

Diagnosis of Intussusception by Physician Novice Sonographers in the Emergency Department

Antonio Riera, MD, Allen L. Hsiao, MD, Melissa L. Langhan, MD, T. Rob Goodman, MBBChir, Lei Chen, MD, MHS

From the Department of Pediatrics, Section of Emergency Medicine (Riera, Hsiao, Langhan, Chen), and Department of Diagnostic Radiology (Goodman), Yale University School of Medicine, New Haven, CT.

Study objective: We investigate the performance characteristics of bedside emergency department (ED) ultrasonography by nonradiologist physician sonographers in the diagnosis of ileocolic intussusception in children.

Methods: This was a prospective, observational study conducted in a pediatric ED of an urban tertiary care children's hospital. Pediatric emergency physicians with no experience in bowel ultrasonography underwent a focused 1-hour training session conducted by a pediatric radiologist. The session included a didactic component on sonographic appearances of ileocolic intussusception, review of images with positive and negative results for intussusceptions, and a hands-on component with a live child model. On completion of the training, a prospective convenience sample study was performed. Children were enrolled if they were to undergo diagnostic radiology ultrasonography for suspected intussusception. Bedside ultrasonography by trained pediatric emergency physicians was performed and interpreted as either positive or negative for ileocolic intussusception. Ultrasonographic studies were then performed by diagnostic radiologists, and their results were used as the reference standard. Test characteristics (sensitivity, specificity, positive and negative predictive values) and likelihood ratios were calculated.

Results: Six pediatric emergency physicians completed the training and performed the bedside studies. Eighty-two patients were enrolled. The median age was 25 months (range 3 to 127 months). Thirteen patients (16%) received a diagnosis of ileocolic intussusception by diagnostic radiology. Bedside ultrasonography had a sensitivity of 85% (95% confidence interval [CI] 54% to 97%), specificity of 97% (95% CI 89% to 99%), positive predictive value of 85% (95% CI 54% to 97%), and negative predictive value of 97% (95% CI 89% to 99%). A positive bedside ultrasonographic result had a likelihood ratio of 29 (95% CI 7.3 to 117), and a negative bedside ultrasonographic result had a likelihood ratio of 0.16 (95% CI 0.04 to 0.57).

Conclusion: With limited and focused training, pediatric emergency physicians can accurately diagnose ileocolic intussusception in children by using bedside ultrasonography. [Ann Emerg Med. 2012;xx:xxx.]

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INTRODUCTION

Background and Importance

Intussusception is a common pediatric abdominal emergency, with an estimated incidence of 38 cases per 100,000 live births in the first year of life and 31 cases per 100,000 live births in the second year of life.¹ Clinical presentations of intussusception may vary and can include nonspecific symptoms such as crying episodes, abdominal pain, vomiting, and lethargy. The appearance of "currant jelly" stools, a late finding and marker for bowel ischemia, is observed in a minority of cases. Delays in diagnosis are associated with increased morbidity rates. Longer periods of intussusception can decrease enema reduction success rates. A high index of suspicion is imperative to reduce the need for surgical intervention in children with intussusception.

Ultrasonography is an accurate method to diagnose intussusception.² In the hands of experienced operators, it is considered the criterion standard for the diagnosis of ileocolic intussusception, with both high sensitivity (98% to 100%) and specificity (88% to 100%).^{2,3} Compared with contrast enema, which once was the diagnostic tool of choice, ultrasonography is a safer and more cost-effective method of diagnosis. Case reports of emergency physicians diagnosing intussusception with bedside ultrasonography exist.⁴ To our knowledge, no study to date has compared the accuracy of bedside ultrasonography performed by emergency physicians with that of diagnostic radiology ultrasonography for the diagnosis of ileocolic intussusception.

Editor's Capsule Summary

What is already known on this topic

In the hands of experienced operators, ultrasonography is considered the criterion standard for the diagnosis of ileocolic intussusceptions.

What question this study addressed

This prospective pilot study sought to determine whether 6 pediatric emergency physicians could use bedside ultrasonography to diagnose intussusception after a brief focused training session.

What this study adds to our knowledge

Bedside ultrasonography by pediatric emergency physicians had acceptable sensitivity (85%) and specificity (97%) in this sample of 82 patients, 13 of whom had intussusception.

How this is relevant to clinical practice

Further large studies need to confirm the accurate use of bedside ultrasonography by trained pediatric emergency physicians before it is routinely used to diagnose ileocolic intussusception in children.

ultrasonographic procedures on adults. No bedside sonographer had experience with bowel ultrasonography. Bedside ultrasonography was performed and interpretation recorded before diagnostic radiology ultrasonography was performed. Radiologists interpreting diagnostic radiology ultrasonography were not aware of the bedside ultrasonographic findings. A medical record review was performed to determine characteristics and outcomes of intussusceptions diagnosed by diagnostic radiology. This study was approved by our institutional human investigation committee.

A 1-hour focused training session was conducted by a pediatric radiologist, who is the chief of pediatric imaging at our institution. This voluntary session consisted of a didactic component and a hands-on scanning technique component. During the didactic component, the pathophysiology of intussusception was reviewed and a comprehensive series of still images analyzed. These images contained cases consistent with intussusception, normal bowel, or other intra-abdominal findings that are commonly construed as false positives. During the hands-on scanning component, a child served as the pediatric model. Participants were taught how to perform bedside evaluation for intussusception while being directly supervised by the pediatric radiologist. The objective of this focused training was to teach bedside sonographers to either rule in or rule out the presence of an ileocolic intussusception. Assessment of secondary findings was not performed.

Bedside ultrasonography was performed by 6 pediatric emergency physicians (4 attending physicians and 2 fellows). Participating pediatric emergency physician sonographers were eligible to enroll patients if they attended the voluntary training session as described above. Bedside ultrasonography was performed with the L38 linear transducer (5 to 10 MHz) and a SonoSite MicroMaxx ultrasonographic system (SonoSite, Bothell, WA). Grayscale 2-dimensional images were obtained without Doppler. After the application of ultrasonographic gel, the transducer was placed in the right lower quadrant in a transverse orientation, with the indicator pointing toward the patient's right side. The psoas muscle was identified as a starting landmark. An appropriate depth setting was chosen. The transducer was then slowly swept superolaterally toward the right upper quadrant, where the liver and gallbladder served as landmarks. At this point, the transducer was rotated 90 degrees clockwise, now with the indicator toward the patient's head, and swept across the epigastrium toward the left upper quadrant in a longitudinal orientation. From the left upper quadrant, the transducer was rotated 90 degrees counterclockwise to lie in a transverse orientation and swept inferiorly toward the left lower quadrant. A complete bedside scan included views of all 4 quadrants as described (Figure 1). Still images were saved for review and quality assurance. Image review was performed on all bedside ultrasonography by study physician 1 at the study's completion.

According to a prevalence rate of 15% for ultrasonographic diagnosis of suspected intussusception,³ with a desired

Goals of This Investigation

The goal of this study was to investigate the performance characteristics of bedside ultrasonography by pediatric emergency physicians who received limited and focused training in the diagnosis of ileocolic intussusception in children.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective study of pediatric emergency department (ED) patients who underwent ultrasonography for the evaluation of suspected ileocolic intussusception. The study was performed in an urban pediatric ED at a tertiary care children's hospital from July 2008 to September 2011. The pediatric ED has an annual census of approximately 34,000 visits. Pediatric diagnostic radiology ultrasonography is available continuously.

Children with suspected ileocolic intussusception were enrolled if they were to undergo ultrasonography in the diagnostic radiology department and an eligible pediatric emergency physician sonographer was available. After verbal consent, bedside sonography was performed by either a pediatric emergency physician attending or fellow. Pediatric emergency physician sonographers may have acted as the treating physician. All pediatric emergency physician sonographers had at least 1 month of clinical instruction in performing a variety of bedside ultrasonography in our hospital's ED. Study physicians had minimal experience with bedside sonography, aside from the clinical instruction of being supervised to perform 100 to 150

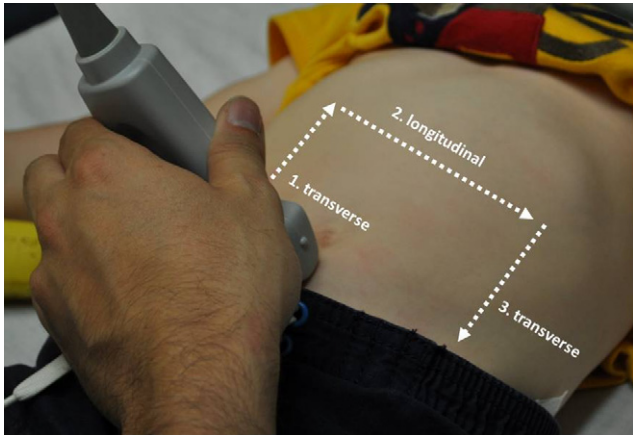


Figure 1. Transducer positioning and trajectory to include views of the right lower quadrant, right upper quadrant, left upper quadrant, and left lower quadrant.

Table. Demographics.*

Study Population	N=82
Median age (range), mo	25 (3–127)
Age <3 y	57 (70)
Age ≥3 y	25 (30)
Sex	
Male	48 (59)
Female	34 (41)
Radiology department ultrasonographic diagnosis	
Normal	35 (43)
Ileocolic intussusception	13 (16)
Mesenteric adenitis	12 (15)
Enteritis	7 (9)
Free fluid only	6 (7)
Copious stool	3 (4)
Small bowel intussusception	2 (2)
Appendicitis	2 (2)
Distended bladder	1 (1)
Debris within bladder	1 (1)

*Data are presented as No. (%) except where indicated.

sensitivity of 0.8, specificity of 0.9, and a 95% confidence interval (CI) of SD 0.25 for sensitivity, enrollment of at least 67 subjects was required.

RESULTS

Eighty-two subjects were enrolled. Patient characteristics are listed in the Table. All patients were able to sufficiently cooperate with bedside ultrasonography. A total of 6 pediatric emergency physicians performed the bedside ultrasonographic studies. Study physician 1 enrolled 43 patients; study physician 2, 16 patients; study physician 3, 9 patients; study physician 4, 7 patients; and study physicians 5 and 6, 5 and 2 patients, respectively. Of the 13 patients who received a diagnosis of ileocolic intussusception by diagnostic radiology, there were 11 true-positive and 2 false-negative bedside ultrasonographic scans. Of the 69 patients who did not receive a diagnosis of intussusception by diagnostic radiology, there were 67 true-

negative and 2 false-positive bedside ultrasonographic scans. Therefore, bedside ultrasonography had a sensitivity of 85% (95% CI 54% to 97%), specificity of 97% (95% CI 89% to 99%), positive predictive value of 85% (95% CI 54% to 97%), and negative predictive value of 97% (95% CI 89% to 99%) for the diagnosis of ileocolic intussusception. The likelihood ratio of a positive bedside ultrasonographic result was 29 (95% CI 7.3 to 117), whereas the likelihood ratio of a negative bedside ultrasonographic result was 0.16 (95% CI 0.04 to 0.57). Review of still images by study physician 1 did not reveal any discrepancies with the bedside physician's interpretation of the ultrasonographic findings.

The incidence of ileocolic intussusception according to a diagnosis made in the diagnostic radiology department was 16% (13/82 cases). The median age of children who received a diagnosis of ileocolic intussusception was 16 months (range 3 to 127 months). The proportion of ileocolic intussusceptions found in the right upper quadrant was 62% (8/13 cases). Four cases were detected in the right lower quadrant and 1 case was detected in the left upper quadrant. A pathologic lead point was present in 2 cases, a 4-month-old girl with a Meckel's diverticulum and a 10-year-old girl with Puetz-Jegher's syndrome and multiple polyps. There were 2 cases of ileocolic intussusception that were observed to spontaneously reduce during the evaluation by diagnostic radiology. Air enema reductions were attempted on all patients with fixed ileocolic intussusception. Successful air enema reductions were observed in 6 of 11 (55%) cases. The remaining 5 cases required operative intervention.

LIMITATIONS

Our study has several limitations. Because spontaneous resolution and recurrence of intussusception is possible, there is the potential for misclassification at the bedside and in the diagnostic radiology department. The majority of bedside ultrasonography (52%) was performed by study physician 1, which may skew the results toward the performance of this physician. However, a sensitivity analysis involving study physicians 2 to 6 alone showed findings similar to those of the overall study results (sensitivity 82%, specificity 96%, negative predictive value 96%, positive predictive value 90%, positive likelihood ratio 23, and negative likelihood ratio 0.19). Although the participating bedside sonographers had no previous experience with ultrasonographic evaluation of the pediatric bowel, each had at least 1 month of clinical experience with bedside ultrasonography in adults. Therefore, our results may not be generalizable to physicians with no previous training in emergency ultrasonography.

One important challenge is that many ultrasonographic indications are operator dependent. The collective performance was lower than that reported in the radiologic literature. Performance characteristics may have been improved by use of a ramp-up period. Our limited number of subjects did not permit an analysis based on accrued experience of individual sonographers. Our study was not powered to detect differences

in performance characteristics between individual bedside sonographers, and interrater variability was not assessed. Studies involving more patients, as well as a diverse array of operators followed longitudinally, may provide this important information.

DISCUSSION

In this prospective observational study, we demonstrated good performance characteristics of pediatric emergency physician–performed bedside ultrasonography for the diagnosis of intussusception in children after a single, focused training session.

The performance of bedside ultrasonography in our study exhibited high specificity with narrow CIs, which would make it an excellent test to rule in intussusception. The lower sensitivity scores make bedside ultrasonography less useful as a screening test to rule out the condition. The false-negative cases in our series require further attention. The first case was a 20-month-old boy with ileocolic intussusception in the right lower quadrant. This patient had small bowel and ileocolic intussusceptions observed to spontaneously resolve during the ultrasonography performed by diagnostic radiology. The patient was observed and discharged home after a brief inpatient stay. It is possible that no ileocolic intussusception was present while the bedside ultrasonography was performed. The second case involved a 16-month-old boy with ileocolic intussusception detected in the right upper quadrant by diagnostic radiology. In this single case, the bedside ultrasonographic technique deviated from that of the intended study protocol. A curvilinear probe was used and depth was inadvertently set to 13 cm, which led to suboptimal image acquisition. Accurate interpretation of the images obtained would have been difficult.

The findings of our study are important for several reasons. The use of bedside ultrasonography has led to prompt recognition and treatment of other life-threatening conditions.⁵⁻⁸ Intussusception is a leading cause of bowel obstruction and ischemia in children. The majority of pediatric emergency visits in the United States occur in hospitals in which specialized pediatric services are limited or unavailable. Expanding the use of bedside ultrasonography for goal-directed, pediatric-specific emergencies has been suggested.^{9,10} Bedside detection of intussusception would be especially advantageous in settings in which no comprehensive pediatric radiology services are available. This has the potential to improve patient care by facilitating a more timely diagnosis and expeditious transfer of patients to centers in which reduction can be performed. A rapid, bedside diagnosis made at a referring hospital would allow radiology and surgical services at the receiving hospital time to better prepare for consultation and reduction procedures. Furthermore, ED patients cared for in institutions with pediatric ultrasonographic capability could also benefit by having a prompt diagnosis made at the bedside. The ability to perform serial, rapid, focused assessments at the bedside has the potential to improve resource use and more efficiently prioritize the care of patients with suspected intussusception. Our study demonstrates that bedside

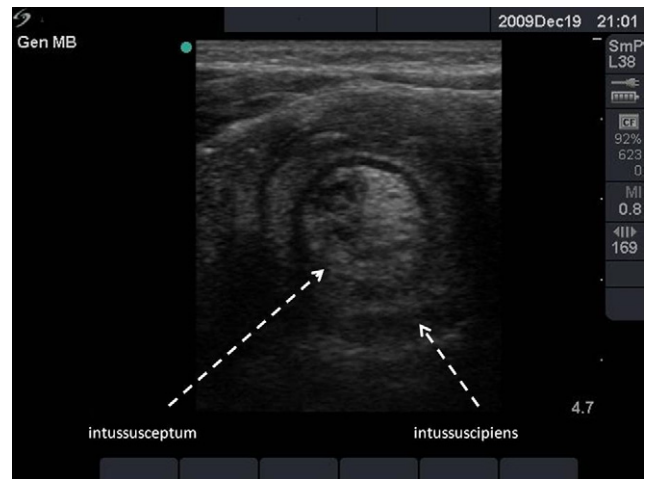


Figure 2. Appearance of typical ileocolic intussusception in transverse orientation as detected by bedside ultrasonography.

ultrasonographic detection of intussusception has the potential to be quickly learned and accurately performed by pediatric emergency physicians after appropriate, focused training.

Additional findings in this study warrant further discussion. Generally, sonographic diagnosis of intussusception is accomplished by the identification of a “target” or “bull’s-eye” that represents the appearance of intussuscepted bowel in cross-section (Figure 2). When images from the positive-result cases were reviewed, this configuration of an intussusception in transverse orientation was universally identified. Although the majority of the cases were identified in the right upper quadrant, a limited right upper quadrant scan would have missed several cases, which emphasizes the importance of starting in the right lower quadrant and performing a complete scan throughout the abdomen, as described. We did not assess for bowel perfusion with color Doppler imaging, attempt to identify free fluid or trapped fluid, or attempt to identify lead points. Although these findings may have prognostic value in predicting successes with reduction techniques, they were not part of our goal-directed bedside evaluations.

With appropriate and focused training, pediatric emergency physicians can accurately diagnose ileocolic intussusception in children by using bedside ultrasonography.

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Address for correspondence: Antonio Riera, MD, E-mail antonio.riera@yale.edu.

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