder Building, Suite 300, Birmingham, AL 35233. Tel.: +1 205 638 9688; fax: +1 205 975 4972.

E-mail address: Robert.russell@childrensal.org (R.T. Russell).

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Introduction

Appendicitis is the most common surgical abdominal emergency in children; however, accurate and timely diagnosis remains challenging. Although acute abdominal pain is the most common presenting complaint in United States emergency departments,¹ appendicitis is often difficult to differentiate from other possible etiologies. The current standard for diagnosing appendicitis incorporates history and physical exam findings with laboratory data. Although the disease runs a predictable course, initial patient presentation may vary from vague nausea and abdominal pain to classic McBurney's point tenderness. Misdiagnosis of appendicitis carries the potential for significant consequences, including longer lengths of stay (LOSs), higher rates of perforation, and/or increased cost and morbidity following an unnecessary operation.^{2,3} Therefore, radiological studies are a crucial adjunct to improve diagnostic accuracy, reduce misdiagnosis rates, and avoid costly delays in treatment.

The most common imaging modalities used to diagnose appendicitis are computed tomography (CT) and ultrasonography (US). The American College of Radiology recommends US as the first-line imaging study for children with suspected appendicitis.⁴ Despite this recommendation, debate remains regarding the comparative safety, efficacy, ease of use, and cost-effectiveness of the two imaging modalities.^{5–12}

Data from a comparative analysis of 29 children's hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP)–Pediatric Appendectomy study found a large degree of variability among US and CT use and negative appendectomy rates.¹³ The data identified our institution, Children's of Alabama, Birmingham, as an outlier for preoperative CT scan utilization for suspected appendicitis and a low outlier for compliance with the American College of Radiology guidelines. The rate of preoperative CT scan use at Children's of Alabama was 70% of all appendicitis admissions, which is well above the aggregate cohort rate of approximately 25%. Similarly, only 30% of appendicitis admissions at Children's of Alabama had preoperative US in contrast to an aggregate cohort rate of approximately 85%.

Owing to concerns regarding the overuse of CT scans at our institution, we sought to improve imaging strategies at our institution without sacrificing diagnostic accuracy or patient care. We hypothesized that we could reduce CT utilization in favor of US-based diagnoses through application of an evidence-based diagnostic appendicitis algorithm.

Methods

This study is a quality improvement project to decrease the utilization of CT in diagnosing appendicitis at our hospital. This is a tertiary care, freestanding 380-bed children's hospital affiliated with University of Alabama at Birmingham Health Systems that provides services to all pediatric patients in the state of Alabama. Annual overall admissions approximate 15,000 with approximately 6200 annual surgical admissions. Of the surgical admissions, approximately 75% present directly to the children's hospital, whereas 25% are transferred from other facilities in the state.

An evidence-based algorithm was created by a multidisciplinary team, including representatives from pediatric surgery, pediatric radiology, and pediatric emergency medicine. This algorithm incorporates the Pediatric Appendicitis Score (PAS) to direct surgical consultation and imaging recommendations for all patients presenting directly to our facility¹⁴ (Fig. 1). The PAS, which was not currently in use in our emergency department on a routine basis, allowed for initial patient risk stratification into low, moderate, or high risk for appendicitis. Based on the initial classification, imaging modalities and other diagnostic interventions were used as indicated by the algorithm. To maintain standardization of US reporting and to assist surgical decision-making, we implemented an US template based on that of Nordin et al.¹⁵ that incorporates secondary signs of appendicitis for all US imaging.

We evaluated data from a 2-y period, including 1 y preceding institution of the protocol (pre-algorithm: February 2015–February 2016) and 1 y following institution of the protocol (post-algorithm: April 2016–April 2017), to assess changes in imaging strategies for pediatric appendicitis. We incorporated a 1-mo break between the two periods to allow for adequate education of providers and implementation of the protocol. During this 1-mo period, we held educational lectures with the emergency medicine residents and surgical house staff, and we maintained communication with involved staff during the study to monitor implementation and continue education regarding the protocol. All data were evaluated on a quarterly basis to follow trends in use of CT and US, thus monitoring both the implementation and success of the program.

The study population included all patients under the age of 18 y presenting to our institution's emergency department who received diagnostic imaging (either US or CT) and subsequent operation for suspicion of acute appendicitis. Patients were excluded if (1) they transferred from referring facilities with prior imaging, (2) they received either imaging study with concern for another diagnosis, (3) they underwent interval appendectomy, or (4) they had a previous appendectomy. In total, we excluded 170 patients for the aforementioned criteria. Charts were reviewed for the type of imaging performed, imaging findings, and final diagnosis. We documented intraoperative findings, final pathology results, and surgical outcomes, including LOS and postoperative complications.

For all imaged patients with suspected appendicitis, basic characteristics were compared before and after protocol implementation using the chi-square test of independence for categorical variables and the nonparametric, independent sample test of medians for numerical variables. The usage of CT and US was then compared before and after protocol implementation using the chi-square test of independence. Data were found to be statistically significant if $P < 0.05$. All analysis was done using IBM SPSS (version 25.0; IBM Corp, Armonk, NY). This study was approved by the University of Alabama, at Birmingham, Institutional Review Board (Protocol #131023003).

Results

A total of 227 patients (117 preprotocol and 110 postprotocol implementation) were evaluated in our emergency department

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