Bedside Ultrasonography to Identify Hip Effusions in Pediatric Patients

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Study objective: We determine whether pediatric emergency physicians can use bedside ultrasonography to accurately identify hip effusions in pediatric patients.

Methods: This was a prospective study conducted in the emergency department (ED) of an urban tertiary care freestanding pediatric hospital. A convenience sample of children younger than 18 years and who required hip ultrasonography as part of their ED evaluation was enrolled. Pediatric emergency physicians with focused ultrasonographic training performed bedside ultrasonography on patients' symptomatic and contralateral hips and categorized the findings as "effusion" or "no effusion," according to a priori definitions. Physicians rated their confidence for each bedside ultrasonographic result on a scale of 1 (not confident) to 5 (very confident). Bedside ultrasonographic results were compared with the radiology department's ultrasonographic results, which were considered the criterion standard. Standard performance metrics (sensitivity, specificity, and positive and negative predictive values) were calculated.

Results: Three physicians enrolled patients. Twenty-eight patients were enrolled, and 55 hips were studied. In all hips (both symptomatic and contralateral), bedside ultrasonography had a sensitivity of 80% (95% confidence interval [CI] 51% to 95%), a specificity of 98% (95% CI 85% to 99%), a positive predictive value of 92% (95% CI 62% to 99%), and a negative predictive value of 93% (95% CI 79% to 98%). In the 28 symptomatic hips, bedside ultrasonography had a sensitivity of 85% (95% CI 54% to 97%), a specificity of 93% (95% CI 66% to 99%), a positive predictive value of 92% (95% CI 60% to 99%), and negative predictive value of 88% (95% CI 60% to 98%). When physician self-rated confidence was high, the sensitivity of bedside ultrasonography in symptomatic hips was 90% (95% CI 54% to 99%), the specificity was 100% (95% CI 70% to 100%), the positive predictive value was 100% (95% CI 63% to 100%), and the negative predictive value was 92% (95% CI 62% to 99%).

Conclusion: With focused training, pediatric emergency physicians were able to use bedside ultrasonography to identify hip effusions in pediatric ED patients. [Ann Emerg Med. 2010;55:284-289.]

Please see page 285 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background and Importance

Emergency physicians are often faced with the diagnostic challenge of evaluating pediatric patients with hip pain, the causes of which range from benign self-limited conditions to surgical emergencies (eg, septic arthritis). Identification of a hip effusion by ultrasonography steers the evaluation and management of this broad differential diagnosis.

Traditionally, hip ultrasonography is performed in a radiology department. Many hospitals have ultrasonography available only on weekdays or during daytime hours, often in a location outside the emergency department (ED). These factors can affect the timeliness of the evaluation of ED patients who require hip ultrasonography.

Emergency physicians have used bedside ultrasonography for more than 20 years for various applications. To date, to our knowledge there have been no published prospective studies evaluating the test characteristics of bedside ultrasonography to identify hip effusions in the ED. This application could allow emergency physicians to more quickly identify effusions in children who present to the ED with hip pain, narrowing an otherwise broad differential diagnosis, directing further management, and decreasing time to definitive diagnosis and treatment.

Goals of This Investigation

We sought to determine the diagnostic accuracy of pediatric emergency medicine–performed bedside hip ultrasonography compared with a Department of Radiology study. We were most interested in the specificity and positive predictive value because identifying a hip effusion with bedside ultrasonography could allow for more timely consultation of subspecialty

Editor's Capsule Summary

What is already known on this topic

Identification of hip effusion using ultrasonography is helpful in the treatment of pediatric patients with hip pain.

What question this study addressed

This prospective study of a convenience sample of 28 patients (55 hips) addressed whether 3 pediatric emergency physicians with minimal previous ultrasonographic training could adequately perform bedside ultrasonography for hip effusions compared with radiology department ultrasonography as the criterion standard.

What this study adds to our knowledge

Bedside ultrasonography showed good specificity. Sensitivity was 80% to 90%, depending on whether all hips or symptomatic hips were counted.

How this might change clinical practice

Additional study is needed to confirm whether these pilot results on 3 physicians apply to most typical emergency physicians.

services, expedite synovial fluid analysis, and lead to faster initiation of definitive therapy.

MATERIALS AND METHODS

Study Design

This was a prospective study of pediatric ED patients who underwent hip ultrasonography as part of their ED evaluation. Bedside hip ultrasonography was performed by pediatric emergency physicians with focused ultrasonographic training. These results were compared with the Department of Radiology's ultrasonographic results, which were considered the criterion standard. Written informed consent was obtained from each patient or legal guardian. The study was approved by the hospital's institutional review board and was in compliance with the Health Insurance Portability and Accountability Act.

Setting

The study was conducted in the ED of a tertiary-care, Level I trauma, freestanding pediatric hospital from April 2007 to December 2007. The ED serves an urban and suburban population and has an annual census of approximately 58,000 visits per year. The hospital is the primary training site of an Accreditation Counsel for Graduate Medical Education-accredited pediatric emergency medicine fellowship program.

Selection of Participants

Individuals in a convenience sample of patients younger than 18 years, who had hip ultrasonography ordered by the treating clinicians as part of their ED evaluation, were eligible. The need for a hip ultrasonography was determined by the treating team according to the patient's clinical presentation. Patients who had diagnostic hip imaging before their evaluation in our ED were excluded. Patients were enrolled according to the availability of the study physicians. Information about the study was distributed to the emergency medicine division physicians by e-mail and at division conferences. ED staff members were asked to page the study investigators when a potential study patient was identified.

Pediatric emergency medicine fellows and faculty were trained as study physicians on a voluntary basis. Three physicians (2 pediatric emergency medicine attending physicians and 1 fellow) completed the training and enrolled patients. All study physicians had minimal experience with bedside ultrasonography and no experience performing hip ultrasonography before this study. Training was provided by the division's director of ultrasonography, a pediatric emergency medicine–trained physician who has completed additional education in the field of bedside ultrasonography. Study physicians were trained with the division's Sonosite Micromaxx 2005 ultrasonography device (SonoSite, Inc., Bothell, WA). Each enroller received a 30-minute didactic session, followed by practice sessions on pediatric volunteers under the supervision of the training physician. Physicians were considered trained for the purpose of this study after they accurately performed and recorded 10 hip ultrasonographs, with at least 1 positive hip ultrasonograph result. The division's director of ultrasonography did not enroll patients because it was thought that his experience with bedside ultrasonography cannot be generalized to all pediatric emergency physicians.

Methods of Measurement

Study physicians performed bedside ultrasonography on each patient's symptomatic and contralateral hip. They were not blinded to the patients' clinical information. For every patient, both hips were measured and assessed for the presence of an effusion. Standard techniques were used to identify and measure the hip joint capsule.[1] With the patient lying supine, the linear probe was positioned parallel to the femoral neck in the sagittal plane. Once the capsule was identified, the distance between the anterior surface of the femoral neck and the posterior surface of the iliopsoas muscle was measured for each hip. A measurement of greater than 5 mm or a measurement of greater than a 2-mm difference from the contralateral hip was considered positive for an effusion, in agreement with standard radiology texts.[1] For each hip, study physicians interpreted their measurements as "effusion" or "no effusion" according to this definition and rated their confidence in the measurements and interpretation on a scale of 1 (not confident) to 5 (very confident). For Department of Radiology ultrasonography results, the presence of an effusion was determined from the final written report of the attending radiologist. The Figure shows examples of a normal hip (A) and hip effusion (B).

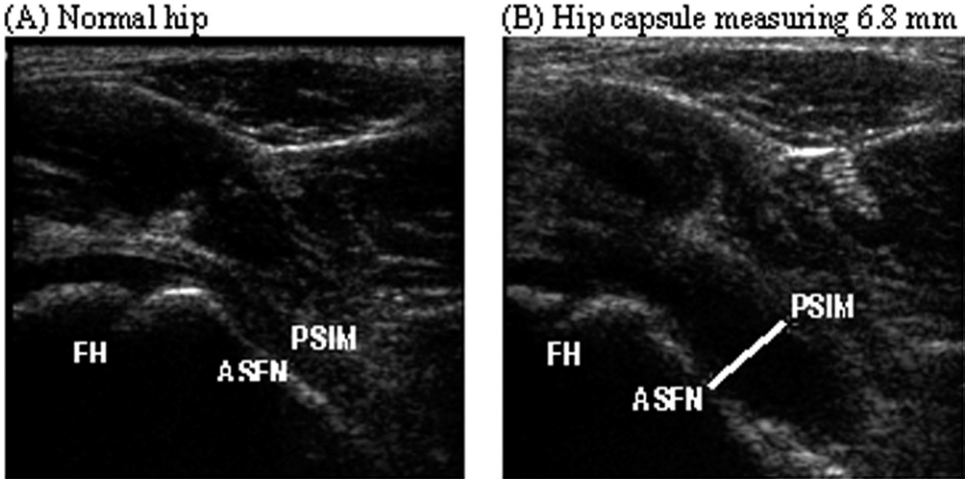

Figure. *A,* Normal hip. *B,* Hip with effusion. *FH,* Femoral head; *ASFN,* anterior surface femoral head; *PSIM,* posterior surface iliopsoas muscle.

Table 1. Characteristics of study participants.

Characteristic	Value
Patients enrolled	28
Total hips	55
Age (range)	24 mo–16 y
Age, y (median)	7.5
Male, %	64
Prevalence hip effusion (affected hip), %	43

Table 2. Results of bedside hip ultrasonography compared with Department of Radiology results: all hips.

	DOR+	DOR−
BUS+	12	1
BUS−	3	39

DOR, Department of Radiology; *BUS,* bedside hip ultrasonography.

Table 3. Results of bedside hip ultrasonography compared with Department of Radiology results: symptomatic hips.

	DOR+	DOR−
BUS+	11	1
BUS−	2	14

Data Collection and Processing

Study physicians were blinded to the results of the Department of Radiology ultrasonography when the bedside ultrasonography was performed. Study physicians recorded results on standardized data sheets and placed them in a lock box. Results of the Department of Radiology ultrasonography were later obtained from the final written attending physician report. Data were entered into an SPSS (SPSS, Inc., Chicago, IL) database by the primary investigator (R.L.V.) and reviewed by the senior author (J.A.L.).

Primary Data Analysis

Data were analyzed with SPSS, version 13.0, in 3 a priori chosen categories: (1) all hips (both symptomatic and contralateral); (2) symptomatic hips; (3) symptomatic hips in studies in which physician confidence was rated high (>3 on a 5-point scale). For each subgroup, sensitivity, specificity, and positive and negative predictive values were calculated. This research was intended to be a preliminary investigation, and as such, no sample size calculation was performed.

RESULTS

Characteristics of Study Subjects

Characteristics of study subjects are shown in Table 1. During the enrollment period, from April 16 to December 21, 2007, 59 hip ultrasonographs were ordered for ED patients. Twenty-nine patients were screened by study physicians, and 1 patient was determined to be ineligible (hip magnetic resonance imaging performed before transfer to our ED). All of the patients who were approached for enrollment consented to participate, leaving a sample of 28 patients enrolled. Fifty-five hips were studied. In one patient, the Department of Radiology did not perform ultrasonography on the contralateral hip, so only the data from the symptomatic hip were analyzed. Three physicians enrolled patients. Study physician 1 enrolled 14 patients (27 hips; one patient did not have ultrasonography on the contralateral hip by the Department of Radiology). Study physician 2 enrolled 12 patients (24 hips), and study physician 3 enrolled 2 patients (4 hips).

Fifteen hip effusions were identified by the Department of Radiology; 13 of these effusions were in symptomatic hips. One patient had bilateral effusions, and 1 patient had an effusion found only in the unaffected hip. Arthrocentesis was performed on 3 of the study patients with hip effusions.

Main Results

Results of the bedside ultrasonography compared with those of the Department of Radiology ultrasonography for each

Table 4. Results of bedside hip ultrasonography compared with Department of Radiology results: symptomatic hips, high physician confidence.

	DOR+	DOR−
BUS+	9	0
BUS−	1	12

Table 5. Performance metrics of bedside ultrasonography to identify hip effusions in each a priori selected subgroup.

	All Hips (95% CI)	SYM Hips (95% CI)	SYM Hips, High PC (95% CI)
N	55	28	22
Sensitivity, %	80 (51–95)	85 (54–97)	90 (54–99)
Specificity, %	98 (85–99)	93 (66–99)	100 (70–100)
PPV, %	92 (62–99)	92 (60–99)	100 (63–100)
NPV, %	93 (79–98)	88 (60–98)	92 (62–99)

SYM, Symptomatic; *PC,* physician-rated confidence (>3 on 5-point scale); *PPV,* positive predictive value; *NPV,* negative predictive value,

subgroup are shown in Tables 2 to 4. Test characteristics of bedside hip ultrasonography for each subgroup are shown in Table 5.

In all hips (both symptomatic and contralateral), bedside ultrasonography had a sensitivity of 80% (95% confidence interval [CI] 51% to 95%), a specificity of 98% (95% CI 85% to 99%), a positive predictive value of 92% (95% CI 62% to 99%), and a negative predictive value of 93% (95% CI 79% to 98%). In the 28 symptomatic hips, bedside ultrasonography had a sensitivity of 85% (95% CI 54% to 97%), a specificity of 93% (95% CI 66% to 99%), a positive predictive value of 92% (95% CI 60% to 99%), and a negative predictive value of 88% (95% CI 60% to 98%). In 79% (22/28) of studies of symptomatic hips, physician confidence was rated high (>3). In these studies, the specificity of bedside ultrasonography for effusion was 100% (95% CI 70% to 100%) and the positive predictive value was 100% (95% CI 63% to 100%). The sensitivity of bedside ultrasonography in this group was 90% (95% CI 54% to 99%), and the negative predictive value was 92% (95% CI 62% to 99%).

Of the 55 hip studies analyzed, bedside ultrasonography results did not match the Department of Radiology results for 4 studies (3 symptomatic hips and 1 contralateral hip). There were 3 false-negative study results (hip effusion identified by the Department of Radiology but not by bedside ultrasonography) and 1 false-positive study result (hip effusion identified by bedside ultrasonography but not by the Department of Radiology). These studies were distributed among 2 of the 3 study physicians. For these studies, the bedside ultrasonography images and Department of Radiology images were reviewed and the joint capsule measurements were compared. In 2 of the false-negative results, the capsule measurements of the Department of Radiology ultrasonography did not meet our study definition of effusion. Neither of these patients underwent arthrocentesis. In 1 false-negative result, the study physician incorrectly measured the joint capsule and failed to identify the effusion. Physician confidence for this study was rated high (4 on a 5-point scale). This patient underwent arthrocentesis ultimately received a diagnosis of transient synovitis. In the one false-positive bedside ultrasonographic result, the study physician incorrectly measured the joint capsule. Physician confidence for this study was rated lowest (1 on a 5-point scale).

LIMITATIONS

Only 3 physicians completed the training and enrolled patients. As ultrasonography is an operator-dependent test affected by personal attributes, such as hand-eye coordination and visual acuity, this may limit the generalizability of our study to all emergency physicians. However, the enrolling physicians had no experience performing hip ultrasonography and only minimal ultrasonographic experience in general.

Study physicians were not blinded to the patients' clinical information. We believe that this represents a more realistic application of bedside ultrasonography because physicians who use bedside ultrasonography to guide decisionmaking do so in the context of their patients' clinical presentation.

There was a lack of consistency in the definition of "effusion" between the Department of Radiology ultrasonography and the a priori definition we applied to our bedside ultrasonographic studies. Most Department of Radiology reports commented on the presence or absence of an effusion, without including the joint capsule measurements. As observed above, 2 of our false-negative results were due to discrepancies between the study definition and the Department of Radiology classification of effusion.

We included both symptomatic and asymptomatic hip ultrasonography in our analysis of "all hips." The reason we a priori chose to measure both hips is 2-fold. First, up to 25% of children with transient synovitis have bilateral hip effusions.[2] If physicians were missing effusions in unaffected hips that were not included in our analysis, it would have falsely increased the sensitivity of our test. In our sample, there were 2 "unaffected" hips that were ultimately diagnosed with hip effusions by the Department of Radiology. One was not identified with bedside ultrasonography. We believed that excluding this study would not have been appropriate. Second, in our experience, the finding of bilateral effusions reduces the clinical suspicion for septic arthritis and increases the suspicion for transient synovitis or a rheumatologic process. Clinicians are much less likely to perform arthrocentesis on a child with bilateral effusions. Thus, missing an effusion on the contralateral hip could lead to unnecessary arthrocentesis of the symptomatic hip.

Our sample size was small, and as such, we cannot suggest that this study should be used to change clinical practice. Nevertheless, our results are encouraging and advocate for larger studies in alternate settings to further evaluate this novel application of bedside ultrasonography.

DISCUSSION

Limp, leg pain, and refusal to bear weight are common pediatric complaints encountered in the ED. Many of these patients are found to have pain that localizes to the hip. The differential diagnosis of hip pain in children is broad and includes benign self-limited processes such as muscle strain; serious orthopedic conditions, such as fracture, Legg-Calvé-Perthes disease, and slipped capital femoral epiphysis; inflammatory conditions such as transient synovitis and juvenile rheumatoid arthritis; and infectious processes such as Lyme disease, osteomyelitis, and septic arthritis. The identification of a hip effusion narrows the differential diagnosis and may raise the suspicion for septic arthritis, a surgical emergency.[3-5]

Although many early studies investigating the applications of bedside ultrasonography in the ED focused on adult patients, a growing number of studies have addressed the utility of bedside ultrasonography in children.[6] The use of bedside ultrasonography to identify hip effusions is a relatively novel application. Limited case reports have shown that emergency physicians can use bedside ultrasonography to identify hip effusions.[7-9] Shavit et al[8] reported the use of bedside ultrasonography to facilitate the evaluation and diagnosis of 5 pediatric patients with hip pain. Similarly, Tsung and Blaivas[9] described 5 pediatric patients in whom bedside ultrasonography was used to identify hip effusions and guide arthrocentesis when formal ultrasonography was not available. The authors suggest that the ability to quickly identify hip effusions would improve patient care by decreasing the time to definitive diagnosis and treatment of patients with hip pain.

In our study the specificity and positive predictive value of bedside ultrasonography to identify hip effusions were excellent, and when the performing physicians felt confident in their interpretation, specificity and positive predictive value were 100%. Although high sensitivity is the goal of a screening test, maximizing specificity and positive predictive value are paramount when a positive finding can improve time to definitive management. As is the case with focused assessment with sonography in trauma, a positive finding (ie, free fluid within the pelvis) is used to expedite definitive diagnosis and treatment, whereas a negative study does not always obviate the need for further investigation when clinical suspicion is high. Identifying a hip effusion with bedside ultrasonography could allow for more timely consultation of subspecialty services, expedite synovial fluid analysis, and lead to faster initiation of antibiotics or operative joint irrigation in situations in which arthrocentesis results are consistent with septic arthritis. If future studies confirm high specificity of bedside ultrasonography for hip effusion, emergency medicine clinicians may consider using this technology to guide arthrocentesis in the ED.

There were 15 effusions identified in our study population (13 in symptomatic hips and 2 in contralateral hips), and 3 of these patients underwent arthrocentesis. All 3 of these patients ultimately received a diagnosis of transient synovitis and were discharged home. According to these results, physicians in our institution do not use hip ultrasonography results alone when deciding which patients require synovial fluid analysis. Chart review of the patients in our sample revealed that patients who were found to have hip effusions and who did not undergo arthrocentesis ultimately received a diagnosis of transient synovitis (6 patients), hip effusion (2 patients), or hip pain (2 patients). The decision not to perform arthrocentesis on these patients was based on other clinical characteristics and laboratory results. In our institution, all patients who were found to have hip effusions had Lyme titers sent from the serum (regardless of whether they had arthrocentesis).

In this study, the sensitivity of 80% suggests that patients with negative bedside ultrasonographic results should still undergo formal ultrasonography by a radiologist. As is the case with many applications of focused ultrasonography in the ED, when the bedside study result is negative, definitive imaging may still be needed, depending on clinical suspicion. For example, a stable trauma victim who has a negative focused assessment result with sonography in trauma examination will often still undergo computed tomography if there is a high clinical suspicion for intraabdominal injury.

Although bedside ultrasonography is included in emergency medicine residency curriculums,[10] pediatric emergency medicine fellowships are not required to include this training. In the future, ongoing quality training in bedside ultrasonography will continue to gain importance as more studies demonstrate the increasing applications of this valuable technology. For now, individual institutions may consider developing proficiency standards and quality assurance measures when deciding whether physicians can use bedside ultrasonography to evaluate for hip effusions.

In this study, pediatric emergency physicians were able to accurately identify hip effusions in pediatric patients by using bedside ultrasonography. According to our results, bedside ultrasonography may be more useful in identifying rather than ruling out hip effusions. These findings are the first step in determining whether this novel application of bedside ultrasonography could be a practical and valuable adjunct to the ED evaluation of pediatric patients with hip pain.

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