Pediatric intussusception can have serious consequences in cases of delayed diagnosis or treatment. In this article, we conduct a retrospective review of bedside ultrasound (BUS) performed by trained emergency physician at our institution. We found that BUS was highly sensitive and specific for detection of pediatric intussusception compared to radiology study results.

INTRODUCTION
Intussusception is a condition with an incidence of 1-2.24 per 1000 children in Europe and is second only to appendicitis as the most common cause of an acute abdominal emergency in children [1,2]. If left undiagnosed and untreated, it can potentially lead to bowel necrosis and death. The classic triad of colicky abdominal pain, vomiting, and “currant jelly” stool occur in only 30-40% of cases at presentation [3]. Often patients present with vague symptoms such as crying, abdominal discomfort, or lethargy. Diagnosis is complicated by the fact that most of the cases occur in children younger than 2 years, who are unable to provide a clear history. Barium enema is considered the gold standard in diagnosis of intussusception. However it is invasive, exposes children to radiation, and requires the on-site presence of an experienced radiologist, making it impractical in many hospitals during after-hours.

Ultrasound was first utilized to diagnose intussusception in the 1980s. It has the advantage of being radiation-free and non-invasive. Over the years it has been proven to be highly sensitive and specific [4-6]. Hence ultrasound has become the first-line diagnostic test for suspected intussusception in many radiology departments throughout the world. As the scanning technique is relatively easy to learn and the pathological pattern [“doughnut sign” see Figure 1] quite easy to recognize, it has been found that trainees with as little as 3 months of training in ultrasound can perform the study with similar accuracy as staff radiologists [7]. All these properties make it an ideal tool for the emergency physician with proper training to diagnose intussusception at the bedside.

We conducted a study [8] to measure the test characteristics of emergency physician-performed bedside ultrasound for the diagnosis of pediatric intussusception when compared to radiology department results as a gold standard.

METHODS
This was a single-site, retrospective study on children who received bedside ultrasound (BUS) in our Pediatric Emergency Department (ED) for suspected intussusception. Our ED is a tertiary pediatric referral center with over 30,000 visits per year, and is staffed by board-certified emergency physicians around the clock. Emergency physicians who performed BUS to diagnose pediatric intussusception had undergone a minimum of 1-hour didactic training on the application.

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FIGURE 1. Classic appearance of intussusception on ultrasound “the doughnut sign”.

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Retrospective Review of Emergency Bedside Ultrasound for Diagnosis of Pediatric Intussusception
A Sonosite M-Turbo machine with pediatric transducers was used to perform the studies. Recorded study images [Figures 2 and 3] were archived at the ED ultrasound office. They were reviewed weekly for quality assurance.

Inclusion criteria for the study were:
(1) Patients 0-18 years old seen in the ED from January 1st, 2009 to October 3rd, 2012
(2) Clinical presentation suspicious for intussusception as per emergency physician documentation
(3) BUS performed by credentialed emergency physicians in the ED with documented bedside interpretation in the medical record
(4) A consultative study performed by the radiology department (such as computed tomography, ultrasound, or barium enema) was obtained during the same ED visit. Cases were excluded if any of the following criteria were present: (1) No formal radiology study obtained during the ED visit to evaluate for intussusception (2) No BUS images recorded for quality assurance (3) Undocumented bedside interpretation of BUS performed. A cut-off date of October 3rd, 2012 was chosen because of the transition of our ED to a new electronic medical record system on that date.

Potential cases for the study were identified from the electronic medical record (EMR) by two of the investigators. As a duplicate measure, the ED BUS archive was reviewed by a third investigator to identify potentially missed cases. After the screening was complete, the ED record of each potential case was then reviewed for inclusion in the study based on the aforementioned inclusion and exclusion criteria. Particular attention was paid to the time stamps of BUS impressions in the EMR and dictated radiology reports to ensure that the former preceded the latter, to avoid inadvertent bias by physicians performing the BUS.

The sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of ED BUS studies were calculated using radiology department study results as the gold standard.

RESULTS
A total of 1631 charts were reviewed, with 49 meeting inclusion criteria. Five of those were later excluded for reasons of incomplete documentation or lack of saved BUS images. Prevalence of intussusception was 23%. The mean age of the subjects was 31 months. Seven physicians performed these BUS studies. None of the intussusception cases had a pathological lead point, and all were successfully reduced by barium, air, or gastrograffin enema. BUS was 100% sensitive (95% CI 66-100%) and 94% specific (95% CI 79-99%) for detection of pediatric intussusception compared to radiology study results. Positive and negative likelihood ratios were 16.5 (95% CI 4.30-63.21) and 0 (95% CI 0-0) respectively.

There were two false positive and no false negative BUS studies. One of the false positives was determined to be transient intussusception after review of the BUS images with the pediatric radiologist. This patient was discharged home after his symptoms spontaneously subsided in the ED and he tolerated oral intake. The other BUS was interpreted as positive for intussusception at the bedside but subsequently overread as a negative study during image review. He was also discharged from the ED and had no further visit for related complaints. None of the patients with negative BUS was subsequently treated at our institution for intussusception.

Implications of Our Results
Our study demonstrated that physicians with limited training could diagnose pediatric intussusception by ultrasound with a high degree of accuracy. This is consistent with the results of various published studies [7,9,10].

With a negative likelihood ratio of 0 and a positive likelihood ratio of over 16, BUS results are likely to be helpful in clinical decision-making in the emergency department. In other words, along with clinical suspicion, treatment...
decisions might be made based on negative or positive BUS results. This is especially true in cases of medium or low clinical suspicion, or in cases of atypical presentation of intussusception.

A review of our confirmed intussusception cases revealed that none of these patients presented with the classic triad of colicky abdominal pain, vomiting, and "currant jelly" stool. One patient had intermittent vomiting and abdominal pain for over a week. Another patient was 7 years old at presentation. Some of these patients could have required prolonged and convoluted workups, perhaps even been subjected to unnecessary ionizing radiation before the correct diagnosis was made, had they not had BUS performed. In all of the cases, BUS probably led to timely diagnosis of the patients, and facilitated their workup in the emergency department.

Reports on the use of BUS by emergency physicians to diagnose pediatric intussusception have only begun to appear in the medical literature over the last 6 years [9-12]. Though these study results have been encouraging, a recent review concluded that the value of BUS to rule out intussusception has yet to be proven due to "clinically unacceptable" reported sensitivities, and that further studies would be necessary due to relatively small sample sizes [13]. Our results were similar to the conclusions of the two published trials, in that emergency physicians with focused training could diagnose pediatric intussusception accurately with BUS9,10. Although our total number of cases was less than these existing studies, the number of intussusception cases included was comparable. Furthermore, our case series also yielded a better BUS sensitivity. Thus our results may complement the existing literature, and serve as a rebuttal to the aforementioned comment of limited utility of BUS in ruling out intussusception. Because of the relative rarity of intussusception and the paucity of physician sonographers, future studies on the topic may require multi-institutional collaboration in order to accumulate sufficient positive cases and achieve adequate power.

The major limitation of our study is its retrospective design and the potential for errors and omissions [14]. Despite our efforts to define our inclusion/exclusion criteria as explicitly as possible and to cross-check two different databases, it is possible that some potential cases were inadvertently omitted. Similarly, abstractor bias is likely present in spite of efforts to minimize it, since abstraction was unblinded. False negative rate may be underestimated in our study, as only single institutional data was reviewed, and subjects might have presented to other emergency departments with undetected intussusception or complications. In addition, it is also possible that some BUS studies were not recorded, particularly those that were nondiagnostic or incongruent with radiology department results. All of our physician sonographers had performed more than 500 studies in various BUS applications, and most were emergency ultrasound fellowship-trained or emergency ultrasound fellows at the time of the study. Hence our results may not be typical of less experienced sonographers. Except for the presence of stool, we did not encounter any patient with conditions that might be falsely interpreted as intussusception on BUS such as inflammatory bowel disease, Meckel diverticulum, and appendicitis. Thus the test characteristics might be different in a patient population with more diverse pathology.

CONCLUSION
From our single-site retrospective review, emergency physician performed-BUS was highly sensitive and specific for the diagnosis of pediatric intussusception, and would likely help clinical decision-making at the bedside. Future multi-institutional prospective study with a larger sample size might be needed to confirm these findings.

REFERENCE