Properties of Serial Ultrasound Clinical Diagnostic Pathway in Suspected Appendicitis and Related Computed Tomography Use

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Abstract

Objectives: The primary objective was to determine the diagnostic accuracy of a serial ultrasound (US) clinical diagnostic pathway to detect appendicitis in children presenting to the emergency department (ED). The secondary objective was to examine the diagnostic performance of the initial and interval US and to compare the accuracy of the pathway to that of the initial US.

Methods: This was a prospective cohort study of 294 previously healthy children 4 to 17 years old with suspected appendicitis and baseline pediatric appendicitis scores of ≥2, who were managed with the serial US clinical diagnostic pathway. This pathway consisted of an initial US followed by a clinical reassessment in each patient and an interval US and surgical consultation in patients with equivocal initial US and persistent concern about appendicitis. The USs were interpreted by published criteria as positive, negative, or equivocal for appendicitis. Children in whom this pathway did not rule in or rule out appendicitis underwent computed tomography (CT). Cases with missed appendicitis, negative operations, and CTs after the pathway were considered inaccurate. The primary outcome was the diagnostic accuracy of the serial US clinical diagnostic pathway. The secondary outcomes included the test performance of the initial and interval US imaging studies.

Results: Of the 294 study children, 111 (38%) had appendicitis. Using the serial US clinical diagnostic pathway, 274 of 294 children (93%, 95% confidence interval [CI] = 90% to 96%) had diagnostically accurate results: 108 of the 111 (97%) appendicitis cases were successfully identified by the pathway without CT scans (two missed and one CT), and 166 of the 183 (91%) negative cases were ruled out without CT scans (14 negative operations and three CTs). The sensitivity of this pathway was 108 of 111 (97%, 95% CI = 94% to 100%), specificity 166 of 183 (91%, 95% CI = 87% to 95%), positive predictive value 108 of 125 (86%; 95% CI = 79% to 92%), and negative predictive value 166 of 169 (98%, 95% CI = 96% to 100%). The diagnostic accuracy of the pathway was higher than that of the initial US alone (274 of 294 vs. 160 of 294; p < 0.0001). Of 123 patients with equivocal initial US, concern about appendicitis subsided on clinical reassessment in 73 (no surgery and no missed appendicitis). Of 50 children with persistent symptoms, 40 underwent interval US and 10 had surgical consultation alone. The interval US confirmed or ruled out appendicitis in 22 of 40 children (55.0%) with equivocal initial US, with one false-positive interval US.

Conclusions: The serial US clinical diagnostic pathway in suspected appendicitis has an acceptable diagnostic accuracy that is significantly higher than that of the initial US and results in few CT scans. This approach appears most useful in children with equivocal initial US, in whom the majority of negative cases were identified at clinical reassessment and appendicitis was diagnosed by interval US or surgical consultation in most study patients.


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Acute appendicitis continues to present the challenge of a timely diagnosis with optimal resource use.1–6 Despite its advantages,7 ultrasound (US) by itself has limited diagnostic utility for suspected appendicitis,8 with the rate of equivocal examinations in some studies approaching 50%.9–12 Several scoring systems, including the pediatric appendicitis score (PAS),13 also do not perform well in isolation at diagnosing appendicitis.14–21

An intravenous contrast-enhanced computed tomography (CT) scan is currently recommended in children with equivocal screening US results.22 However, due to rising awareness of a potential CT-related risk of radiation-induced malignancies in children,23–25 there has been a decrease in the CT rate over the past decade.26 Indeed, previous authors have proposed possible utility of a serial US examination in conjunction with the clinical reassessment, given the lower cost of US compared to CT.27,28 However, we do not know the diagnostic performance and the use of CT with this approach. If found to have an acceptable benchmark performance, this strategy may represent a plausible diagnostic option for our colleagues looking after this high-risk population. Furthermore, there is no published information about the diagnostic performance of imaging by serial US in diagnosing appendicitis.

The primary objective of this study was to determine the diagnostic accuracy of a serial US clinical diagnostic pathway to detect appendicitis in previously healthy children 4 to 17 years of age presenting to the emergency department (ED) with suspected appendicitis. This clinical pathway consisted of an initial US followed by a clinical reassessment in all patients and an interval US in patients with equivocal initial US and persistent concern about appendicitis on reassessment. The secondary objective was to examine the diagnostic performance of the initial and interval US and to compare the accuracy of the initial US to that of the pathway.

METHODS

Study Design
This was a prospective cohort study evaluating the diagnostic accuracy of the serial US clinical diagnostic pathway (Figure 1). The study was approved by the research ethics board of our institution.

Study Setting and Population
The study took place at a Canadian pediatric hospital with about 250 trauma team activations in our ED annually, of which 125 have an Injury Severity Score of >12. We chose a consecutive sample of previously healthy children 4 to 17 years old with abdominal pain and right lower quadrant abdominal tenderness, as defined by an initial PAS ≥ 2 points, who in the opinion of the ED staff physician/fellow required imaging (US represents the initial imaging at our institution) for suspected appendicitis. This PAS cutoff reflects a conservative imaging practice of some physicians to ensure that appendicitis is not missed. The PAS quantifies the probability of appendicitis by using clinical data (anorexia, vomiting, migration of pain, right lower quadrant tenderness, pain with hopping/coughing, and fever) and laboratory data (white blood cell count > 10 x 109 cells/L, neutrophil count >7.5 x 109/L).13 This instrument was created specifically for children,13 has previously been demonstrated to have good interobserver reliability.

Figure 1. Serial US clinical diagnostic pathway. PAS = pediatric appendicitis score; RLQ = right lower quadrant; US = ultrasound.
when using consistent measurements,20 has been prospectively validated in multiple settings,18–21 and thus represents the best validated appendicitis-related instrument.18 However, since a high-quality, consistently high-performing clinical prediction rule for appendicitis has not been identified to date,18 we have limited the use of the PAS as an entry criterion, and all management decisions were made without its use. We excluded children with hemodynamic instability, comorbidities, pregnant females, families with language barriers, and subsequent visits by the same patient. Prior to the study, the ED staff and fellows were educated in a consistent measurement of the PAS.

Study Protocol

Following eligibility screening 7 days a week, 24 hours a day and obtaining written informed consent from all participating families, the trained research assistants documented the initial PAS prospectively calculated by the ED staff or fellow and noted other relevant demographic, clinical, and imaging information. USs were performed in the Department of Diagnostic Imaging by trained and experienced ultrasonography technicians in consultation with staff radiologists during the day and by trained diagnostic imaging fellows during evenings, nights, and weekends.

High-resolution (7- to 14-MHz), linear array US transducers (Aploio TM 500, Toshiba Medical Systems Inc.; LOGIQ, General Electric healthcare.iU22, Philips Healthcare) were employed to obtain gray-scale and color Doppler scans of the abdomen, using the graded-compression technique.29 The US was immediately read by the diagnostic imaging staff on weekdays or by the on-call fellow during evenings, nights, and weekends.

An US study was considered positive for appendicitis by previously published criteria,30 such as a noncompressible appendix with a diameter of more than 6 mm, an appendicolith, hypechoic periappendiceal fat, loss of echogenic submucosal layer, and increased blood flow in the appendix on color Doppler. A study was considered negative if a sufficient length of a normal appendix could be visualized.30 If the appendix was incompletely visualized or not visualized, had normal measurements with inflammatory signs, had borderline measurements (6 mm diameter) without inflammatory signs, or was not visualized in the absence of periappendiceal collections, the result was considered equivocal.30 The original interpretation by the staff or fellows was used for the analysis since these were also used for clinical decisions. The US readers were blinded to the initial PAS.

Following the initial US, the children were reexamined. Children with negative initial US were discharged home, those with positive US were evaluated by the pediatric surgeons and underwent appendectomy where appropriate, and each patient with equivocal screening US whose clinical reassessment indicated ongoing concern for appendicitis underwent an interval US and a surgical consultation. Children in whom this pathway did not rule in or rule out appendicitis who were still considered at risk for appendicitis underwent a CT scan, as per the pediatric surgeon. One month later, the assistants reviewed the electronic patient charts for histological findings in the appendices and for delayed diagnoses of appendicitis. They also telephoned all patients without surgery to ensure that appendicitis was not diagnosed elsewhere.

The final diagnosis of appendicitis was based on the histological evidence of appendicitis at surgery, as interpreted by a staff pediatric pathologist.31 The staff pathologists were blinded to the PAS and to US results. No appendicitis meant the pathologist found no evidence of appendicitis in the removed appendix, or there was no appendicitis in the children who did not undergo an operation within 1 month of the index visit. Perforated appendicitis was diagnosed on the screening US showing a periappendiceal abscess/phlegmon, confirmed in the operative report.

Pathway Accuracy. Cases considered diagnostically accurate by the serial US clinical diagnostic pathway included children who underwent surgery at the initial visit (irrespective of the US result) and had appendicitis, those with perforated appendicitis managed with appendectomy or antibiotics ± image-guided abscess drainage, and patients without appendicitis who went home and did not have appendicitis at follow-up. All other patients were considered diagnostically inaccurate, including patients with no appendicitis at surgery and children who returned with missed appendicitis. Children who had CT scans after the pathway were also considered diagnostically inaccurate. Although a CT is sometimes necessary to clarify the diagnosis, the targeted serial US diagnostic pathway had not achieved this goal in these cases.

US Accuracy. Ultrasound accuracy was determined by agreement between the final diagnosis and US interpretation. An equivocal US in a child with appendicitis was considered false-negative, and an equivocal US in a child without appendicitis was false-positive.32

Outcome Measures

We classified the patients into those with and without appendicitis, into diagnostically accurate and inaccurate cases by the serial US clinical diagnostic pathway and into those with positive, negative, or equivocal initial or interval US interpretations with respect to appendicitis. The primary study outcome was the proportion of children with diagnostically accurate serial US clinical diagnostic pathway results, defined as the diagnostically accurate cases by this pathway divided by the total number of cases on the pathway. The secondary outcomes included the sensitivity, specificity, and positive and negative predictive value (PPV, NPV) of the initial and the interval US.

Data Analysis

A statistician carried out the analysis using the SAS version 9.3. The sample size calculation was based on the 95% confidence interval (CI) around the proportion of children with diagnostically accurate serial US clinical diagnostic pathway results. A sample size of 190 patients produces a 95% CI equal to the estimated proportion of diagnostically accurate cases of 90% (SD ± 4%).33,34
The primary analysis consisted of the 95% CI around the proportion of diagnostically accurate cases in the serial US clinical diagnostic pathway. As secondary analyses, the relevant 95% CIs around the sensitivity, specificity, PPVs, and NPVs of the serial US clinical diagnostic pathway were also calculated. The differences in the proportions of the categorical variables in the participants with and without appendicitis were compared using the chi-square test. Student’s t-test and Wilcoxon rank sum test were used to assess the differences between normally and nonnormally distributed continuous variables, respectively. A p-value of <0.05 was defined to denote statistical significance.

RESULTS

Of the 660 children who underwent US for suspected appendicitis during the study period from March 2012 to March 2013, a total of 460 were screened for the study. Of these, 30 refused participation, and 128 met exclusion criteria (15 patients were under 4 years of age, five were enrolled previously, 20 arrived with imaging from other institutions, 59 had comorbidities, and 29 families did not speak English), so 302 were enrolled. The nonapproached population had a comparable rate of appendicitis to the enrolled cohort: 67 of 200 (34%) versus 113 of 302 (37%). A total of 294 children were managed by the serial US clinical diagnostic pathway and constituted the study population. The eight children not managed by the pathway had CT scans after the screening US; two had appendicitis, one of which was perforated. The mean (±SD) age of the study cohort was 10.4 (±3.6) years and 48% were males. A total of 111 patients (38%) had appendicitis (33 were perforated) and 183 did not. Two patients had alternate surgical diagnoses (ovarian torsion and a neurocysticercal tumor). The clinical and demographic characteristics of the participating children are summarized in Table 1. Children with appendicitis were more likely to be male and have higher initial PAS values. Two of 21 children with the presenting PAS of 2 points had appendicitis. None of the study patients with appendicitis developed appendiceal perforation while in hospital.

Of the 294 participants who underwent initial US, 128 (44%) were performed by sonographers, and 166 were done by the diagnostic imaging fellows. One-hundred of the initial US (34%) were interpreted by the diagnostic imaging staff physicians, and 194 were read by the fellows. The mean time from the initial US to the clinical reassessment was 3.2 hours and to the interval US was 9.2 hours. Many participating children had their initial US in the evening and were reassessed around midnight, and the interval US was done the following morning when the US technicians were in the hospital and when many of our surgical colleagues operate on children with high likelihood of appendicitis.

Pathway Accuracy and Performance

Using the serial US clinical diagnostic pathway, 274 of 294 children (93%, 95% CI = 90% to 96%) had diagnostically accurate results: 108 of 111 appendicitis cases were identified by the pathway without CT scans (two were missed and one had a CT scan), for a sensitivity of 97% (95% CI = 94% to 100%), and 166 of 183 negative cases were successfully ruled out without CT scans (14 underwent negative operations and three had CT scans), for a specificity of 91% (95% CI = 87% to 95%). The PPV was 86% (108 of 125, 95% CI = 79% to 92%) and the NPV was 98% (166 of 169, 95% CI = 96% to 100%).

Both children with missed appendicitis had symptoms for less than 12 hours prior to presentation. One had a negative initial US, was discharged home, and returned 8 hours later with increasing abdominal pain. A subsequent US was positive for nonperforated appendicitis. The other child had an equivocal initial US, was sent home after a surgical consultation with decreasing symptoms, and returned with nonperforated appendicitis. Of the 14 children with negative appendectomies, six had hemorrhagic ovarian cysts and one had an ovarian torsion.

Of the 99 patients with positive initial US results, 89 had appendicitis (28 were perforated). Ninety patients in this group underwent surgery, with 86 positive results (25 perforations); three cases of perforated appendicitis were managed with IV antibiotics and abscess drainage. Of the 72 cases interpreted as negative for appendicitis on the initial US, one child with brief symptom duration returned shortly after discharge with appendicitis (see above). Two patients in this group underwent surgery for severe abdominal tenderness; one had a successfully reduced ovarian torsion.

Figure 2 summarizes the management and outcomes of children with equivocal initial US findings. Of the 123 patients in this group, abdominal pain and concern about appendicitis subsided on clinical reassessment in 73. In this group, the mean length of ED stay after the initial US was 3.5 hours. Nine of these patients had surgical consultations shortly after initial US due to severe

Table 1
Characteristics of Patients With and Without Appendicitis

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Appendicitis (n = 111)</th>
<th>No Appendicitis (n = 183)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr), mean ± SD</td>
<td>10 ± 3.2</td>
<td>10.6 ± 3.8</td>
<td>0.14</td>
</tr>
<tr>
<td>Sex (% male)</td>
<td>72 (64.9%)</td>
<td>71 (38.8%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Duration of abdominal pain (hrs),</td>
<td>24 (15.5–48)</td>
<td>48 (12.3–72)</td>
<td>0.0008</td>
</tr>
<tr>
<td>median (IQR)</td>
<td>6.8 ± 1.9</td>
<td>4.7 ± 1.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Initial PAS, mean ± sd</td>
<td>22/86 (25.6%)</td>
<td>37/138 (26.8%)</td>
<td>0.84</td>
</tr>
<tr>
<td>BMI ≥ 95th percentile</td>
<td></td>
<td></td>
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</table>

BMI = body mass index; IQR = interquartile range; PAS = pediatric appendicitis score.
pain, none underwent surgery, and none had missed appendicitis. Of the 50 children with persistent symptoms, 40 underwent interval US and 10 had surgical consultations without interval US due to compelling abdominal findings. Of these 10 children, nine had operations (three had appendicitis, four had hemorrhagic ovarian cysts, and two had lymphoid hyperplasia). One child experienced a marked decrease in symptoms, was sent home, and returned soon thereafter with nonperforated appendicitis. Thirteen of the 40 interval US were read as positive for appendicitis; 12 were found to have appendicitis on surgery (one had a hemorrhagic ovarian cyst). None of the 10 interval US read as negative had appendicitis. Of the 17 patients with equivocal interval US, six underwent surgical exploration (five had appendicitis; one of these had a CT scan and one had a hemorrhagic ovarian cyst), three had CT scans (one appendicitis), and eight were managed medically (no appendicitis).

US Accuracy (Table 2)

**Initial US.** A total of 160 of the 294 (54%) initial USs were diagnostically accurate, with a sensitivity of 80% (89 of 111), a specificity of 39% (71 of 183), and a 42% (123 of 294) equivocal rate. The accuracy of the initial US was significantly lower compared to that of the overall targeted pathway (p < 0.0001).

**Interval US.** The interval US confirmed or ruled out appendicitis in 22 of the 40 (55.0%) children who had equivocal initial US interpretation, with one false-positive interval US. The sensitivity of the interval US was 71% (12 of 17), the specificity was 44% (10 of 23), and the equivocal rate was 45.0% (18 of 40).

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**Clinical reassessment**

N = 123

**Persistent symptoms or concern Re: appendicitis**

Yes: 50
No: 73

**Interval US + surgical consultation**

n = 40

**US positive**

n = 13

Surgery

n = 13

Appendicitis

n = 12

**US negative**

n = 10

Surgery

n = 0

Appendicitis

n = 0

**US equivocal**

n = 17

Discharge

n = 8

Appendicitis

n = 0

**CT**

n = 4

Appendicitis

n = 4

**Surgery**

n = 5

Appendicitis

n = 3

**Table 2**

Diagnostic Performance of Initial and Interval Ultrasound

<table>
<thead>
<tr>
<th>Ultrasound</th>
<th>Appendicitis</th>
<th>No Appendicitis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>89</td>
<td>10</td>
<td>99</td>
</tr>
<tr>
<td>Equivocal</td>
<td>21</td>
<td>102</td>
<td>123</td>
</tr>
<tr>
<td>Negative</td>
<td>1</td>
<td>71</td>
<td>72</td>
</tr>
<tr>
<td>Total</td>
<td>111</td>
<td>183</td>
<td>294</td>
</tr>
<tr>
<td>Interval</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>12</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Equivocal</td>
<td>5</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>23</td>
<td>40</td>
</tr>
</tbody>
</table>
DISCUSSION

To the best of our knowledge, this is the first study to demonstrate that the serial US clinical diagnostic pathway in suspected appendicitis has an acceptable diagnostic accuracy that is significantly higher than that of the initial US and results in very few CTs. This approach appears to be most useful in children with equivocal initial US in whom appendicitis was diagnosed or ruled out by the combination of the clinical reassessment and interval US/surgical consultation in virtually all study patients.

Recently, Kulik et al. 16 examined the performance of six unique clinical decision rules in 4,200 children with suspected appendicitis. The authors concluded that although the PAS and the Alvarado scores were the best validated, 16,18–21 neither score met the current performance benchmarks. With respect to the key diagnostic strategies, Ramarajan et al. 11 conducted a retrospective review of an appendicitis pathway where children with equivocal initial US underwent clinical examinations and those with persistent abdominal pain had CT scans. Although this pathway avoided many CTs that would have been done otherwise, 37% of children still had CT scans. The authors recommended further prospective study be done to investigate alternative diagnostic approaches in this population. These results were subsequently retrospectively confirmed by Krishnamoorthi and colleagues 36 and prospectively by Santillanes and colleagues. 37 In a key study, Kharbanda and colleagues 38 have recently validated and refined a clinical pathway to identify children at low risk of acute appendicitis. A study from Spain prospectively evaluated a modified clinical practice guiding score consisting of a clinical examination, laboratory result, and tissue harmonic US when necessary. 39 Although the overall accuracy of this approach was high, the authors did not mention to what extent these methods contributed to the overall guideline success. In contrast, our diagnostic pathway used a low-risk imaging method with the frequently utilized clinical reassessment and showed that children with equivocal initial US and persistent concern about appendicitis on reassessment are candidates for interval US and surgical consultation, and those without ongoing symptoms on reassessment can be discharged.

Ultrasound is highly operator-dependent and frequently cannot visualize the appendix. 40–43 Our study had a high rate of equivocal US that was comparable to that found in our recent study of appendicitis 9 and higher than that reported in a multisite study by Bachur et al. 44 who found a 14% equivocal US rate. This difference may be in part explained by the difference in the criteria for equivocal US. For example, during our prospective application of previously published criteria 30 we have classified US with incomplete or no visualization of the appendix with no secondary signs of appendicitis as equivocal, 30 whereas Bachur and colleagues 44 classified these as negative.

Our study highlights that a combination of US and clinical reassessment is very helpful in diagnosing appendicitis and that the reassessment represents a powerful tool in identifying children at high risk of appendicitis. Indeed, clinical reassessment was used to exclude appendicitis in the majority of patients with equivocal US, and children no longer judged to be at risk of appendicitis were identified after relatively brief observation. Active observation of patients with suspected appendicitis has been shown over decades to be a safe and effective method without increasing the risk of perforation and minimizing negative appendectomies. 28,45–48 None of the study patients developed perforation while in hospital, which has been previously shown by others. 49,50

Despite previously reported inverse association between the use of diagnostic US and negative appendectomy rate in children, 26,51,52 this pathway was associated with a higher negative appendectomy rate than that reported in the two key U.S.-wide studies by Bachur and colleagues and other authors. 26,44,53 This difference may be in part explained by the high rate of hemorrhagic ovarian cysts (six of 14 negative appendectomies), which may mimic appendicitis on US 54 and one case of successfully managed ovarian torsion that required urgent operative management.

The CT rate in this study was negligible. The American College of Emergency Physicians recommends that an intravenous contrast-enhanced CT be done in children with nondiagnostic screening US. 22 Although a CT is highly accurate in diagnosing pediatric appendicitis, 7 it may increase lifetime mortality risk from malignancies. 24 A large review of large U.S. pediatric institutions showed increasing US use and decreasing CT use in recent years. 26 However, one-third of the children with suspected appendicitis currently undergo CT scans, with considerable practice variation between hospitals. Although a guideline encouraging US and early surgical consultation in suspected appendicitis may decrease the CT rate significantly, 35 as may a staged US-CT protocol, 36 our approach would avoid the majority of the currently recommended CTs. A CT was required in only 3% of the equivocal USs. Bachur and colleagues 44 recently commented that serial examinations potentially followed by repeat US in well-appearing children with inconclusive US examinations represent an option to avoid overreliance on CT, especially in children with brief duration of abdominal pain.

However, our serial US clinical diagnostic pathway involves time and resource utilization with associated costs. Although ordering CT scans in children with equivocal initial US may decrease the overall length of hospital stay, the potential radiation-related morbidity needs to be considered. Our results suggest that children with equivocal initial US who are no longer at risk for appendicitis on reassessment are identified after a relatively brief observation. Furthermore, like this study, Stewart et al. 27 have recently shown that adult and pediatric patients with suspected appendicitis and nondiagnostic initial US have low risk of appendicitis and proposed clinical observation rather than a routine referral for CT scanning. Interestingly, these authors also propose a potential utility of serial US in conjunction with the clinical assessment in view of the lower cost of US compared to CT. 27 Likewise, Pacharn and colleagues 26 suggest that a period of observation be considered in patients with nonvisualization of the appendix. Although a formal cost–benefit analysis of...
this approach is beyond the scope of this study, some hospitals may prefer to observe patients in designated observation or short-stay units, with different cost implications. The decision to perform an interval US is multifactorial and depends in part on US availability as well as on the judgment of the ED physician/consultant surgeon.

LIMITATIONS

Although the sensitivity of the targeted pathway was high, the lower-bound 95% CI around this parameter was just below the benchmark criterion of 95%, and that around diagnostic accuracy also did not meet this standard. It appears that the pathway may be slightly better in diagnosing appendicitis than in ruling it out, likely in part due to several cases of ovarian pathology mimicking appendicitis in children who underwent negative operations.

Due to the small number of diagnostically inaccurate cases by the serial US clinical pathway, we were unable to examine plausible predictors of this outcome, such as the duration of abdominal pain or the body mass index. A small subset of children with equivocal initial US and persistent symptoms had surgical consultations without interval US. Therefore, we cannot comment about the interval US performance in this group. Furthermore, the number of patients with interval US was small, and the conclusions about the accuracy of this imaging approach therefore need to be interpreted with caution. Although the results of this single-center study are likely generalizable to other pediatric institutions with comparable clinical expertise and US experience and access, this serial US clinical diagnostic pathway needs to be further validated in a multicenter study. Also, timely access to US and expertise in pediatric surgery and US remain a challenge in many community hospitals, which would make successful use of this approach difficult.

CONCLUSIONS

The serial ultrasound clinical diagnostic pathway in suspected appendicitis has an acceptable diagnostic accuracy that is significantly higher than that of the initial ultrasound and results in few CT scans. This approach appears to be most useful in children with equivocal initial ultrasounds in whom appendicitis was diagnosed or ruled out by the combination of the clinical reassessment and interval ultrasound/surgical consultation in virtually all study patients.

References


Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement 1. ICD-9-CM and common procedural terminology (CPT) codes for visit, procedure, and diagnostic test identification.