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Quality Assurance and Performance Improvement Project for Suspected Appendicitis

Yasser AlFraih, MD†‡; Tessa Robinson, MSc*§; Nina Stein, MD†¶; April Kam, MD, MScPH†‖; Helene Flageole, MD, MSc*†§*

Abstract

Introduction: Considerable variability exists in the diagnosis and management of acute appendicitis, affecting both quality and costs of care. This prospective cohort study aimed to decrease unnecessary radiological investigations, standardize radiological imaging, avoid unnecessary hospital admissions, and decrease our institution rate of negative appendectomy. **Methods:** A multidisciplinary appendicitis care pathway was implemented. This pathway involved the use of the Pediatric Appendicitis Score, standardization of ultrasound reporting, and risk stratification to determine patient disposition. Patients were prospectively enrolled in the pathway and compared a preimplementation retrospective cohort. **Results:** We included 235 patients in this study that took place between February 2017 and January 2018. An 88.5% pathway adherence rate for appropriate referral for ultrasounds, an 84% compliance rate for correct risk stratification, and the need for a surgical consult were achieved. After implementation, standardization of ultrasound (U/S) reporting increased from 0% to 78%. The rate of computed tomography utilization decreased from 7.3% to 4.7%. An appendectomy was completed in 68 (29%) of patients. There was only 1 (1.5%) negative appendectomy, compared to the prepathway institutional negative appendectomy rate of 4%. **Conclusion:** The implementation of a standardized, evidence-based, appendicitis care pathway has the potential to improve quality of care by reducing negative appendectomies, unnecessary computed tomography scans, and unnecessary hospital admissions. The participation of the emergency and diagnostic imaging departments is critical to the successful implementation of this quality improvement measure. This simple, effective model can be easily implemented at other centers to improve the care of children. *(Pediatr Qual Saf 2020;3:e290; doi: 10.1097/pq9.0000000000000290; Published online 13 May, 2020.)*

INTRODUCTION

Appendicitis is the most common surgical condition among children with abdominal pain presenting to emergency departments (EDs) and outpatient clinics.[1] In the United States, roughly 77,000 pediatric hospital admissions each year are for appendicitis and other appendiceal conditions. The costs associated with treating appendicitis are estimated to be $680 million annually in the United States alone.[2] Distinguishing appendicitis from other abdominal disorders can be difficult, especially in young preverbal children. Because appendicitis has a variable presentation depending on the age of the child, the duration of symptoms, and the exact position of the appendix in the abdomen, accurate diagnosis remains problematic. Clinicians aim to avoid a negative appendectomy as well as a delay in treatment, but these difficulties likely contribute to the high rates of initially misdiagnosed appendicitis in children younger than 12 years.[3–5] Another concern is the considerable variability that exists in the diagnostic approach to acute appendicitis in children, affecting both quality and costs of care.[6] Diagnostic evaluation options range from a simple clinical evaluation to advanced radiological imaging.

Additionally, in one-third of children with appendicitis, the appendix perforates before operative treatment.[7] Evaluation of abdominal pain in children should, therefore, aim to more accurately identify which children with abdominal pain, and likely appendicitis, should undergo immediate surgical evaluation for potential appendectomy, and

*From the *Division of Pediatric General Surgery, Department of Surgery, McMaster University, Hamilton, Ontario, Canada; †McMaster Children's Hospital, Hamilton, Ontario, Canada; ‡Department of Surgery, King Saud University, Riyadh, Saudi Arabia; §McMaster Pediatric Surgery Research Collaborative, McMaster University, Hamilton, Ontario, Canada; ¶Department of Radiology, McMaster University, Hamilton, Ontario, Canada; ‖Division of Pediatric Emergency Medicine, Department of Pediatrics, McMaster University, Hamilton, Ontario, Canada and Department of Surgery, King Saud University, Riyadh, Saudi Arabia.*

**Corresponding author. Address: Helene Flageole, MD, MSc, McMaster Children's Hospital, Suite 4E8, 1200 Main Street West, Hamilton, ON L8N 3Z5, Canada*
PH: (905) 521-2100 x75244; Fax (905) 521-9992.
Email: flageol@mcmaster.ca

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which children with equivocal presentations may benefit from further investigation. To address this variability in the diagnostic approach, we implemented a multidisciplinary appendicitis care pathway to standardize the initial assessment, imaging modality and reporting, and definitive management of patients presenting with suspected appendicitis. With this pathway, we aimed to decrease the rate of negative appendectomies, decrease the rate of unnecessary computed tomography (CT) scans, and decrease the number of unnecessary hospital admissions. We also aimed to act as a guide for other centers in resource allocation and referral patterns.

METHODS

This prospective cohort study of children evaluated for suspected appendicitis occurred at McMaster Children's Hospital, which has an annual census of 50,000 emergency room visits. Patients were prospectively enrolled in the pathway and compared to a preimplementation retrospective cohort of 234 patients that presented to the ED at McMaster Children's Hospital with suspected appendicitis between January 1, 2016, and December 31, 2016. A multidisciplinary team comprised pediatric surgeons, pediatric radiologists, and pediatric emergency medicine physicians met to review and adopt the appendicitis care pathway set forth by Boston Children's Hospital (Fig. 1).[8] Patients between the ages of 0 and 18 years presenting to the ED with abdominal pain suspicious for appendicitis, based on the initial evaluation by the ED physician, were enrolled in the pathway. We excluded patients if they were transferred to the study center and underwent initial assessment and ultrasound (U/S) at an outside institution. The implemented pathway consisted of 3 distinct steps: (1) implementation of the Pediatric Appendicitis Score (PAS); (2) standardization of ultrasound reporting; and (3) risk stratification. Each of these steps is described in further detail below. We obtained ethics approval from the Hamilton Integrated Research Ethics Board before study initiation (REB#2724). The ethics board granted a waiver of consent for prospective patients enrolled in this study as well as those included in the retrospective cohort. Approval was also obtained from the Pediatric Emergency Medicine Research Oversight Committee at McMaster Children's Hospital.

Implementation of the PAS Score in the ED

An ED physician evaluated patients presenting with abdominal pain, and if appendicitis was suspected, the patients were enrolled in the pathway. First, providers ordered laboratory tests and calculated the PAS to determine the need for an abdominal ultrasound. Patients with a PAS of 4 or more received an abdominal ultrasound, while those with a PAS of 3 or less did not. Disposition of the patients with a PAS of 3 or less was at the discretion of the ED physician (Fig. 1).

Standardization of Ultrasound Reporting

Patients who had a PAS of 4 or more were to undergo a whole abdominal and pelvic U/S. When assessing the appendix, the ultrasound technologists noted specific primary and secondary signs of acute appendicitis. This information was incorporated into the ultrasound technologist observation form for findings to be recorded in a uniform and standardized fashion and saved with the ultrasound images (Fig. 2). Before implementation, we conducted an educational session for ultrasound technologists at the hospital to review the new standardization protocol. We included preliminary reports made by radiology residents and not the final report made by the radiologist staff into this study database to reflect the information available at the time of clinical decision making. The use of CT scans to assist in the diagnosis of appendicitis was not a component of this clinical pathway. Therefore, CT scans were only obtained if requested by the consulting pediatric surgeon.

Risk Stratification

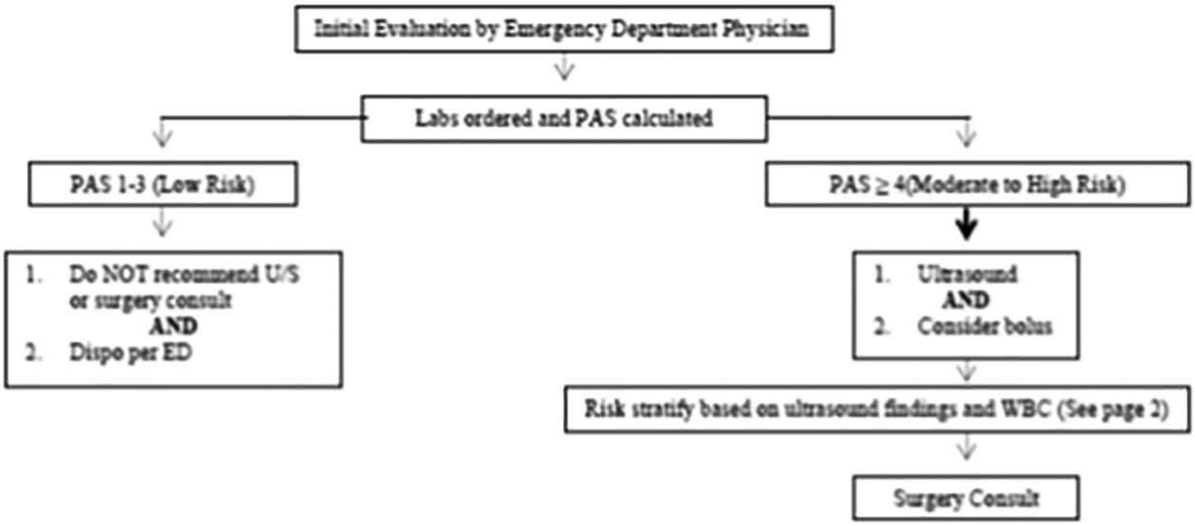
Based on the U/S findings and the white blood cell count, patients were stratified according to the probability of having appendicitis into low-, moderate-, or high-risk groups. Patient management and disposition were determined according to the risk group (Fig. 3). Low-risk patients had a very low likelihood of having appendicitis (3.3%), and surgical consultation was therefore not recommended. The ED physician determined the disposition of these patients. Moderate-risk patients were managed at the discretion of the ED physician with the option of observation in the ED or a surgical consultation. High-risk patients required a surgical consultation for a possible appendectomy.

Pathway Implementation

Before implementation, the clinical pathway was presented at an ED staff meeting, a Pediatric General Surgery Division meeting, and to the Department of Radiology's departmental educational session. Copies of the algorithm, as well as the pathway forms, were posted in the ED. Email reminders were sent to notify the pediatric ED physicians and ultrasound technologists to utilize the pathway. Enrollment occurred 24 hours a day, 7 days per week, for 1 year (February 2017–January 2018). The forms were collected by the pediatric surgical resident or fellow called to consult on the patient or from the ED by the study's research coordinator the next morning, if a surgical consult was not requested. A final follow-up was obtained either by operative and pathologic finding of appendicitis after a surgical procedure, or medical record review of hospital stay of patients admitted to the hospital for observation. The gold standard for the presence of appendicitis was the final pathology report.

Data Storage and Analysis

All collected study data were deidentified and stored in a secure online Research Electronic Data Capture (REDCap) database.[9,10] We report demographic data



Pediatric Appendicitis Score

	Yes	No	If Yes, score
1. Did the patient report pain that started anywhere, migrated to the RLQ and remained there?	☐	☐	1
2. (a) Did the patient report anorexia at any time?	☐	☐	----
(b)Did the patient report decreased appetite at time of presentation?	☐	☐	1
3. (a) Did the patient report nausea or vomiting at anytime?	☐	☐	----
(b) Did the patient report any of the following: emesis, nausea, retching, or gagging in the last 48 hours?	☐	☐	1
4. (a) Was RLQ tenderness present on examination?	☐	☐	----
(b) Was the point of maximal tenderness on exam the RLQ?	☐	☐	2
5. (a) Did the patient report pain with coughing or hopping? ☐Patient refused to cough or hop due to pain (If checked, gets a credit for "Yes")	☐	☐	2 (If answered "Yes" or refused)
(b) Did the patient have tenderness with percussion? ☐Patient or family refused this portion of the exam.	☐	☐	----
6. Was there a documented temperature ≥ 38.5C in the ED?	☐	☐	1
7. Was there a temperature ≥ 38.5C at home in the last 48 hours?	☐	☐	----
8. Did the patient have a WBC of ≥ 9000?	☐	☐	1
9. Did the patient have neutrophils of ≥ 65%?	☐	☐	1
TOTAL (Add all numbers in last column)			

Fig. 1. Initial suspected appendicitis evaluation algorithm and PAS scoring system.

Ultrasound Findings

Was the appendix visualized?
☐Yes ☐No ☐Uncertain

Were the following primary signs present?	Yes	No	Uncertain
a. Hyperemia of appendiceal wall	☐	☐	☐
b. Appendiceal diameter ≥ 7mm	☐	☐	☐
Were the following secondary signs present?			
a. Fecolith	☐	☐	☐
b. Ecogenic fat	☐	☐	☐

Fig. 2. Synoptic ultrasound reporting checklist indicating primary and secondary signs of appendicitis.

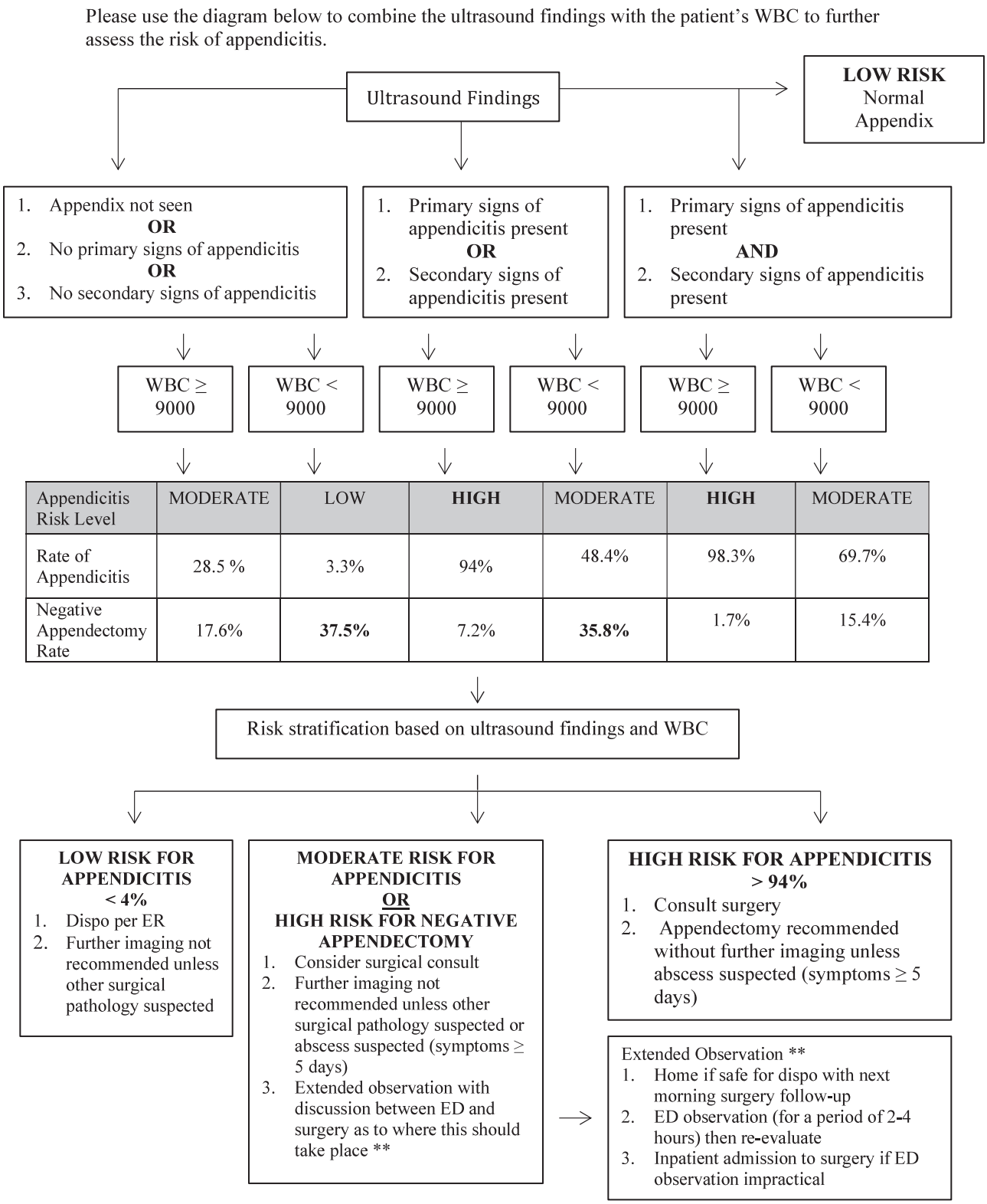


Fig. 3. Risk stratification algorithm based on white blood cell count and ultrasound findings and final disposition recommendations.

collected using descriptive statistics. Continuous variables are reported as means with SDs or median with ranges. Categorical variables are reported as counts with percentages. Adherence with pathway components is reported as the percentage of patients for each step that was pathway adherent. Categorical variables are compared between preimplementation and postimplementation groups using Chi-square or Fisher's exact test where applicable.

RESULTS

Patient Characteristics

A total of 247 patients went through the pathway over 12 months between February 2017 and January 2018. We excluded 12 patients because their initial ultrasound was completed at an outside institution. A total of 235 patients (Quality Assurance and Performance Improvement Project for Suspected Appendicitis [QAPPE]) group were included in the final analysis and were compared to a historical cohort of 234 patients (controls). There were 110 (46.8%) males and 125 (53.2%) females in the QAPPE group, compared to 121 (51.7%) males and 112 (47.9%) in the control group. There were significantly less patients admitted to hospital in the QAPPE group (98/235, 41.7%), than the control group (133/234, 56.8%) ($P = 0.001$). The median length of stay in the QAPPE group was 1.0 days (range 1–28), which did not differ from the control group (1.0 d, range 0–11). An appendectomy was completed in 68/235(29%) patients in the QAPPE group, which was significantly less than in the control group at 97/234 (41.5%) ($P = 0.004$). According to pathologist diagnosis, 56/68 (82.3%) of cases were acute appendicitis (control: 66/97, 68%; $P = 0.039$), 10/68(14.7%) perforated appendicitis (control: 27/97, 28%; $P = 0.046$), and 2/68(3%) a diagnosis other than appendicitis. One patient had a normal appendix, whereas the other had indeterminate pathology. A summary of patient characteristics prepathway and postpathway implementation can be found in Table 1.

Stage 1: Emergency Department PAS and Ultrasound Referral

An initial PAS of 1–3 was noted in 29 (12.3%) patients, whereas 206 (87.7%) scored 4 or more. Of the PAS 1–3 group, 23 (79%) patients underwent an ultrasound, whereas 4 (1.9%) patients with PAS scores > 4 did not receive an ultrasound. The PAS 1–3 group had an ultrasound adherence rate of 21% versus the PAS > 4 group's adherence rate of 98.1% resulting in an overall adherence rate of 88.5% for the appropriate referral for ultrasound-based on PAS score stratification. It is important to note that the ED physician has the autonomy to request an ultrasound regardless of PAS score if a diagnosis other than appendicitis was suspected. Patients with a higher likelihood of appendicitis (PAS score > 4) were significantly more likely to have an appropriate referral for ultrasound compared to those with a PAS of 1–3 ($P < 0.00$). The new protocol of standardized ultrasound reporting was followed for 183 (78%) patients. A computerized tomography (CT) scan was performed for 4.7% of patients (11/235), 5 of whom were deemed to be low risk for appendicitis, with no further imaging required. A CT scan was performed on 2/68 (2.9%) of patients who went on to receive an appendectomy. Before the pathway institution, 7.3% (17/234) ($P = 0.238$) of patients who presented to the ED with suspected appendicitis underwent a CT scan. The overall adherence rate for this first stage of the pathway was 87.6%.

Stage 2: Risk Stratification

After risk stratification, 67 (28.5%) patients were classified as low risk for appendicitis, 97 (41.3%) patients were moderate risk, 68 (28.9%) patients were high risk, and 3 (1.3%) patients were not able to be classified due to incomplete information. All of the patients deemed to be high risk received a surgical consult, as compared to 35.8% of low risk and 76.3% of moderate-risk patients. The number of surgical consultations across all risk groups did not differ significantly between the preimplementation and postimplementation groups (153/234, 65.4% vs 166/235, 70.6%; $P = 0.223$). One patient (1.5%) in the low-risk group had appendicitis, whereas 11 (16.2%) patients in the high-risk group did not have appendicitis. There was only 1 (1.5%) negative appendectomy, compared to the prepathway institutional negative appendectomy rate (NAR) of 4% (4/97; $P = 0.65$). The overall adherence rate for this second stage of the pathway was 84%. This information is summarized in Table 2.

DISCUSSION

At our institution, we see over 50,000 patients in the ED every year. We perform over 10,000 abdominal ultrasounds

Table 1. Comparison of Study Patients Included in the QAPPE Pathway to a Historical Cohort

	QAPPE Group (n = 235)	Historical Cohort (n = 234)	*P*
Male	110 (46.8%)	121 (51.7)	0.267
Female	125 (53.2%)	112 (47.9%)	
Other	0 (0%)	1 (0.4%)	
Median LOS (d)	1.0 (1–28)	1.0 (0–11)	
CT scan	11 (4.7%)	17 (7.3%)	0.238
Surgical consult	166 (70.6%)	153 (65.4%)	0.223
Admitted	98 (41.7%)	133 (56.8%)	0.001*
Appendectomy	68 (29%)	97 (41.5%)	0.004*
Mean age at surgery	10.8 (+4.1)	11.04 (+3.7)	
Pathology diagnosis			
Acute appendicitis	56 (81.2%)	66 (68%)	0.039*
Perforated appendicitis	10 (14.5%)	27 (28%)	0.046*
Negative appendectomy	1 (1.5%)	4 (4%)	0.65
Indeterminate pathology	1 (1.5%)	0 (0%)	

*A significant *P* value.
LOS, length of stay.

Table 2. Outcomes by Risk Group

	Low Risk (n = 67)	Moderate Risk (n = 97)	High Risk (n = 68)
Admitted	7 (10.5%)	28 (29%)	62 (91.2%)
CT scan	5 (7.5%)	4 (4.1%)	2 (3%)
Surgical consult	24 (35.8%)	74 (76.3%)	68 (100%)
Appendectomy	1 (1.5%)	9 (9.3%)	58 (85.3%)
Negative appendectomy	0 (0%)	1 (11%)	0 (0%)
Stage 1 adherence	52 (77.6%)	89 (91.8%)	64 (91.1%)
Stage 2 adherence	35 (52.3%)	87 (89.7%)	66(97.1%)

annually and an average of 200 appendectomies. Until the implementation of this pathway, the workup of patients with suspected appendicitis had been variable and guided by the treating physician. A previous study by AlFraih et al.[11] revealed a significant practice variation among pediatric surgeons when diagnosing acute appendicitis. This observation was ascertained through an international survey of pediatric surgeons across 3 countries, including Canada. The survey results showed no consensus on the workup of patients with suspected appendicitis and almost no utilization of an appendicitis scoring system or care pathway.[11]

The goal of a clinical pathway is to standardize care, improve outcomes, and reduce inappropriate resource utilization in carrying out a diagnostic process or treatment plan.[8] In the evaluation of a child with suspected appendicitis, clinical pathways have been used to streamline the diagnostic process by incorporating appendicitis risk scores as a screening tool and providing a standardized framework for selective diagnostic imaging based on risk stratification.[12,13] Several studies, including one by Saucier et al.,[12] have shown that the diagnostic accuracy of a clinical pathway to risk-stratify patients with suspected appendicitis and had high sensitivity and specificity of 92.3% and 94.7%, respectively. In another comparative study by Glass and Rangel,[8] the implementation of an appendicitis pathway decreased CT utilization as well as median hospital cost per case. This finding was also seen in our study, where the CT utilization rate decreased after the implementation of the pathway from 7.3% to 4.7% of patients. This decrease was not statistically significant, but CT scans are used conservatively at this institution. Patients usually undergo a CT scan only after receiving at least 2 abdominal ultrasounds that are nondiagnostic, and if the patient is still symptomatic. Institutions with higher rates of CT use may see more significant reductions with the implementation of similar care pathways. The implementation of an appendicitis pathway by Santillanes et al.[13] led to an NAR of 1%. We observed a drop in the NAR from 4% to 1.5% in this study. Although this reduction in the rate of negative appendectomies was not statistically significant, we believe that it has clinical significance. This rate reduction is similar to that reported at Boston Children's Hospital, where they noted a 50% reduction in their baseline NAR of 5.8%.[8]

In addition to the decrease in our institutional NAR to 1.5%, this pathway prevented 69 potential admissions for serial abdominal examinations. Before pathway implementation, patients who had equivocal presentations, now classified as moderate risk, would have been routinely admitted and observed. This finding is evidenced by the reduction in admissions by 15% seen in our study. In an era where increasing importance is placed on resource allocation and utilization, limiting unnecessary admissions improves patient flow, relieves space constraints, and lowers costs. More importantly, it prevents subjecting children to unnecessary distress and lost days from school. It also decreases severe anxiety for the parents and lost productivity from days off work.

We also saw a decrease in the number of appendectomies and perforated appendicitis in the study cohort as compared to the historical controls. We postulate that this decrease in perforated appendicitis may be due in part to the broader screening for appendicitis employed as part of this study, potentially increasing the number of patients diagnosed as having acute appendicitis and subsequently undergoing appendectomy before progressing to perforation.

Before pathway implementation, there was a CT utilization rate of 7.3%. This result is in keeping with the recent trend of relying on CT scans to evaluate suspected appendicitis. A 10-year review of the National Ambulatory Medical Care Survey data in pediatric patients noted an increase in CT imaging from 0.9% to 15.4% during that period.[14] Because of heightened concerns of radiation exposure in children, U/S has become an increasingly popular alternative modality for first-line imaging. The inconsistent quality of U/S due to variation in imaging technique and reporting of results, however, remains problematic. Acknowledging this, our pathway standardized ultrasound reporting and specified key imaging characteristics to avoid diagnostic ambiguity and allow for a unified common language between radiologists and clinicians. This intervention, in turn, reduced our postpathway implementation CT utilization to 4.7%.

No child at our institution underwent a CT scan for the evaluation of suspected appendicitis until after an ultrasound had been performed. This result is in keeping with the Choosing Wisely recommendations, which state that although CT is accurate in the evaluation of suspected appendicitis in the pediatric population, U/S is nearly as good when conducted by experienced technologists, making it the preferred initial modality in children. If the results of the U/S examinations are equivocal, it may be followed by CT. This approach reduces potential radiation

risks and has excellent accuracy. It has a reported sensitivity and specificity of 94%.[15–19]

Few studies have examined the performance of using a clinical pathway for children with suspected appendicitis prospectively while comparing it to a retrospective cohort, which is one of the strengths of this study.

Furthermore, we used a standardized, strict, straight-forward pathway to decrease variability in patient assessment among differing clinicians. There are, however, some limitations to this study. Because we did not track patients with suspected appendicitis, who were not enrolled in the pathway, some patients with suspected appendicitis may have been evaluated in the emergency department and not enrolled in our study. Furthermore, the ED physician also could deviate from the pathway based on the clinical scenario. This finding is suggested by our 86% pathway adherence rate for appropriate U/S referral. Also, some patients did not have standardized ultrasound reporting.

Due to the positive outcomes of this pathway at our institution, it has become the standard of care for children presenting to our hospital with suspected appendicitis. Other neighboring institutions have expressed interest in adopting this pathway as well, fulfilling our goal of being a guide for other centers in resource allocation and referral patterns.

CONCLUSIONS

Implementation of a standardized, evidence-based appendicitis care pathway has the potential to improve outcomes by reducing negative appendectomies, unnecessary CT scans, and unnecessary hospital admissions. The participation of the emergency and diagnostic imaging departments is critical to the successful implementation of this quality improvement measure. This simple, effective model can be easily implemented at other centers to improve the care of children.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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