Time From Emergency Department Evaluation to Operation and Appendiceal Perforation

Michelle D. Stevenson, MD, MS,a Peter S. Dayan, MD, MSc,b Nanette C. Dudley, MD,c Lalit Bajaj, MD, MPH,d Charles G. Macias, MD, MPH,e Richard G. Bachur, MD,f Kelly Sinclair, MD,g Jonathan Bennett, MD,h Manoj K. Mittal, MD,i Macarius M. Donneyong, PhD, MPH,j Anupam B. Kharbanda, MD, MSc,k on behalf of the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics

BACKGROUND AND OBJECTIVES: In patients with appendicitis, the risk of perforation increases with time from onset of symptoms. We sought to determine if time from emergency department (ED) physician evaluation until operative intervention is independently associated with appendiceal perforation (AP) in children.

METHODS: We conducted a planned secondary analysis of children aged 3 to 18 years with appendicitis enrolled in a prospective, multicenter, cross-sectional study of patients with abdominal pain (<96 hours). Time of initial physical examination and time of operation were recorded. The presence of AP was determined using operative reports. We analyzed whether duration of time from initial ED physician evaluation to operation impacted the odds of AP using multivariable logistic regression, adjusting for traditionally suggested risk factors that increase the risk of perforation. We also modeled the odds of perforation in a subpopulation of patients without perforation on computed tomography.

RESULTS: Of 955 children with appendicitis, 25.9% (n = 247) had AP. The median time from ED physician evaluation to operation was 7.2 hours (interquartile range: 4.8–8.5). Adjusting for variables associated with perforation, duration of time (≤24 hours) between initial ED evaluation and operation did not significantly increase the odds of AP (odds ratio = 1.0, 95% confidence interval, 0.96–1.05), even among children without perforation on initial computed tomography (odds ratio = 0.95, 95% confidence interval, 0.89–1.02).

CONCLUSIONS: Although duration of abdominal pain is associated with AP, short time delays from ED evaluation to operation did not independently increase the odds of perforation.

WHAT’S KNOWN ON THIS SUBJECT: Perforation is a common complication of appendicitis in children. Although appendectomy is often postponed for a short period, the impact of time from emergency department evaluation to operation on the risk of perforation is not fully understood.

WHAT THIS STUDY ADDS: In our prospective, multicenter cohort of children with appendicitis, time delays of up to 12 hours from initial emergency department evaluation to operation did not appear to independently contribute to the odds of appendiceal perforation.

Timely diagnosis of appendicitis has long been a challenge for medical practitioners, especially in children. Annually, an estimated 80,000 children <15 years of age undergo appendectomy in the United States. One important clinical outcome in children is perforated appendicitis, with its associated risk of postoperative complications, such as abscess formation and prolonged hospitalization. Several important risk factors for perforated appendicitis have been described in the literature in children, including young age, Medicaid insurance, low socioeconomic status, African American race, Hispanic ethnicity, and longer duration of pain before presentation to the hospital. Most previous studies, however, have been retrospective and from single centers.

The effect of short delays in surgical intervention on the risk of appendiceal perforation (AP) and subsequent morbidity is controversial. Delays may be secondary to transfer for definitive care (eg, consultation with a pediatric surgeon), use of advanced imaging (computed tomography [CT], ultrasound [US], or MRI), limited availability of resources, or concerns about fatigued operative personnel. In the case of advanced imaging, 1 previous study did not find an increase in the rate of perforated appendicitis with increased CT use; however, the investigators recognized the need for multicenter, prospective studies to evaluate whether cross-sectional imaging is associated with delay until appendectomy.

Recent reports in the pediatric surgical literature have suggested that delays of 12 to 24 hours after initial evaluation are not associated with an increased risk of perforation, prolonged hospital length of stay, or intraabdominal abscess. Furthermore, a recent survey conducted through the American Pediatric Surgical Association revealed that few pediatric surgeons (4%) consider nonperforated appendicitis to be a surgical emergency and often prefer to postpone surgery overnight due to fatigue and lack of operating room availability.

Given the limitations of previous studies, the objective of our study was to determine if the time from emergency department (ED) physician evaluation until surgical intervention was independently associated with an increased risk of AP in children.

**METHODS**

**Study Design**

We performed a planned secondary analysis of a prospective, cross-sectional, 10-center study whose main objective was to validate a clinical decision rule for pediatric appendicitis. Our participating sites were urban, teaching facilities with pediatric EDs and members of the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics. The combined volume of pediatric EDs was ~350,000 visits annually. The study was approved by the institutional review board at each participating site.

**Study Participants**

Patients in the parent study were eligible if they were 3 to 18 years of age and presented to a participating ED with abdominal pain of <96 hours in duration for whom the treating physician had enough concern so that blood tests, imaging studies (CT and/or US because MRI was not widely used during the study period), or a surgical consult were obtained to evaluate for appendicitis. We excluded patients with previous abdominal surgery, chronic abdominal pain/illness, pregnancy, sickle cell anemia, cystic fibrosis, abdominal trauma within the last week, imaging before arrival at the site ED, or a medical condition hindering the provider’s ability to obtain an accurate history.

Specifically, for this secondary analysis, we only included children who were ultimately diagnosed with appendicitis. To avoid inclusion of children who underwent a purposeful delayed appendectomy, we also excluded children who underwent appendectomy >24 hours after ED evaluation.

**Data Collection and Definitions**

Physicians conducted history and physical examinations before having knowledge of any imaging results (if obtained) and recorded their findings on standardized case report forms. As part of ED data collection, ED clinicians assessed the duration of abdominal pain before ED physical examination, categorized on the data form as <12 hours, 12 to 23 hours, 24 to 35 hours, 36 to 47 hours, 48 to 71 hours, and 72 to 95 hours. Additionally, the ED clinicians recorded the time of performance of the history and physical examination (time of ED physical examination). The time that the operation was performed was also recorded through subsequent review of the operative report. We defined the duration of time from ED evaluation to operation as the difference between these documented times. We separated total duration of pain into 2 components: duration of pain before initial ED physical examination (collected as a categorical variable) and duration of pain after initial physical examination in the ED. From the times documented in the electronic radiology reports, we also recorded the time of CT or US imaging (if obtained).

We determined the presence or absence of appendicitis using the pathology reports and AP through review of surgical reports. We defined AP as: ruptured appendix, an abscess in the right lower quadrant.
In operative care, we repeated the
additionally assess the role of delays
Hosmer-Lemeshow goodness-of-fit
the likelihood ratio test and the
of abdominal tenderness). We used
illness (eg, anorexia, emesis, degree
potential indicators of severity of
selection techniques to test for other
ED evaluation as predictors of
of perforation. We then used forward
ED provider physical examination
whether the duration of time from ED
variables indicated as potentially associated
regression techniques were used
test for independent predictors
Appendicitis when noted in the attending
case definitions were defined a priori
and site research assistants received
detailed instruction on interpreting
and coding of radiologic, operative,
and pathology reports. We performed
data quality checks monthly, and
discrepant findings were reviewed
and corrected.

Data Analysis
We conducted standard bivariate
analysis (χ² and independent
sample t test, as appropriate) to test
whether the duration of time from
ED provider physical examination
until surgical intervention, use of CT
or US, or previously suggested risk
factors were potentially associated
with AP. Subsequently, logistic
regression techniques were used
to test for independent predictors
of perforation. Variables indicated
as potentially associated with
perforation (P < .1) on the bivariate
analysis were included in the
inferential modeling. The primary
model was developed in 2 stages.
A priori, we fixed the variable of
interest (time from ED physical
examination to operation), age,
Hispanic ethnicity (shown to be a
predictor of perforation in a previous
analysis of this dataset⁵), whether
the child underwent imaging (CT
and/or US), fever (temperature
≥100.4°F¹⁸), white blood cell (WBC)
count, and duration of pain before
ED evaluation as predictors of
perforation. We then used forward
selection techniques to test for other
potential indicators of severity of
illness (eg, anorexia, emesis, degree
of abdominal tenderness). We used
the likelihood ratio test and the
Hosmer-Lemeshow goodness-of-fit
test to evaluate overall fit to establish
the most parsimonious model. To
additionally assess the role of delays
in operative care, we repeated the
regression modeling only including
predictors that could be considered
to be on the causal pathway between
appendicitis and AP (eg, fever,
degree of abdominal tenderness,
and elevated inflammatory markers
were excluded).

Subgroup Analyses
To evaluate patients with longer
delays from evaluation to operation,
we repeated the main regression
modeling among children who had
delays of 12 to 23 hours from ED
physical examination until operation.
We then analyzed 2 subgroups
who were more likely to have
nonperforated appendicitis on
presentation to the ED. First, we
developed logistic regression
models restricted to those with
nonperforated appendicitis on ED
CT. Next, we examined children
aged 5 to 18 years who were not
ill appearing, had a WBC count
of <18000/µL, pain <36 hours before
the ED physical examination, and
no evidence of perforation on CT or
ultrasound. In this second group of
patients, we calculated perforation
rates categorized by duration of
pain from onset until ED physical
examination (in 12-hour increments)
for each 4-hour block of time from ED
physical examination until operation.

Finally, we also calculated the
correlation coefficient (Spearman’s
ρ) between the presence or absence
of perforation on the surgical
report to the presence or absence
of perforation as recorded on the
pathology report.

SAS, version 9.3 (SAS Institute,
Inc, Cary, NC) and SPSS, version
22.0 (IBM SPSS Statistics, IBM
Corporation) were used for all
analyses. The test significance level
was set at .05 without correction for
multiple comparisons because each
outcome was viewed as important in
isolation.

RESULTS
Among 2625 patients originally
enrolled with abdominal pain,
1017 (38.7%) were diagnosed with
appendicitis via pathology reports.
There were 62 patients who met
exclusion criteria, leaving 955
patients in the present analysis (Fig 1).
The mean age of the sample was
10.8 years, with 60.1% being boys.
Overall, 247 patients (25.8%) had AP.
The median time from ED physical
examination to operation was 7.2
hours; 22% of children had their
operations ≥12 hours after the initial
ED physical examination.

Table 1 presents the patient
characteristics and their bivariate
relationship with AP. Several clinical
findings that suggest more severe
illness were associated with AP. As
expected, patients were significantly
more likely to have AP with
increasing duration of pain before ED
physical examination.

Table 2 depicts the multivariable
logistic regression model subsequent
to the stepwise procedure, in which
independent factors associated
with perforation are indicated.
The final model consisted of 10
predictors with good model fit
(Hosmer-Lemeshow P value = .998,
likelihood ratio test χ² = 254.6, P <
.0001). Each category of increasing
duration of abdominal pain before
the ED physical examination was
associated with perforation, and the
strength of this association generally
increased as duration of abdominal
pain before the ED physical
examination increased. However,
even after adjustment for all other
factors associated with perforation,
increased time from ED physical
examination until operation was not
associated with increased odds of
perforation. Repeating the regression
modeling excluding predictors
that could be the consequence of
perforation did not materially change
the results (Supplemental Table 4).
Subgroup Analyses

There was no significant association between time from ED physical examination to operation and perforation among children who underwent operation 12 to 23 hours after ED evaluation (adjusted odds ratio [OR], 0.93; 95% confidence interval [CI], 0.79–1.08).

In the restricted regression model among only children without evidence of perforation on CT conducted in the ED (n = 403), there was no increase in odds of perforation with increasing duration of time from ED physical examination to operation (adjusted OR, 0.95; 95% CI, 0.89–1.02; Table 3). In this first subgroup, regression model results were similar when predictors that could have been the consequence of perforation were excluded (data available on request). In the second population of patients who were likely to have nonperforated appendicitis based on both CT and clinical findings, no clear relationships were noted between the time from ED physical examination to the operating room and perforation when stratified by the time of onset of symptoms until ED physical examination (Fig 2).

Impact of Advanced Diagnostic Imaging

There were 255 children (26% of those with appendicitis) who underwent surgical intervention without CT or US. Patients for whom imaging was obtained had a longer median time from ED physician physical examination until operation than those for whom no imaging was obtained (8.2 vs 4.9 hours, P = .001; Fig 1). Performance of CT and/or US was not associated with increased odds of perforation in the adjusted model (OR, 1.39; 95% CI, 0.86–2.26; Table 2).

Discussion

In our multiinstitutional study of children with acute abdominal pain evaluated in pediatric EDs, we found that the duration of abdominal pain before ED physical examination was strongly associated with AP, but that the time from ED physical examination to operation was not. The lack of a statistically significant association for the time from ED evaluation to operation was evident despite using several methods to account for or remove patients who may have had perforated appendicitis on initial ED presentation. Our findings support current beliefs reported by pediatric surgeons in the United States, most of whom (92%) believe that postponement of an appendectomy overnight for nonperforated appendicitis does not significantly increase the risk of perforation.10 Importantly, our findings should be interpreted with the recognition that the majority of the patients (77.8%) had an operation within 12 hours of ED presentation.

Duration of symptoms (ie, time) has been well accepted as a significant predictor for AP. However, the literature regarding the relationship between the time from ED physical examination until operation and the risk of perforation is less clear. Surana et al13 were among the first investigators to describe similar rates of perforation without increased postoperative complications in children with appendicitis who underwent surgery within 6 hours compared with those with a delay of surgery from 6 to 18 hours. This study, similar to others,14,19 suffered from retrospective design and thus raised questions about the accuracy of the duration of symptoms of the patients. In support of these previous studies, a small prospective study of largely adult patients demonstrated no significant difference in rates of perforation with short delays (<12 hours) until surgery.20 Recent pediatric-specific studies have also demonstrated mixed findings,16 with 1 study noting an increased rate of perforation among children who had surgery within 8 hours of ED physical examination compared with those with longer delays (47% vs 36%).15 In comparison, Bonadio et al21 recently reported that in children without perforation on initial CT, longer delays were associated with...
increased odds of perforation; however, no children developed perforation when appendectomy was performed in <9 hours from ED triage. Finally, Almström et al.\textsuperscript{22} were unable to detect an association between in-hospital delay and perforation or postoperative complications in a large retrospective study of children with appendicitis in Sweden. In aggregate, these findings suggest that perforation occurs in children largely before presentation to the ED. Mitigating factors, such as the lack of primary care or infrastructure delays (e.g., substantially prolonged wait times in the ED/operating room), may be significant contributors in certain health care settings.

Although previous data have clearly demonstrated that AP leads to a prolonged hospital stay,\textsuperscript{19} our data do not clarify if a subgroup of children may benefit from undergoing emergent appendectomy without delay. Perforated appendicitis in adults\textsuperscript{23} and children\textsuperscript{23,24} has been increasingly recognized as a heterogeneous condition, with pathophysiology that is distinct from nonperforated appendicitis and a variable course. Although perforation at the time of surgery is a risk factor for subsequent abscess formation,\textsuperscript{16} only 10% to 27% of children develop this complication.\textsuperscript{16,25} Suspected early perforated appendicitis may be successfully managed with intravenous antibiotics with interval appendectomy.\textsuperscript{25}

Our study is subject to several limitations. First, although we collected patient assessment data from ED clinicians prospectively, we relied on reporting of the duration of pain from guardians, which likely had a degree of inaccuracy. Second, because our study was observational in nature, our results do not prove causation.

**TABLE 1** Bivariate Association Between Demographic and Clinical Findings and Perforated Appendicitis

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Overall Cohort, N = 955</th>
<th>Perforated, n = 247 (25.9%)</th>
<th>Nonperforated, n = 708 (74.1%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean (SD)</td>
<td>10.8 (3.5)</td>
<td>9.8 (3.6)</td>
<td>11.1 (3.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Boy, n (%)</td>
<td>574 (60.1)</td>
<td>141 (57.1)</td>
<td>433 (61.2)</td>
<td>.26</td>
</tr>
<tr>
<td>English-speaking, n (%)</td>
<td>754 (79)</td>
<td>186 (75.3)</td>
<td>568 (80.3)</td>
<td>.1</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>.36</td>
</tr>
<tr>
<td>White</td>
<td>673 (70.5)</td>
<td>167 (67.6)</td>
<td>506 (71.5)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>282 (29.5)</td>
<td>80 (32.4)</td>
<td>202 (28.5)</td>
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<tr>
<td>Ethnicity, n (%)</td>
<td></td>
<td></td>
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<td>.11</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>629 (66.1)</td>
<td>147 (59.5)</td>
<td>482 (68.4)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>323 (33.8)</td>
<td>100 (40.5)</td>
<td>223 (31.6)</td>
<td></td>
</tr>
<tr>
<td>History and physical examination</td>
<td></td>
<td></td>
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<tr>
<td>Temperature in ED, °F, mean (SD)</td>
<td>99.3 (1.6)</td>
<td>100.2 (1.7)</td>
<td>99 (1.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Well-appearing, n (%)</td>
<td>342 (35.8)</td>
<td>50 (20)</td>
<td>292 (41)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Nausea, a n (%)</td>
<td>523 (54.8)</td>
<td>154 (62)</td>
<td>369 (52)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Anorexia, a n (%)</td>
<td>671 (70.3)</td>
<td>204 (83)</td>
<td>467 (68)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Emesis, n (%)</td>
<td>630 (66)</td>
<td>199 (81)</td>
<td>431 (61)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Duration (h) of pain before evaluation, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>&lt;12</td>
<td>219 (22.9)</td>
<td>18 (7)</td>
<td>201 (28)</td>
<td></td>
</tr>
<tr>
<td>12–23</td>
<td>313 (32.7)</td>
<td>55 (22)</td>
<td>258 (38)</td>
<td></td>
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<tr>
<td>24–35</td>
<td>196 (20.5)</td>
<td>55 (22)</td>
<td>141 (10)</td>
<td></td>
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<tr>
<td>36–47</td>
<td>82 (8.6)</td>
<td>38 (15)</td>
<td>44 (6)</td>
<td></td>
</tr>
<tr>
<td>48–71</td>
<td>94 (9.8)</td>
<td>55 (22)</td>
<td>39 (6)</td>
<td></td>
</tr>
<tr>
<td>72–95</td>
<td>51 (5.3)</td>
<td>26 (11)</td>
<td>25 (4)</td>
<td></td>
</tr>
<tr>
<td>Degree of abdominal tenderness, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mild</td>
<td>81 (8.5)</td>
<td>10 (4)</td>
<td>81 (11)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>624 (65.3)</td>
<td>126 (51)</td>
<td>498 (70)</td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>240 (25.1)</td>
<td>111 (45)</td>
<td>129 (18)</td>
<td></td>
</tr>
<tr>
<td>Maximal tenderness right lower quadrant, a n (%)</td>
<td>784 (83.1)</td>
<td>181 (73)</td>
<td>613 (87)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rebound, a n (%)</td>
<td>446 (46.7)</td>
<td>137 (58)</td>
<td>309 (44)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Guarding, a n (%)</td>
<td>682 (71.4)</td>
<td>197 (80)</td>
<td>485 (69)</td>
<td>.002</td>
</tr>
<tr>
<td>Laboratory and imaging</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WBC count (x10^3/μL), mean (SD)</td>
<td>15.9 (4.8)</td>
<td>17.5 (5.7)</td>
<td>15.3 (4.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Absolute neutrophil count (x10^3/μL), mean (SD)</td>
<td>13 (4.9)</td>
<td>14.9 (5.4)</td>
<td>12.4 (4.5)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Imaging (CT and/or US), n (%)</td>
<td>700 (73.3)</td>
<td>178 (72)</td>
<td>522 (74)</td>
<td>.51</td>
</tr>
<tr>
<td>Time from (h)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation to CT (n = 475), mean (IQR)</td>
<td>2.7 (1.7–4.2)</td>
<td>2.7 (1.7–4.1)</td>
<td>2.7 (1.6–4.3)</td>
<td>.59</td>
</tr>
<tr>
<td>Evaluation to US (n = 303), mean (IQR)</td>
<td>1.5 (0.8–2.6)</td>
<td>1.5 (0.8–2.2)</td>
<td>1.6 (0.8–2.8)</td>
<td>.45</td>
</tr>
<tr>
<td>Evaluation to surgery (n = 955), mean (IQR)</td>
<td>7.2 (4.9–11.1)</td>
<td>7.1 (5.0–11.1)</td>
<td>7.3 (4.9–11.1)</td>
<td>.82</td>
</tr>
</tbody>
</table>

IQR, interquartile range.

a Variable had missing/unsure values that were categorized as negative.
pediatric surgeons may have chosen to operate on certain patients more quickly based on clinical findings, potentially negating our ability to detect the impact of time from ED physical examination until operation on the risk of perforation. Third, the actual time of perforation may not be able to be determined. Previous literature has suggested that surgeon assessment of perforation may be less than ideal.\textsuperscript{26} However, we used a consensus panel of surgeons and ED providers to establish a manual of operations to guide interpretation of perforation from surgical reports. In addition, across the centers in our study, the presence or absence of AP, as reported in the pathology report, was reasonably correlated with the surgical report of perforation (Spearman’s $\rho = 0.65$). Because some children who were found to have perforation at the time of surgery did not have perforation demonstrated at the time of advanced diagnostic imaging, we cannot exclude the possibility that some children suffered AP while awaiting surgical intervention. Fourth, we did not include children who underwent advanced diagnostic imaging at another facility before transfer, and therefore our results must be interpreted with caution in this population.

In addition, we did not collect data regarding time of antibiotic administration or duration of hospital stay. Studies of children treated nonoperatively for appendicitis suggest that antibiotics may halt the progression of appendicitis to perforation.\textsuperscript{27,28} However, all sites in our study report that $>$90% of children would have received antibiotics before appendectomy, with all but 2 sites estimating that $>$75% of patients with nonperforated appendicitis on advanced imaging would have received antibiotics in the ED. Therefore, we think that inclusion of data on timing administration would not change our results substantially.

Although the duration of hospital stay is related to the presence of perforation, future studies could include this outcome when evaluating ED treatment of appendicitis in children. Finally, although we performed a multicenter study, our sites were all highly specialized children’s hospitals, potentially limiting the generalizability of our findings. Centers with more limited access to diagnostic imaging, pediatric surgical

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR</th>
<th>95% CI</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>0.97</td>
<td>0.92–1.04</td>
</tr>
<tr>
<td>Hispanic ethnicity</td>
<td>1.21</td>
<td>0.80–1.84</td>
</tr>
<tr>
<td>Fever ($\geq 100.4^\circ F$)</td>
<td>3.66</td>
<td>2.38–5.66</td>
</tr>
<tr>
<td>Duration of pain before ED evaluation (h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$&lt;$12</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>12–23</td>
<td>1.92</td>
<td>0.97–3.83</td>
</tr>
<tr>
<td>24–35</td>
<td>3.20</td>
<td>1.57–6.52</td>
</tr>
<tr>
<td>36–47</td>
<td>9.35</td>
<td>4.16–21.0</td>
</tr>
<tr>
<td>48–71</td>
<td>14.3</td>
<td>6.32–32.4</td>
</tr>
<tr>
<td>$&gt;$72</td>
<td>12.0</td>
<td>4.82–29.7</td>
</tr>
<tr>
<td>WBC count ($\times 10^3/\mu L$)</td>
<td>1.08</td>
<td>1.04–1.13</td>
</tr>
<tr>
<td>CT and/or US completed</td>
<td>1.39</td>
<td>0.86–2.26</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1.88</td>
<td>1.13–3.11</td>
</tr>
<tr>
<td>Emesis</td>
<td>1.85</td>
<td>1.14–3.02</td>
</tr>
<tr>
<td>Maximal tenderness right lower quadrant</td>
<td>0.40</td>
<td>0.23–0.70</td>
</tr>
<tr>
<td>Degree of abdominal tenderness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>3.29</td>
<td>1.34–8.07</td>
</tr>
<tr>
<td>Severe</td>
<td>7.36</td>
<td>2.67–18.9</td>
</tr>
<tr>
<td>Time from evaluation to surgery (h)</td>
<td>1.0</td>
<td>0.96–1.05</td>
</tr>
</tbody>
</table>

All variables listed were included in the model. Ref, reference.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>1.02</td>
<td>0.92–1.12</td>
</tr>
<tr>
<td>Hispanic ethnicity</td>
<td>1.07</td>
<td>0.54–2.12</td>
</tr>
<tr>
<td>Fever ($\geq 100.4^\circ F$)</td>
<td>4.68</td>
<td>2.21–9.90</td>
</tr>
<tr>
<td>Duration of pain before ED evaluation (h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$&lt;$12</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>12–23</td>
<td>2.46</td>
<td>0.88–6.85</td>
</tr>
<tr>
<td>24–35</td>
<td>4.58</td>
<td>1.47–14.3</td>
</tr>
<tr>
<td>36–47</td>
<td>6.95</td>
<td>1.95–24.8</td>
</tr>
<tr>
<td>48–71</td>
<td>7.18</td>
<td>1.80–28.6</td>
</tr>
<tr>
<td>$&gt;$72</td>
<td>3.92</td>
<td>0.78–19.8</td>
</tr>
<tr>
<td>WBC count ($\times 10^3/\mu L$)</td>
<td>1.06</td>
<td>0.99–1.13</td>
</tr>
<tr>
<td>Anorexia</td>
<td>3.04</td>
<td>1.29–7.16</td>
</tr>
<tr>
<td>Emesis</td>
<td>1.30</td>
<td>0.61–2.76</td>
</tr>
<tr>
<td>Maximal tenderness right lower quadrant</td>
<td>0.57</td>
<td>0.34–1.81</td>
</tr>
<tr>
<td>Degree of abdominal tenderness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>2.82</td>
<td>0.81–9.79</td>
</tr>
<tr>
<td>Severe</td>
<td>6.27</td>
<td>1.58–24.8</td>
</tr>
<tr>
<td>Time from evaluation to surgery (h)</td>
<td>0.95</td>
<td>0.89–1.02</td>
</tr>
</tbody>
</table>

All variables listed were included in the model. Ref, reference.
Consultation, or operating room availability may experience disparate results.

CONCLUSIONS

We found that longer durations of abdominal pain were strongly associated with AP in children. However, short time delays from ED physical examination to surgical intervention did not independently increase the odds of perforation. Future studies should focus on identifying a subpopulation of patients who may benefit from early appendectomy.

FIGURE 2

Perforation rates among patients with likely nonperforated appendicitis. Children aged 5 to 18 years, with <36 hours of pain before initial ED physical examination, not ill appearing on exam, WBC count <18,000/μL, and CT or US demonstrating no perforation (n = 308).

**ABBREVIATIONS**

AP: appendiceal perforation
CI: confidence interval
CT: computed tomography
ED: emergency department
OR: odds ratio
US: ultrasound
WBC: white blood cell

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Address correspondence to Michelle D. Stevenson, MD, MS, FAAP, Department of Pediatrics, University of Louisville, 571 S Floyd St, Suite 412, Louisville, KY 40202. E-mail: michelle.stevenson@louisville.edu

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