A Clinical Score to Predict Appendicitis in Older Male Children

Anupam B. Kharbanda, MD, MSc; Michael C. Monuteaux, ScD; Richard G. Bachur, MD; Nanette C. Dudley, MD; Lalit Bajaj, MD, MPH; Michelle D. Stevenson, MD, MS; Charles G. Macias, MD, MPH; Manoj K. Mittal, MD; Jonathan E. Bennett, MD; Kelly Sinclair, MD; Peter S. Dayan, MD, MSc; for the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics

From the Department of Pediatrics Emergency Medicine, Children's Minnesota (Dr Kharbanda), Minneapolis; Division of Emergency Medicine, Boston Children's Hospital, Harvard Medical School (Drs Monuteaux, and Bachur), Boston, Mass; Department of Pediatrics, University of Utah School of Medicine (Dr Dudley), Salt Lake City; Department of Pediatrics, University of Colorado School of Medicine (Dr Bajaj), Denver; Department of Pediatrics, University of Louisville (Dr Stevenson), Louisville, Ky; Department of Pediatrics, Baylor College of Medicine (Dr Macias), Houston, Texas; Department of Pediatrics, The Children's Hospital of Philadelphia and Perelman School of Medicine, University of Pennsylvania, Philadelphia (Dr Mittal); Department of Pediatrics, Alfred I. duPont Hospital for Children, Jefferson Medical College (Dr Bennett), Wilmington, Del; Department of Pediatrics, University of Missouri (Dr Sinclair), Kansas City; and Department of Pediatrics, Columbia University (Dr Dayan), New York, NY

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Address correspondence to Anupam B. Kharbanda, MD, MSc, Children's Minnesota, Department of Pediatric Emergency Medicine, 910 Building, Suite 40-460, Minneapolis, MN 55404 (e-mail: Anupam.kharbanda@childrensmn.org).

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ABSTRACT

OBJECTIVE: To develop a clinical score to predict appendicitis among older, male children who present to the emergency department with suspected appendicitis.

METHODS: Patients with suspected appendicitis were prospectively enrolled at 9 pediatric emergency departments. A total of 2625 patients enrolled; a subset of 961 male patients, age 8–18 were analyzed in this secondary analysis. Outcomes were determined using pathology, operative reports, and follow-up calls. Clinical and laboratory predictors with $<10\%$ missing data and kappa > 0.4 were entered into a multivariable model. Resultant β-coefficients were used to develop a clinical score. Test performance was assessed by calculating the sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratios.

RESULTS: The mean age was 12.2 years; 49.9% (480) had appendicitis, 22.3% (107) had perforation, and the negative appendectomy rate was 3%. In patients with and without appendicitis, overall imaging rates were 68.6% (329) and 84.4% (406), respectively. Variables retained in the model included maximum tenderness in the right lower quadrant, pain with walking/coughing or hopping, and the absolute neutrophil count. A score ≥ 8.1 had a sensitivity of 25% (95% confidence interval [CI], 20%–29%), specificity of 98% (95% CI, 96%–99%), and positive predictive value of 93% (95% CI, 86%–97%) for ruling in appendicitis.

CONCLUSIONS: We developed an accurate scoring system for predicting appendicitis in older boys. If validated, the score might allow clinicians to manage a proportion of male patients without diagnostic imaging.

KEYWORDS: appendicitis; clinical scoring systems; pediatrics

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WHAT'S NEW

With the recent emphasis on reducing diagnostic imaging as well as health care costs, our high-risk clinical score could provide clinicians a more judicious and standardized approach to the care of male children with possible appendicitis.

APPENDICITIS REPRESENTS A common and challenging diagnosis within pediatric emergency medicine. A clinician's ability to diagnose appendicitis on the basis of historical and physical examination findings alone is variable, with a sensitivity of 75% and specificity of 78%.[1] This diagnostic uncertainty, coupled with a desire to reduce negative appendectomy rates, has led to a heavy reliance on diagnostic imaging such as computed tomography (CT), ultrasound (US), and magnetic resonance imaging.[2–4] Recent data have indicated a reduction in the utilization of CT at children's hospitals, but with an increase in total diagnostic imaging rates (use of US and magnetic resonance imaging above and beyond the declines in CT use).[5] Although not associated with direct exposure to ionizing radiation, the mixed test performance of US could potentially lead to unnecessary testing and

increased health care expenditures.[6] For this reason, a more nuanced approach in which risk for appendicitis is more accurately determined might offer clinical benefit.

Clinical scoring systems can help identify patients at high or low risk for appendicitis.[7–9] Unfortunately, prospective validation of these scores has shown mixed test performance, and thus limited their acceptance as alternatives to diagnostic imaging.[10,11] The heterogeneous presentation of children with possible appendicitis, especially among females and young children, might be an important reason for the lack of success of these rules.[12] In comparison, male patients are known to present with more typical findings for appendicitis and have fewer alternative etiologies for right lower quadrant (RLQ) pain, and might serve as better target populations for an appendicitis clinical scoring system.[13] Therefore, in this study, we sought to develop a clinical scoring system to identify male patients who were at highest risk for appendicitis. The ultimate benefit for such a rule might be to identify a subpopulation of patients who require urgent referral for surgical evaluation or for whom diagnostic imaging is not required to confirm the diagnosis.

METHODS

STUDY DESIGN AND SETTING

We conducted a planned secondary analysis of a prospective, observational study of patients with suspected appendicitis at 9 pediatric emergency departments (EDs) located in children's hospitals. Study subjects were enrolled from March 2009 through April 2010. All enrolling sites were members of the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics. The Pediatric Emergency Medicine Collaborative Research Committee reviewed and approved the final study protocol. Each participating site's institutional review board also approved the study. Six institutional review boards granted a waiver of written informed consent/assent and instead verbal consent was obtained. At the 3 remaining sites, written consent from the guardians and assent from children 7 years of age and older was obtained.

STUDY PATIENTS

In the parent study, we enrolled children and adolescents between 3 and 18 years of age who presented to the ED with acute abdominal pain of <96 hours duration and were being evaluated for suspected appendicitis. "Suspected appendicitis" was defined as patients who were being evaluated using blood tests (eg, complete blood count), radiologic studies (CT and/or US) and/or a surgical consultation for the purpose of diagnosing appendicitis. In the current analysis, we limited our analytic sample to male patients between the ages of 8 and 18 years. We excluded patients with any of the following conditions: previous abdominal surgery (eg, gastrostomy tube, abdominal hernia repair), chronic gastrointestinal illness or abdominal pain (eg, inflammatory bowel disease, chronic pancreatitis, chronic/recurrent appendicitis), sickle cell anemia, cystic fibrosis, a medical condition affecting the provider's ability to obtain an accurate history (eg, significant language/developmental delay), or history of abdominal trauma within 7 days of evaluation. We also excluded patients who had radiologic studies (CT or US) of the abdomen performed before ED arrival. Study procedures related to training of site staff, patient enrollment, standardized data collection, and transmission to the central data management warehouse have been described previously.[14]

STUDY PROCEDURES AND DATA COLLECTION

Site principal investigators received standardized training, a detailed procedures manual of operations, and instructions on the proper completion of case report forms (CRFs). CRFs were completed by a pediatric emergency medicine attending/fellow or resident physician with attending oversight. CRFs were completed before knowledge of CT or US results. The decision to obtain laboratory studies, radiologic studies, or surgical consultation was not dictated by study protocol. We conducted telephone follow-up (in English or Spanish, as appropriate) within 2 weeks of the index ED visit to determine resolution of signs and symptoms, visits to other sites of care, and need for surgery. If we were unable to contact the guardian, research coordinators reviewed the medical record for 90 days after the index pediatric ED visit to determine if the patient underwent a CT scan, US examination, or surgery at that specific facility.

OUTCOME MEASURES

The primary outcome was presence or absence of appendicitis. Final diagnosis of appendicitis was determined using pathology, operative reports, or telephone follow-up. For those who underwent an appendectomy, we determined the presence or absence of appendicitis according to pathology reports. The presence or absence of perforation was determined from the attending surgeon's written operative report.

DATA ANALYSIS

We used standard descriptive statistics to describe our 2 groups (patients with and without appendicitis). Potential predictors were selected from review of the previous literature and were collected prospectively during patient enrollment. For the present analysis, we only included predictors with <10% missing data and at least moderate inter-rater reliability ($\kappa > 0.4$) in the male subgroup.[15] The predictors analyzed were (coded as binary variables unless otherwise indicated): age (in years), duration of pain (categorized as <12, 12–23, 24–35, 36–47, 48–71, and ≥72 hours), history of anorexia, history of nausea, history of emesis, migration of pain to the RLQ, focal pain in the RLQ, abdominal tenderness (coded as mild, moderate, or severe), right-sided abdominal tenderness, maximum tenderness in the RLQ, presence of rebound tenderness, guarding, and pain with walking, coughing, or hopping. For this analysis, "unsure" or "don't know" responses