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Diagnosis of intussusception by physician novice sonographers in the emergency department

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Abstract

Objective—To investigate the performance characteristics of bedside emergency department ultrasound by non-radiologist, physician sonographers in the diagnosis of ileo-colic intussusception in children.

Methods—This was a prospective, observational study conducted in a pediatric emergency department of an urban tertiary care children's hospital. Pediatric emergency medicine (PEM) physicians with no previous experience in bowel ultrasound underwent a focused one-hour training session conducted by a pediatric radiologist. The session included a didactic component on sonographic appearances of ileo-colic intussusception, review of positive and negative images for intussusceptions, and a hands-on component using a live child model.

Upon completion of the training a prospective convenience sample study was performed. Children were enrolled if they were to undergo a diagnostic radiology (DR) ultrasound for suspected intussusception. Bedside ultrasound (BUS) by trained PEM physicians were performed and interpreted as either positive or negative for ileo-colic intussusception. Ultrasound studies were

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then performed by DR 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 PEM physicians completed the training and performed the bedside studies. Eighty two patients were enrolled. The median age was 25 months (range 3 months – 127 months). Thirteen patients (16%) were diagnosed with ileo-colic intussusception by DR. BUS 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 BUS had a likelihood ratio of 29 (95% CI 7.3 to 114) and a negative BUS had a likelihood ratio of 0.16 (95% CI 0.04 to 0.57).

Conclusions—With limited and focused training, PEM physicians can accurately diagnose ileo-colic intussusception in children using BUS.

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 non-specific 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 seen in a minority of cases. Delays in diagnosis are associated with increased morbidity rates. Longer periods of intussusception can lower enema reduction success rates. A high index of suspicion is imperative to reduce the need for surgical intervention in children with intussusception.

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

Goal of Study

The goal of this study was to investigate the performance characteristics of BUS by pediatric emergency medicine (PEM) physicians who received limited and focused training in the diagnosis of ileo-colic intussusception in children.

Methods

Study Design and Setting

This was a prospective study of pediatric emergency department (PED) patients who underwent ultrasound for the evaluation of suspected ileo-colic intussusception. The study was performed in an urban PED at a tertiary care, children’s hospital from July 2008 to September 2011. The PED has an annual census of approximately 34,000 visits. Pediatric DR ultrasounds are available 24 hours a day, seven days a week.

Children with suspected ileo-colic intussusception were enrolled if they were to undergo ultrasound in the DR department and an eligible PEM sonographer was available. After

verbal consent, bedside sonography was performed by either a PEM attending or fellow. PEM sonographers may have acted as the treating physician. All PEM sonographers had at least 1 month of clinical instruction performing a variety of BUS in our hospital's emergency department. Study physicians had minimal experience with bedside sonography aside from the clinical instruction of being supervised to perform 100–150 ultrasounds on adults. No bedside sonographer had prior experience with bowel ultrasonography. BUS was performed and interpreted prior to DR ultrasounds. Radiologists interpreting DR ultrasounds were not aware of the BUS findings. A medical record review was performed to determine characteristics and outcomes of intussusceptions diagnosed by DR. This study was approved by our institutional human investigation committee.

Focused Training

A one-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 either cases consistent with intussusception, normal bowel or other intra abdominal findings which 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 ileo-colic intussusception. Assessment of secondary findings was not performed.

Methods Related to Sonography

BUS was performed by six PEM physicians (four attendings and two fellows). Participating PEM sonographers were eligible to enroll patients if they attended the voluntary training session as described above. BUS were performed using the L38 linear transducer (5–10 MHz) and a SonoSite MicroMaxx ultrasound system (Sonosite, Bothwell, Washington). Grayscale two dimensional images were obtained without the use of Doppler. After the application of ultrasound gel, the transducer was placed in the right lower quadrant (RLQ) in a transverse orientation with the indicator pointing towards 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 superiolaterally towards the right upper quadrant (RUQ) where the liver and gallbladder served as landmarks. At this point the transducer was rotated 90 degrees clockwise, now with the indicator towards the patient's head, and swept across the epigastrium towards the left upper quadrant in a longitudinal orientation. From the left upper quadrant (LUQ), the transducer was rotated 90 degrees counter clockwise to lie in a transverse orientation and swept inferiorly towards the left lower quadrant. A complete bedside scan included views of all four quadrants as described (Figure 1). Still images were saved for review and quality assurance. Image review was performed on all BUS by study physician 1 at the study's completion.

Sample Size

Based on a prevalence rate of 15% for ultrasound diagnosis of suspected intussusception,³ with a desired sensitivity of 0.8, specificity of 0.9 and a 95% confidence interval of +/- 0.25 for sensitivity, enrollment of at least 67 subjects was required.

Results

Eighty two subjects were enrolled. Patient characteristics are listed in Table 1. All patients were able to sufficiently cooperate with BUS. A total of 6 PEM physicians performed the

BUS studies. Study physician 1 enrolled 43 patients. Study physician 2 enrolled 16 patients. Study physician 3 enrolled 9 patients. Study physician 4 enrolled 7 patients. Study physician 5 and study physician 6 enrolled 5 and 2 patients respectively. Of the 13 patients where an ileo-colic intussusception was diagnosed by DR, there were 11 true positive BUS and 2 false negative BUS scans. Of the 69 patients where no intussusception was diagnosed by DR, there were 67 true negative BUS and 2 false positive BUS scans. Therefore, BUS 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%) for the diagnosis of ileo-colic intussusception. The likelihood ratio of a positive BUS was 29 (95% CI 7.3 to 117) while the likelihood ratio of a negative BUS 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 ultrasound findings.

The incidence of ileo-colic intussusception based on a diagnosis made in the DR department was 16% (13 of 82 cases). The median age of children diagnosed with ileo-colic intussusception was 16 months (range 3 months – 10 years). The proportion of ileo-colic intussusceptions found in the RUQ was 62% (8/13 cases). Four cases were detected in the RLQ and one case was detected in the LUQ. A pathologic lead point was present in two cases; a 4 month old female with a Meckel's diverticulum and a 10 year old female with Puetz-Jegher's and multiple polyps. There were 2 cases of ileo-colic intussusception that were observed to spontaneously reduce during the evaluation by DR. Air enema reductions were attempted on all patients with fixed ileo-colic intussusception. Successful air enema reductions were observed in 6/11 (55%) cases. The remaining 5 cases required operative intervention.

Limitations

Our study has several limitations. Since spontaneous resolution and recurrence of intussusception is possible, there is the potential for misclassification at the bedside and in the DR department. The majority of BUS (52%) were performed by study physician 1, which may skew the results towards the performance of this physician. However, a sensitivity analysis involving study physicians 2–6 alone showed similar findings to 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 prior experience with ultrasound evaluation of pediatric bowel, each had at least 1 month of clinical experience with BUS in adults. Therefore, our results may not be generalizable to physicians with no prior training in emergency ultrasound.

One important challenge is that many ultrasound indications are operator-dependent. The collective performance was lower than that reported in the radiological literature. Performance characteristics may have been improved by utilization 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 inter-rater 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 PEM physician-performed BUS for the diagnosis of intussusception in children after a single, focused training session.

The performance of BUS in our study exhibited high specificity with narrow confidence intervals which would make it an excellent test to rule in intussusception. The lower sensitivity scores make BUS 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 male with ileo-colic intussusception in the RLQ. This patient had small bowel and ileo-colic intussusceptions noted to spontaneously resolve in real time during the ultrasound performed by DR. The patient was observed and discharged home after a brief inpatient stay. It is possible that no ileo-colic intussusception was present while performing the BUS. The second case involved a 16 month-old male with ileo-colic intussusception detected in the RUQ by DR. In this single case, the BUS technique deviated from the intended study protocol. A curvilinear probe was used and depth was inadvertently set to 13cm 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 BUS 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 where specialized pediatric services are limited or unavailable. Expanding the use of BUS for goal directed pediatric specific emergencies has been suggested.^{9, 10} Bedside detection of intussusception would be especially advantageous in settings where 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 where 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, emergency department patients cared for in institutions with pediatric ultrasound 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 utilization and more efficiently prioritize the care of patients with suspected intussusception. Our study demonstrates that BUS detection of intussusception has the potential to be quickly learned and accurately performed by PEM 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” which represents the appearance of intussuscepted bowel in cross section (Figure 2). When images from the positive cases were reviewed, this configuration of an intussusception in transverse orientation was universally identified. Although the majority of the cases were identified in the RUQ, a limited RUQ scan would have missed several cases. This emphasizes the importance of starting in the RLQ and performing a complete scan throughout the abdomen as described. We did not assess for bowel perfusion using color Doppler imaging, attempt to identify free fluid or trapped fluid, nor did we attempt to identify lead points. While these findings may have prognostic values in predicting successes with reduction techniques, they were not part of our goal-directed bedside evaluations.

Conclusion

With appropriate and focused training, PEM physicians can accurately diagnose ileo-colic intussusception in children using BUS.

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

Figure 2.
Appearance of typical ileo-colic intussusception in transverse orientation as detected by bedside ultrasonography.

Table 1

Demographics

Study Population	N = 82
Median age (range)	25 mo (3 mo – 127 mo)
Age < 3 years	57 (70%)
Age > 3 years	25 (30%)
Gender	
Male	48 (59%)
Female	34 (41%)
Radiology Department US Diagnosis	
Normal	35 (43%)
Ileo-colic 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%)