

Ability of Pediatric Physicians to Judge the Likelihood of Intussusception

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Background: Intussusception is the most common cause of intestinal obstruction in infants and children. To date, no study has evaluated the ability of physicians to predict the likelihood of intussusception.

Objective: This study aimed to determine the ability of pediatric physicians to predict intussusception in patients being evaluated for intussusception and to investigate whether certain clinical findings correlate with physicians' risk assessment.

Methods: A prospective cohort study of children aged 1 month to 6 years who presented with possible intussusception. The predicted likelihood of intussusception was recorded by physicians before knowledge of imaging results or final diagnosis. We defined a physician's prediction as high versus low risk based on a threshold prediction of 25% likelihood.

Results: A total of 308 patients were studied including 38 (12.3%) with intussusception. Physicians' prediction was positively associated with the risk of intussusception (test for linear trend: odds ratio [OR], 2.1; 95% confidence interval [CI], 1.6–2.7; $P < 0.001$). Among patients considered high risk, the rate of intussusception was 36% (95% CI, 25%–49%) compared with 6% for those judged to be low risk (95% CI, 4%–10%). Using a threshold of 25% likelihood, successful prediction of high versus low risk occurred in 82% (95% CI, 77%–86%). Clinical predictors associated with assigning a designation of higher risk of intussusception included lethargy at home (OR, 2.7; 95% CI, 1.4–5.5) and bloody stool (OR, 2.5; 95% CI, 1.0–5.9).

Conclusions: Pediatric physicians can accurately predict the likelihood of intussusception. This ability to properly judge the risk of intussusception can be incorporated into management strategies.

Key Words: intussusception, abdominal pain, predictions, likelihood

(*Pediatr Emer Care* 2012;28: 136–140)

Intussusception is the most common cause of intestinal obstruction in infants and young children,^{1–6} and delayed diagnosis may lead to bowel necrosis and perforation.^{1,5,7} The diagnosis can be difficult in children because of a nonspecific presentation and physical examination. Many children with intussusception present with atypical signs and symptoms. Multiple studies have shown that the “classic triad” of abdominal pain, bloody stool, and palpable abdominal mass is present in fewer than 40% of cases.^{2,4,5,8,9}

As previous investigations have not been able to identify specific diagnostic signs and symptoms of intussusception, clinicians often rely on plain radiography and ultrasound to help determine whether a contrast enema or surgical consultation is needed. Ideally, pediatric physicians would be able to use their

overall clinical judgment to help determine which patients should go directly to air enema without delay. To date, no studies have assessed the ability of physicians to predict the likelihood of intussusception based on history and physical examination. Herein, we prospectively studied children who presented to an emergency department (ED) with signs or symptoms suspicious for intussusception. Our goals were to (1) determine the accuracy of physicians' prediction of intussusception and (2) investigate whether certain clinical findings correlated with physicians' risk assessment.

METHODS

Study Design and Participants

This investigation was designed as a prospective cohort study of children with possible intussusception. The study was conducted at an urban, tertiary care, pediatric ED with 58,000 annual visits. From December 2008 to January 2010, we prospectively enrolled children aged 1 month to 6 years with possible intussusception as determined by the treating physician after obtaining a history and performing a physical examination. The threshold to consider a patient as possible intussusception implied that the patient would receive radiologic imaging or surgical consultation for the consideration of intussusception. All medical care, including radiologic studies, was guided by the clinical care team. Children were excluded if they had a previous diagnosis of intussusception, prior abdominal surgery, any chronic gastrointestinal disorder other than gastroesophageal reflux, any chronic medical condition with intestinal manifestations (eg, cystic fibrosis), or any known possible lead point for intussusception (eg, jejunal tube, Henoch-Schonlein purpura, or intestinal polyps).

Data Collection

Standardized data collection forms were completed by the physicians responsible for the patient's care. Each standardized form collected data on historical and physical examination variables. We also asked physicians to indicate the likelihood of intussusception based on their history and clinical examination before any diagnostic imaging (plain radiograph, ultrasound, air enema fluoroscopy, or computed tomography) and knowledge of final diagnosis. Predicted likelihood was listed as a forced-choice, categorical list: 5% or less, 6% to 10%, 11% to 25%, 26% to 50%, 51% to 75%, 76% to 90%, and greater than 90%. Physicians were introduced to the study forms before the study. The forms were either completed by an attending physician or reviewed by the primary attending if completed by a resident. Attending physicians included both fellowship-trained pediatric emergency medicine physicians and general pediatricians.

To estimate a capture rate, ED records and radiology logs were screened for the first 3 days of every month to determine the proportion of eligible patients who were enrolled.

Outcome Measure

Our primary outcome measure was the presence or absence of intussusception. Intussusception was defined by visualization

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This study was presented in part at the Pediatric Academic Societies Meeting, Vancouver, British Columbia, Canada; May 2010.

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ISSN: 0749-5161

of intussusception by air enema or by operative diagnosis. The absence of intussusception was defined by negative air enema (primary determinant) or negative ultrasound (secondary) or, if neither air enema or ultrasound was performed, a telephone call to the patient's caregiver at least 2 weeks after the index visit (tertiary) to inquire about subsequent medical visits. If a patient could not be reached by telephone, their records were reviewed for any repeat ED visits. Coding of the primary outcome was reviewed by 2 authors; any conflicts were discussed and resolved before analysis.

Analysis

We tested the association between the predicted likelihood by the evaluating physician and the actual diagnosis of intussusception. For each categorical group, the proportion with intussusception was determined. To investigate the influence of specific clinical findings on the prediction of intussusception, we analyzed the association between historical and clinical factors and physician-determined likelihood of intussusception using multivariate logistic regression. On the basis of the authors' consensus of a risk cutoff, a prediction of more than 25% likelihood of intussusception was considered as a possible threshold for the consideration of air enema over an ultrasound screening examination. Thus, we modeled physician-determined likelihood of intussusception ($\leq 25\%$ likelihood vs $> 25\%$) as a function of demographic, history, and physical examination findings.

Descriptive and multivariate data analysis was performed with STATA (Version 10.1; StataCorp, College Station, Tex). Distributions were described as mean (SD) or medians and interquartile ranges. The α level was set at 0.05, and all tests were 2-tailed.

This study was approved by the hospital's committee on clinical investigation. Verbal consent was obtained from all participating attending physicians. Caregivers were given an informational sheet and asked for verbal consent.

RESULTS

During the study period, 339 children were enrolled. Twenty-nine patients were excluded because of a specific medical condition, imaging before evaluation, or age older than 6 years. An additional 2 patients were excluded because the physician did not indicate their predicted likelihood of intussusception, leaving a total of 308 patients for analysis. On the basis of our audit strategy, 68% of patients with possible intussusception were enrolled. There were no statistical differences between the missed patients and enrolled patients for age, sex, or final diagnosis.

The clinical characteristics of patients enrolled are detailed in Table 1. The median age was 21.1 months (interquartile range, 10.1–36.4 months). Most patients were male (61%). Thirty-eight patients (12.3%) were diagnosed with intussusception. Among the full sample, the most common historical finding was abdominal pain, followed by vomiting and diarrhea. On physical examination, abdominal tenderness was the most frequent finding, followed by lethargy and heme-positive stool on rectal examination. Follow-up was completed on all patients. No patient initially discharged returned to the ED with intussusception.

Figure 1 shows the percent likelihood of intussusception at the time of initial evaluation, based on history and physical examination. At initial evaluation, ED physicians predicted 205 patients (67%) to have a 10% or less likelihood of intussusception, 77 patients (25%) to have 11% to 50% likelihood, and only 26 patients (8%) to have more than 50% likelihood of intussusception. Using a threshold of 25% likelihood to divide the predictions, 247 (80%) were assessed to be at lower risk ($\leq 25\%$ likelihood) and 61 patients (20%) were thought to be at higher risk ($> 25\%$ likelihood) of intussusception.

The ability of pediatric emergency medicine physicians to predict a diagnosis of intussusception based on history and physical examination is shown in Figure 2. These results demonstrate that, as the physician assessment of the likelihood of intussusception increases, the risk for the final diagnosis of intussusception also increases (test for linear trend: odds ratio

TABLE 1. Characteristics and Outcomes of the Study Patients (N = 308)

| Descriptive Characteristic | Entire Sample (n = 308) | Intussusception Cases (n = 38) | No Intussusception Cases (n = 270) |
|------------------------------------|-------------------------|--------------------------------|------------------------------------|
| Sex (male), n (%) | 189 (61) | 31 (82) | 158 (59) |
| Age, mean (SD), mo | 25 (18) | 30 (18) | 24 (18) |
| History,* n (%) | | | |
| Fever | 89 (29) | 8 (21) | 81 (30) |
| Abdominal pain | 255 (83) | 32 (86) | 223 (83) |
| Vomiting | 174 (56) | 26 (68) | 148 (55) |
| Bilious vomiting | 22 (7) | 8 (21) | 14 (5) |
| Diarrhea | 99 (32) | 7 (18) | 92 (34) |
| Bloody stool | 36 (12) | 5 (13) | 31 (11) |
| Physical examination, n (%) | | | |
| Lethargy | 71 (23) | 13 (34) | 58 (21) |
| Abdominal distension | 31 (10) | 4 (11) | 27 (10) |
| Abdominal tenderness | 115 (37) | 16 (42) | 99 (37) |
| Abdominal mass | 8 (3) | 1 (3) | 7 (3) |
| Rectal examination (heme positive) | 54 (18) | 9 (24) | 45 (17) |
| Disposition, n (%) | | | |
| Discharge | 207 (67) | 0 (0) | 207 (77) |
| Admission | 94 (31) | 33 (87) | 61 (23) |
| Operating room | 7 (2) | 5 (13) | 2 (1) |

*Determined by parental report.

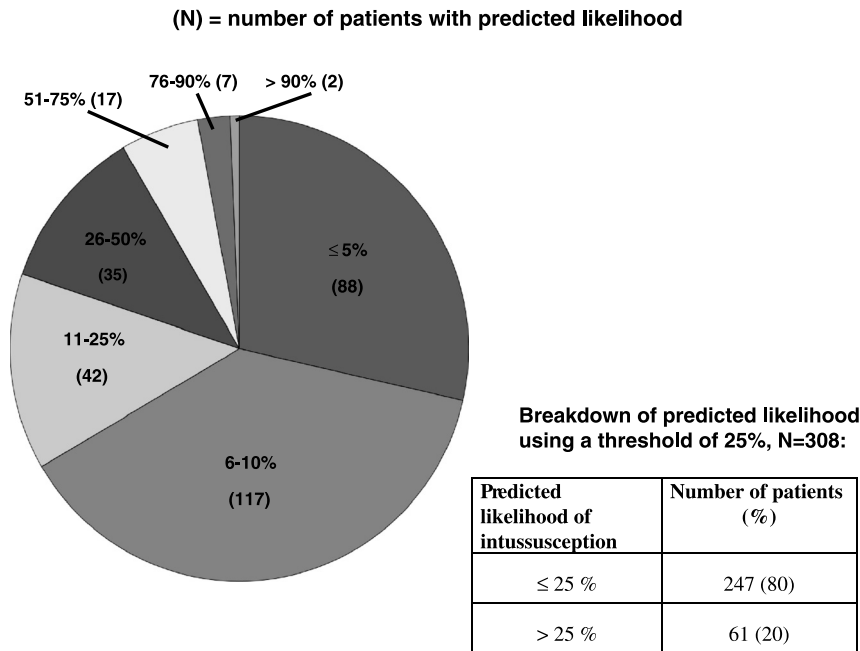
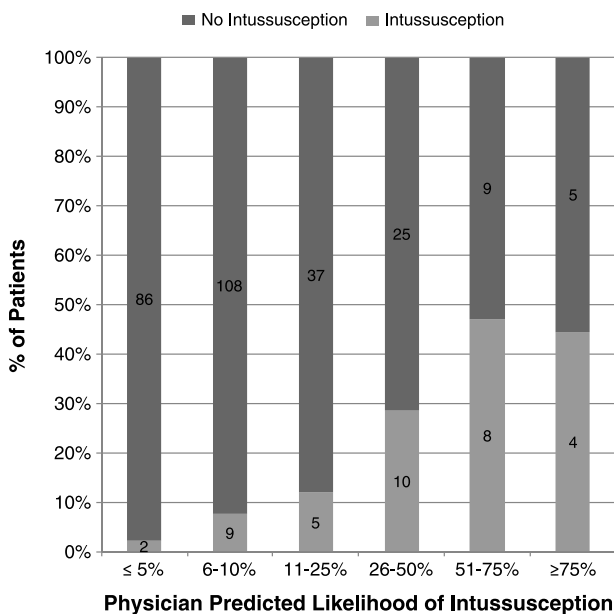


FIGURE 1. Physician-determined percent likelihood of intussusception at time of initial evaluation (N = 308). Numbers in parentheses indicate the number of patients with predicted likelihood.

[OR], 2.1; 95% confidence interval [CI], 1.6–2.7; $P < 0.001$). Of the patients thought to be at low risk for intussusception ($\leq 25\%$ likelihood), the rate of intussusception was low (6%; 95% CI, 4%–10%). Of the patients thought to be at higher risk of intussusception ($> 25\%$ likelihood), the rate of intussusception was 36% (95% CI, 25%–49%). Among patients who ultimately did not have intussusception, most were judged by physicians to be at low risk (94%; 95% CI, 90%–96%).

Using 25% likelihood to discriminate high- and low-risk patients, physicians had an overall accuracy of 82% (Table 2). Physicians were able to predict the likelihood of intussusception with a specificity of 85% (95% CI, 80%–89%) and a negative predictive value of 94% (95% CI, 90%–96%). Physicians can more accurately identify patients who are at low risk of intussusception than those at high risk (positive predictive value, only 36% [95% CI, 29%–49%]).



* Test for linear trend: OR =2.1, 95% CI: 1.6-2.7, $p < 0.001$

FIGURE 2. Ability of physicians to predict a diagnosis of intussusception based on history and clinical examination. *Numbers in the bars represent actual patient numbers.

We also evaluated the association between specific clinical factors and the ability of physicians to positively predict intussusception (Table 3). Clinical predictors that were significantly associated with assigning higher risk of intussusception ($> 25\%$ likelihood), included lethargy at home and bloody stool. That is, patients reporting lethargy and bloody stool at home are 2.7 and 2.5 times more likely, respectively, to be classified by their physician as having a high likelihood of intussusception, relative to patients who did not report these symptoms.

DISCUSSION

Prior investigations have tried to identify clinical predictors of intussusception; the individual clinical findings have not been found to be strong discriminators and are not routinely applied in clinical practice.^{1,2,4,8,9} We sought to determine whether pediatric physicians can accurately predict the diagnosis of intussusception based on history and physical examination. Rather than specific findings, we suspected that clinicians might integrate all available information including objective data (captured by a real-time data form) plus additional, and hard to measure, subjective factors such as clinical experience or intuition to make their predictions. By understanding the accuracy of a physician’s judgment, management strategies can incorporate this information to guide the timing and type of imaging, as well as the collaboration with general surgery.

Other studies have evaluated physicians’ ability to predict the likelihood of specific clinical diagnoses.^{10,11} A study by Neuman et al¹¹ prospectively investigated 2071 patients with

TABLE 2. PEM Physician’s Rate of Success in Predicting Intussusception in Pediatric ED Patients

| | Overall Success Rate (Entire Sample, N = 308) | Sensitivity (Intussusception; Cases, n = 38) | Specificity (No Intussusception; Cases, n = 270) | Positive Predictive Value | Negative Predictive Value |
|-----------------------|--|---|--|------------------------------|------------------------------|
| 25% likelihood cutoff | 0.82 (0.77–0.86) | 0.58 (0.42–0.72) | 0.86 (0.80–0.89) | 0.36 (0.25–0.49) | 0.94 (0.90–0.96) |

Values in parentheses are 95% CI.

definite or probable pneumonia. They sought to determine the correlation between physicians’ assessment of the likelihood of pneumonia and the radiographic presence of pneumonia among children presenting to the ED in whom a chest radiograph was obtained. They found that, among patients thought to be at low risk for pneumonia (estimated <5%), the rate of probable or definite pneumonia was low (10%; 95% CI, 8.3%–12.5%). Conversely, those patients felt to be at higher risk (estimated >75%) had a higher rate of probable or definite pneumonia (52.5%; 95% CI, 37.7%–70.3%). They conclude that overall physicians accurately, but slightly over estimate, the risk of pneumonia based on historical and physical examination findings. These results are similar to the current study, where physicians had more accurate predictions for low risk of intussusception.

A prospective cohort study of 350 patients by Kharbanda et al¹⁰ investigated physician-predicted likelihood of appendicitis. They compared both pediatric emergency medicine (PEM) physician and surgeon predictions to the patients’ final diagnosis. Their results showed that PEM physicians identified 55 patients as having more than 90% chance of appendicitis and were correct in 80%. They were also accurate in their negative prediction of appendicitis. Of the 66 patients thought to be at low risk for appendicitis (≤10% likelihood), they were correct in 95%.

The authors conclude that, when the PEM physicians and surgeons agree that a patient has a high likelihood of appendicitis, urgent operative care, rather than additional diagnostic testing, should be considered.

Our study is the only prospective study evaluating the pediatric physician’s ability to predict the likelihood of intussusception in patients presenting to a pediatric emergency department. The prospective nature of the study allowed for a greater than 90% completion rate for all our potential predictors and complete follow-up on all patients. Unlike the prior investigations to identify clinical predictors of intussusception, the subjects in our study comprised a full clinical spectrum of children with possible intussusception, rather than just those undergoing contrast enemas.^{2,4,5} On the basis of this investigation, we believe that pediatric physicians can reasonably discriminate which patients being considered for intussusception are at high risk; depending on the exact setting, these higher risk patients might be managed more expeditiously, transferred to pediatric centers with appropriate radiologic or surgical capabilities, or might be better directed to contrast enema reduction over ultrasound. This was best evidenced by the finding that 94% of patients felt to be low risk did not have intussusception. For those patients predicted to have a greater risk of intussusception (>25% likelihood), 36% had intussusception, compared with only 6% of those thought to be at lower risk (≤25%).

TABLE 3. Association Between Clinical Factors and PEM Physicians’ Assessment of High Risk (>25% Likelihood) for Intussusception

| Clinical Feature | OR | 95% CI | |
|---------------------------|------|-------------|-------------|
| | | Lower Bound | Upper Bound |
| Age, y | 0.98 | 0.78 | 1.22 |
| Sex (female) | 0.76 | 0.40 | 1.45 |
| Fever at home* | 0.82 | 0.38 | 1.77 |
| Abdominal pain at home* | 2.57 | 0.87 | 7.62 |
| Lethargy at home* | 2.73 | 1.35 | 5.49 |
| Vomiting at home*† | | | |
| Vomiting | 1.35 | 0.69 | 2.65 |
| Bilious vomiting | 1.57 | 0.42 | 5.89 |
| Diarrhea at home*† | | | |
| Diarrhea | 0.50 | 0.21 | 1.20 |
| Bloody stool | 2.46 | 1.03 | 5.90 |
| Lethargy‡ | 1.50 | 0.67 | 3.38 |
| Mental status‡ | 0.26 | 0.05 | 1.38 |
| Abdominal distension‡ | 1.91 | 0.75 | 4.91 |
| Abdominal tenderness‡ | 1.45 | 0.76 | 2.78 |
| Temperature in ED (≥38°C) | 1.87 | 0.83 | 4.18 |

*Determined by parental report.

†Absence of symptom/sign is referent category.

‡Determined by physical examination.

LIMITATIONS

Several limitations of this investigation require acknowledgment. Although the study population realistically represents children with possible intussusception, our statistical analyses were constrained by relatively limited number of patients with intussusception. Enrollment depended on consideration of intussusception as determined by the treating staff physician; this judgment has the potential for an enrollment bias. In addition, we did not consider the different levels of experience among the attending physicians who provided the predicted likelihood of intussusception. Our capture rate was only 68%; fortunately, the characteristics of the patients missed were similar to those enrolled in the study. Lastly, the study was done at a single institution which may limit the generalizability of our results.

CONCLUSIONS

Pediatric physicians can accurately predict the likelihood of intussusception based on history and physical examination. With a high suspicion of intussusception, physicians should consider early surgical consultation and contrast enema rather than delaying treatment by obtaining a confirmatory ultrasound.

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