

ORIGINAL RESEARCH

Infectious Disease

Point-of-care hip ultrasound leads to expedited results in emergency department patients with suspected septic arthritis

Christopher Thom MD RDMS | Azhar Ahmed MD | Matthew Kongkatong MD | James Moak MD RDMS

Emergency Medicine, University of Virginia Health System, Charlottesville, Virginia, USA

Correspondence

Christopher Thom, MD, UVA Department of Emergency Medicine, PO Box 800699, Charlottesville, VA 22908, USA.
Email: ct9k@virginia.edu

Funding and support: By *JACEP Open* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Abstract based on this study was accepted to annual American Institute of Ultrasound in Medicine assembly in New York, NY, March 2020. Presentation was done via virtual format secondary to meeting cancellation due to coronavirus disease 2019 (COVID-19).

Abstract

Background: The evaluation of septic hip arthritis often incorporates the utilization of hip ultrasonography to determine the presence of a hip joint effusion, as well as to guide arthrocentesis. Point-of-care (POC) hip ultrasound has previously been demonstrated to be accurate when performed by the emergency physician. Time to diagnosis and subsequent intervention in septic arthritis (SA) is critical to favorable outcomes.

Methods: Retrospective single-center study of all emergency department (ED) patients who had a POC or radiology hip ultrasound or arthrocentesis as part of their ED evaluation for SA in a 3-year period. We investigated the difference in time to obtain hip ultrasonography results and the time to arthrocentesis between radiology and emergency physician-performed studies in cases of suspected septic hip arthritis.

Results: Seventy-four patients met inclusion criteria. The median time to hip ultrasound completion was 68 (interquartile range [IQR], 38.8–132) minutes in the emergency physician-performed ultrasound group versus 208.5 (IQR, 163.8–301.3) minutes for the radiology group ($P < 0.001$). A total of 17 patients had a hip arthrocentesis performed. Time to arthrocentesis was 211 (IQR 141.3–321.5) minutes in the emergency physician-performed arthrocentesis group and 602 (IQR 500–692) minutes in the radiology arthrocentesis ($P < 0.001$).

Conclusion: There was a statistically shorter time to ultrasound result and arthrocentesis when POC hip ultrasound was utilized by the emergency physician. Given that unfavorable outcomes in SA are associated with delay in treatment, further study is warranted to determine if emergency physician-performed hip ultrasound and arthrocentesis could lead to improved patient-centered clinical end points.

KEYWORDS

atraumatic hip pain, hip arthrocentesis, hip ultrasound, joint effusion, septic arthritis, toxic synovitis, transient synovitis

Supervising Editor: Steven G. Rothrock, MD.

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1 | INTRODUCTION

1.1 | Background

Septic arthritis (SA) is an important diagnostic consideration in patients who present to the emergency department with atraumatic hip pain. The evaluation of these patients typically involves a thorough examination, laboratory testing, and radiographic imaging.¹ Ultrasonography is a diagnostic component that has demonstrated utility in aiding the investigative workup of suspected SA of the hip.²⁻⁵ Further, ultrasonography is easy to obtain, non-invasive, and does not involve the risks associated with ionizing radiation. It can quickly identify the presence or absence of hip joint effusions and can guide arthrocentesis for synovial fluid analysis.^{3,6} In addition, as point-of-care (POC) ultrasound has become more common and accepted into ED practice, there has been increasing interest in emergency physician-performed hip ultrasound and ultrasound-guided arthrocentesis.⁶⁻¹² The efficacy and accuracy of emergency physician-performed hip ultrasound has been previously demonstrated.^{8,13}

1.2 | Importance

SA is associated with a high morbidity and mortality, with mortality rates of up to 10% and poor joint outcomes noted in up to one third of patients.^{14,15} Prompt diagnosis and intervention has been demonstrated to be a factor in reducing the risk of joint damage and poor functional outcomes.^{16,17} Progression of disease in SA can be rapid and untreated disease can lead to irreversible damage to the bony articular surface.^{17,18} Furthermore, delayed therapy can lead to a longer treatment course needed to eradicate the joint infection.¹⁹

1.3 | Goals of this investigation

Our objective was to determine whether patients with suspected SA of the hip who were evaluated with POC ultrasound had expedited care as compared to patients receiving a technician-performed ultrasound in the radiology department. Secondly, we sought to investigate time differences in the performance of hip arthrocentesis between patients who received a hip arthrocentesis by the treating emergency physician versus those who had this procedure performed in the radiology suite. Further objectives were to evaluate for complications that arose from emergency physician-performed hip arthrocentesis and to evaluate overall ED time to disposition in both groups.

2 | METHODS

2.1 | Study design

This was a retrospective single-center study of all patients who received a hip ultrasound or hip arthrocentesis as part of their ED

The Bottom Line

This is the largest study of emergency physician-performed, point-of-care ultrasound-guided, hip arthrocentesis to date. This retrospective study indicates that emergency physician arthrocentesis has the potential to expedite care and improve outcome of patients with suspected septic arthritis of the hip.

evaluation for suspected SA over a 3-year period from April 2016 to April 2019. The institutional review board approved this study.

The study took place at a Level I academic ED with an annual census of 65,000 patients. The ED has a 3-year residency training program and an active POC ultrasound education program. This includes scheduled yearly didactics on hip sonography and arthrocentesis, as well as annual hands-on teaching session of both diagnostic hip effusion evaluation and hip arthrocentesis in the cadaver lab. Attending physicians and resident physicians both participate in these activities. Attending physicians are required to maintain their POC ultrasound skills through a combination of reviewed scans and hands-on scanning sessions on a biennial basis. At our institution, attending physicians review and sign off on each POC ultrasound that is performed and are required to be at the bedside for invasive procedures including hip arthrocentesis. Patients were selected for inclusion in this study if the treating emergency physician had suspicion for SA and the patient received a radiology-performed (RP) hip ultrasound or an emergency physician-performed hip ultrasound as part of their ED evaluation. Additionally, patients were included if they had a hip arthrocentesis performed during their evaluation for SA by either the emergency physician or by radiology. Our orthopedics department does not routinely perform hip arthrocentesis in the ED, and we did not identify any patients who had an orthopedics-performed hip arthrocentesis in the ED. RP hip ultrasounds are performed in the radiology department by certified sonographers and subsequently interpreted by board-certified radiologists. Emergency physician-performed hip ultrasound is performed and interpreted contemporaneously by the treating physician in the ED at the patient's bedside.

The standard technique for emergency physician-performed hip ultrasound at our institution is to visualize the femoral neck in long axis and assess this area for the presence or absence of an effusion. We then obtain images of the contralateral hip for comparison. An examination is considered positive if the effusion is 5 mm or greater as measured from the anterior surface of the femoral neck to the posterior surface of the iliopsoas muscle. Additionally, an exam is considered positive if there is a >2 mm difference between the symptomatic and the contralateral hip joint. During the study period, both the radiology department and the ED had access to modern ultrasound imaging machines with both high frequency and curvilinear ultrasound transducers. The ED utilized machines from Sonosite (Bothell, Washington), and the

radiology department utilized Philips (Amsterdam, the Netherlands) ultrasound machines.

The patient archiving and communication system (PACS) imaging database was queried for all ED patients receiving RP hip ultrasounds in the 3-year period. Likewise, the ED POC ultrasound archive was queried for those receiving emergency physician-performed hip ultrasounds. ED POC ultrasound imaging during the study period was archived on a local secure hospital drive. In order to extract data from the archive, we used the sorting function of the EasyFind application (Devon Technologies, LLC, Coeur d'Alene, Idaho) to open the last saved image in each POC ultrasound study that was performed during the study period. Our institution required the saving of an interpretation image at the end of each study performed. These individual images were reviewed to identify studies that included a hip ultrasound or arthrocentesis. After extraction of all ED patients receiving emergency physician-performed and RP hip ultrasounds during the study period, a review of each individual ED chart was performed to confirm that SA was a consideration for the treating emergency physician. Patients were included in the study if they had a hip ultrasound or arthrocentesis performed, as well as a documented suspicion or differential diagnosis inclusive of SA. Given that we wanted to ensure the capture of all eligible patients in the study, including those that may have had incomplete or missing interpretations in the POC ultrasound database, the electronic health record (EHR; Epic Systems Corporation, Verona, Wisconsin) was also queried via ICD-10 codes (*International Classification of Diseases, Tenth Revision* codes) during the study period. The following ICD-10 codes were queried; toxic synovitis (M67.30), transient synovitis of hip (M67.359), transient synovitis of left hip (M67.352), transient synovitis of right hip (M67.351), transient synovitis of hip, unspecified laterality (M67.359), right hip joint effusion (M25.451), left hip joint effusion (M25.452), effusion of hip joint (M25.459), pyogenic arthritis of hip and septic hip (M00.9), pyogenic bacterial arthritis of hip (M00.859), pyogenic bacterial arthritis of left hip (M00.852), pyogenic bacterial arthritis or right hip (M00.851), s/p arthrocentesis (Z98.890), and positive culture of synovial fluid obtained by arthrocentesis (R89.5). The medical charts of these patients were then reviewed to evaluate whether they met the inclusion criteria above.

2.2 | Data abstraction

A standardized data abstraction form (Appendix A) was utilized to query the electronic health record timeline for each ED encounter and record the time elapsed from first emergency physician contact to the time of emergency physician-performed or RP hip ultrasound. For those patients who received an emergency physician-performed or RP hip arthrocentesis, the time from first emergency physician contact to time of arthrocentesis was also recorded. Overall ED disposition time, which was defined as the time elapsed from patient arrival to time of ED disposition, was recorded. The time from first emergency physician contact to time of operative case start was recorded in those cases that went on to operative intervention for SA of the hip. Data on ambulatory status, laboratory val-

ues, and final diagnosis were also abstracted. We utilized the original Kocher criteria plus C-reactive protein (CRP) for laboratory data analysis.

Medical record review and data abstraction of each patient was performed independently by 2 physicians to ensure accuracy. Abstractors were trained on inclusion and exclusion criteria for patient selection, which included the process for performing imaging database and electronic health record search functions. Both abstractors were also trained on the process for recording time data points, calculating the time values for the study outcomes, and recording the targeted laboratory data points. Data were collected and recorded in a standardized format for both reviewers for each patient included. Any discrepancies identified in the data abstraction between the reviewers were resolved through further review of the electronic health record timeline and consensus. Patients were excluded from the study if they had a history of prior hip surgery, prior hip infection, or trauma preceding the ED visit. Patients were also excluded if they were transferred from a referring facility with a known diagnosis of SA.

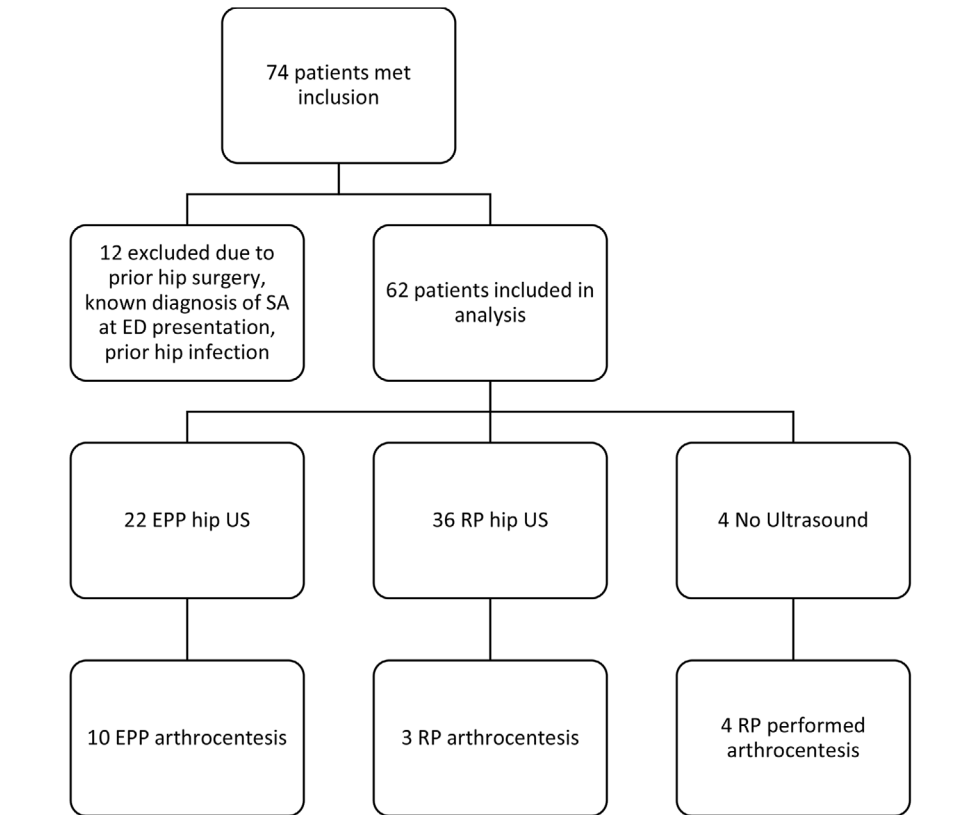
2.3 | Outcomes

The primary outcome measure was time from first emergency physician patient contact to time of emergency physician-performed or RP hip ultrasound. The Epic EHR timeline was used to identify the time of first emergency physician contact. For the RP hip ultrasound, the time to first ultrasound interpretation by radiology was used as the measured time point. For the emergency physician-performed hip ultrasound, the time point used was the actual time the ultrasound was performed by the emergency physician at the bedside.

Secondary outcomes included the time from first emergency physician patient contact to time of arthrocentesis performed. The time of needle entry into the joint spaced was used in both RP hip arthrocentesis and emergency physician-performed hip arthrocentesis. We also sought to identify any complications that occurred following an emergency physician-performed arthrocentesis through chart review. The overall ED time to disposition was also compared between patients who received an RP hip ultrasound versus those receiving an emergency physician-performed hip ultrasound. In addition, the number of unique resident and attending emergency physicians who performed the hip ultrasound studies and arthrocentesis procedures was also recorded.

2.4 | Analysis

Descriptive statistics were generated for the participants' characteristics (eg, laboratory values, temperature in ED, final diagnosis), primary study measurements, and secondary study measurements. VassarStats statistical computation software was utilized for the statistical analyses. Mann-Whitney tests were performed for nonparametric data including physician contact to ultrasound completion time, physician contact to arthrocentesis time, physician contact to operating room (OR) start time, and overall ED disposition time. The Mann-Whitney



SA = Septic Arthritis; ED = Emergency Department; EPP = Emergency Physician performed; RP = Radiology performed;

FIGURE 1 Allocation diagram for patient inclusion

test was also utilized for comparison of ordinal data including the Kocher criteria. Student *t* tests and Fisher exact tests were performed for continuous data and categorical data for comparison between the cohort groups. Nonparametric data are presented as median values with interquartile ranges (IQRs) and *P* = values < 0.05 were considered statistically significant.

3 | RESULTS

3.1 | Characteristics of study subjects

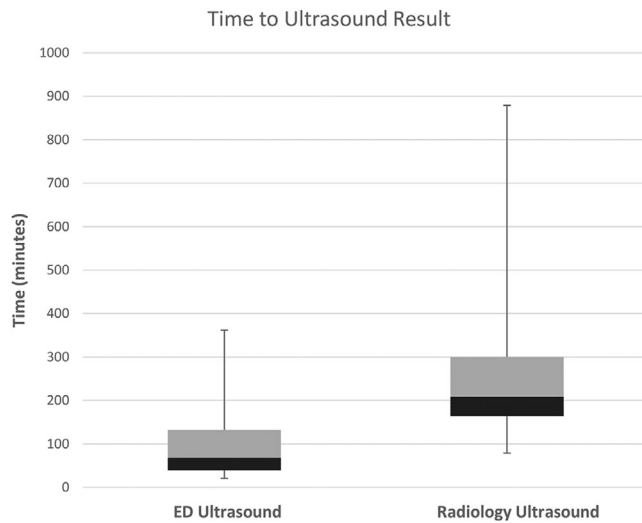
During the 3-year study period, a total of 74 patients were identified who received a RP or emergency physician-performed hip ultrasound, or underwent a hip arthrocentesis, in the setting of suspicion for SA. A total of 64 patients were identified through a search of ICD-10 codes, with 46 of these meeting study inclusion criteria (Appendix B). The additional 28 patients in the study were identified through the search of the radiology and POC imaging archives. The chart diagnoses on these 28 patients were varied and included diagnoses such as right leg pain (M79.604) and pain of left hip joint (M25.552). The 74 patients meeting initial inclusion criteria are displayed in the allocation diagram in Figure 1. There were 12 patients excluded secondary to prior hip surgery, a history of prior hip infection,

or a known diagnosis of septic arthritis at time of ED arrival. The remaining 62 patients were analyzed for primary and secondary outcomes. Twenty-two patients received emergency physician-performed hip ultrasound (with 10 of these undergoing emergency physician-performed arthrocentesis), 36 received RP hip ultrasound (with 3 of these undergoing RP arthrocentesis), and 4 had RP hip arthrocentesis following computed tomography or magnetic resonance imaging (MRI) without a preceding ultrasound having been performed.

3.2 | Main results

The 22 patients who received an emergency physician-performed hip ultrasound as part of their diagnostic workup had a median time from first emergency physician contact to ultrasound of 68 (IQR, 38.8–132) minutes, as compared to 208.5 (IQR, 163.8–301.3) minutes for the 36 patients who received RP ultrasound (*P* = < 0.001). Figure 2 shows the median time and IQR for each group. The laboratory results, ambulatory status, adult, or pediatric status, and overall Kocher criteria between the emergency physician-performed hip ultrasound and RP hip ultrasound groups are shown in Table 1.

The 10 patients who had an emergency physician-performed hip arthrocentesis had a median time from first emergency physician contact to arthrocentesis procedure of 211 (IQR 141.3–321.5) minutes, as



ED = Emergency Department

FIGURE 2 Box and whisker plot demonstrating the time to ultrasound completion between the study groups. The maximum and minimum time values for each group are represented by the vertical error bars, while the box area represents the interquartile range (IQR). ED, emergency department

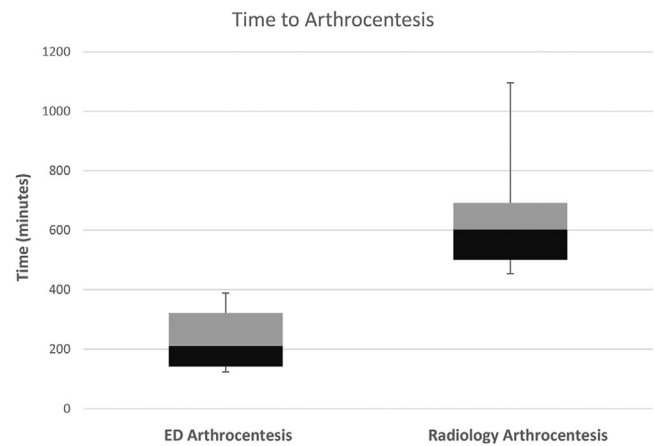
TABLE 1 Characteristics of patients receiving a diagnostic hip ultrasound in the emergency department

Patient characteristics	EPP US (n = 22)	RP US (n = 36)	P
Adult (age > 17 years old)	6 (27.3%)	5 (14%)	0.21
Final Dx SA	6 (27.3%)	6 (16.7%)	0.33
Final Dx TS	12 (54.5%)	15 (41.7%)	0.34
OR intervention	6 (27%)	5 (14%)	0.21
Admission	7 (32%)	15 (42%)	0.45
Kocher criteria	1 (0.75-2)	1.5 (1-2)	0.25
ESR (mm/h)	15 (8.5-52.5)	18 (8.5-75)	0.50
WBC (per mm ³)	9.7 (7-12.8)	9.8 (7.7-14.6)	0.26
CRP (mg/dL)	0.6 (0.15-1.4)	1.3 (0.2-6.3)	0.17
Able to ambulate	8 (36%)	13 (36%)	0.74
Number in group	10 (45%)	3 (8%)	0.02
Undergoing Arthrocentesis			

Continuous and ordinal data are displayed with medians and IQR (interquartile range).

CI, confidence interval; CRP, C-reactive protein; Dx, diagnosis; EPP, emergency physician performed; ESR, erythrocyte sedimentation rate; OR, operating room; RP, radiology performed; SA, septic arthritis; TS, transient synovitis; US, ultrasound; WBC, white blood cell.

compared to 602 (IQR 500–692) minutes for the 7 patients who had a RP hip arthrocentesis ($P = < 0.001$, Figure 3). Of the 10 patients receiving emergency physician-performed hip arthrocentesis, no procedural complications were noted to have occurred and each attempted hip arthrocentesis was successful. Table 2 notes the patient characteristics of all patients undergoing arthrocentesis, and Table 3 provides fur-



ED = Emergency Department

FIGURE 3 Box and whisker plot demonstrating the time to ultrasound completion between the study groups. The maximum and minimum time values for each group are represented by the vertical error bars, while the box area represents the interquartile range.

TABLE 2 Characteristics of patients who received a hip arthrocentesis in their emergency department evaluation

Arthrocentesis-patient characteristics	EPP (10)	RP (7)	P
Percentage pediatric	50%	57%	0.78
Percentage adult	50%	43%	0.78
Final Dx SA	60%	71%	0.65
Final Dx TS	30%	0%	.12
Final Dx other Infectious	0%	14%	0.24
OR intervention	60%	86%	0.26
Admission	60%	100%	0.06
ESR	48 (11.5-74)	44 (24-54)	0.60
WBC	9.3 (7.1-12.2)	14 (11.5-16)	0.036
CRP	1.4 (1.1-4.5)	1.8 (0.6-4.7)	1
Ambulatory	40%	0%	0.06

Continuous and ordinal data are displayed with medians and IQR (interquartile range).

CRP, C-reactive protein; Dx, diagnosis; EPP, emergency physician performed; ESR, erythrocyte sedimentation rate; OR, operating room; RP, radiology performed; SA, septic arthritis; TS, transient synovitis; WBC, white blood cell.

ther detail on the 10 patients who had emergency physician-performed arthrocentesis.

The diagnosis for these 62 patients included 15 cases of SA, 26 cases of transient synovitis, and 7 cases of alternate infectious diagnosis such as osteomyelitis and pyomyositis. The remaining final diagnoses were non-specific and included leg pain, inflammatory arthritis, trochanteric bursitis, and crystalline arthropathy. The Kocher criteria and CRP differences among patients with these diagnoses is represented in terms of final diagnosis in Table 4.

TABLE 3 Patients who underwent emergency physician-performed ultrasound guided hip arthrocentesis

Patient age (years)	Operating room	Final diagnosis
8	No	TS
60	Yes	SA
26	No	Inflammatory Arthritis
5	No	TS
19	Yes	SA
34	Yes	SA
65	Yes	SA
3	Yes	SA
4	No	TS
9	Yes	SA

SA, septic arthritis; TS, transient synovitis.

TABLE 4 Variance of Kocher criteria and CRP levels by final diagnosis

Kocher criteria + CRP	SA (15)	TS (26)	Other infectious (7)
Able to ambulate	13%	62.50%	28.60%
WBC (per mm ³)	12.1 (11–16.1)	8.8 (7.1–12.8)	13.7 (9.1–14.6)
ESR (mm/h)	49 (24–75)	13 (6–18.3)	35 (9–98)
Fever ($\geq 38.5^{\circ}\text{C}$)	2 (13.3%)	0 (0%)	4 (57%)
Kocher Criteria	2 (2–3)	1 (0–1.25)	3 (1–3)
CRP (mg/dL)	2.55 (1.3–8.5)	0.5 (0.1–1)	7.7 (1–23.6)

Continuous and ordinal data are displayed with medians and IQR (interquartile range).

CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; SA, septic arthritis; TS, transient synovitis; WBC, white blood cell.

Fourteen patients went to the OR for treatment of SA following ED evaluation. Six of these were after an emergency physician-performed ultrasound and hip arthrocentesis, 6 of them were after RP hip arthrocentesis, and 2 after a RP hip ultrasound without a subsequent arthrocentesis procedure. The median time from ED arrival to OR start was 586 (IQR 448–1032) minutes in the emergency physician-performed hip arthrocentesis group and 1019 (IQR 595–1614) minutes among the 8 patients who had received RP arthrocentesis or RP hip ultrasound ($P = 0.27$). Additionally, we found that the median time from ED arrival to ED disposition was 313 (IQR 268–502) minutes among patients who had an emergency physician-performed hip ultrasound and 407 (IQR 288–583) minutes in those who had a RP hip ultrasound performed ($P = 0.19$).

Ten different resident physicians and 9 different supervising attending physicians performed the 22 emergency physician-performed hip ultrasound studies. Among the 10 emergency physician-performed hip arthrocentesis procedures, there were 7 different resident physicians who performed these, along with 4 different supervising attending physicians.

4 | LIMITATIONS

By virtue of the retrospective study design, the authors acknowledge there are inherent limitations that must be taken into account when evaluating these findings. The risk of confounding variables is present and these may have affected our results. Importantly, the selection of a patient for an emergency physician-performed hip ultrasound instead of a RP hip ultrasound could have been biased toward different types of patients or different patient complexity. Those physicians utilizing POC hip ultrasound may have had other attributes or practice patterns that influenced times. Additionally, we did not record if the ultrasound imaging was more difficult in either study arm due to factors such as obesity or difficulty with manipulating the position of the hip. We also did not evaluate if there were significant differences in pain levels or sedation requirements between study groups. Our study did demonstrate that patients in the RP hip ultrasound and the emergency physician-performed hip ultrasound arm had similar key presenting features including ambulatory status, underlying inflammatory markers, and overall Kocher criteria. They also had similar rates of admission versus discharge and a similar frequency of septic arthritis and transient synovitis as a final chart diagnosis. Further research with a randomized control trial would be helpful to further evaluate the above study questions.

Although any disagreements in the data abstraction process between the 2 reviewers were resolved through further review and consensus, abstractors were not blinded to the purpose of the study during data abstraction. Interrater reliability assessment between the 2 abstractors was also not performed, though each case did conclude with a consensus data entry for each time point.

Importantly, our study was conducted in an academic tertiary care center ED and thus the findings may not translate to the community ED setting. Our annual training process in this technique also could make our results difficult to translate to other EDs. Another limitation of note is the possibility that an emergency physician-performed ultrasound might not have been documented or saved and that a RP ultrasound was then subsequently ordered. Our standard practice is to both save the emergency physician-performed ultrasound study regardless of findings and to document this in the emergency physician note. However, if neither of these occurred, then it is conceivable that an ultrasound study could go unaccounted for and this could have impacted our findings.

Given that SA of the hip is not a common diagnosis, it was also challenging to recruit a robust number of patients in this study cohort, particularly patients who went on to diagnostic arthrocentesis. The low numbers of arthrocentesis and OR patients did make our data susceptible to outliers and a larger cohort would be ideal to validate our findings. Additionally, as noted previously, prior studies have demonstrated the sensitivity of emergency physician-performed hip ultrasound for the presence of effusion is 80% to 85%. Although we did not assess sensitivity or diagnostic accuracy of emergency physician-performed hip ultrasound in the current study, a false negative result could lead to additional downstream imaging being required, which may cause deleterious effects in time points such as length of stay.

We also acknowledge that the focus of this study was on patients receiving a hip ultrasound as the diagnostic modality for their ED workup, with a few additional patients who met inclusion criteria secondary to a hip arthrocentesis performed without a preceding ultrasound. MRI is an alternate diagnostic test that can demonstrate a hip effusion, as well as additional features such as pyomyositis or osteomyelitis.²⁰ However, the cost, availability, and necessity of sedation in many pediatric cases make this modality challenging in certain patient populations and clinical scenarios. There has been work to identify patient characteristics and laboratory tests that can help identify patients at risk for concurrent infections in SA and who would thus benefit from early MRI in addition to, or in place, of hip ultrasonography.^{21,22} Laine et al utilized a retrospective study to show that MRI is potentially unnecessary for a majority of these patients once an effusion is identified unless there is failure to respond clinically to appropriate medical and surgical treatment.²³ However, Nguyen et al demonstrated that concomitant osteomyelitis was not uncommon in patients with hip effusions and high Kocher criteria.²⁴ The appropriate utilization of MRI in the evaluation of these patients deserves more study in order to guide clinicians in the best imaging strategy for each individual patient presentation.

Although median times were lower for time to OR and time to disposition, these did not reach statistical significance. Given our low enrollment numbers, it is possible that larger sample sizes would have demonstrated these trends to be statistically significant. Finally, it is important to note that we did not seek to identify whether this decrease in time for diagnostic testing leads to improved patient-centered outcomes. Existing literature noted previously suggests that early diagnosis and intervention are beneficial and this may be particularly true for the severely ill or septic patient with SA as their underlying source of infection. However, we do not know if the time differences demonstrated in this study are significant with regards to clinical outcomes. Further study would be needed to determine if emergency physician-performed hip ultrasound and arthrocentesis is beneficial with regards to patient-centered clinical outcomes.

5 | DISCUSSION

The current study is the first to our knowledge that seeks to evaluate if ED patient care can be expedited through the use of POC ultrasound in cases of suspected septic arthritis of the hip. This study also represents the largest series of emergency physician-performed ultrasound-guided hip arthrocentesis to date. Previous work has highlighted the importance of early diagnosis and treatment in order to reduce the risk of joint damage and poor long-term function.¹⁶ Vispo Seara et al found that early diagnosis and intervention in septic arthritis increased the chance of long-term favorable functional outcomes.²⁵ Yanmis et al performed an evaluation of arthroscopic irrigation and debridement on cases of knee SA and found that delay in arthroscopic treatment resulted in poor functional outcomes.²⁶ Balabaud et al found that treatment delay in SA was a major factor in treatment failure.¹⁹ Weston et al similarly found an association with joint destruction and

poor functional outcomes when treatment was delayed in their review of 242 patients with SA.¹⁸ It is important to note that the treatment delays discussed in these studies were generally on the order of a few days and not hours. However, this potential for increased risk of poor outcomes resulting from treatment delays prompts expedited intervention once the diagnosis of SA is suspected. This is perhaps particularly important for those cases with sepsis and systemic illness, where early source control is important. The existing research implies that it is beneficial to diagnose this disease entity and initiate treatment as accurately and expeditiously as possible. The patients in our cohort were taken expeditiously to the OR once SA was identified.

Although sonography of the hip has traditionally been performed in the radiology suite, it is increasingly common for the emergency physician to perform this exam at the bedside.^{6,8} This could carry the advantage of offering an expedited answer to the diagnostic question of whether a joint effusion is present and subsequently could result in a decreased time to diagnosis, arthrocentesis, and definitive management for these patients. Several case reports and series have reported the utilization and accuracy of POC hip ultrasound by emergency physicians.⁹ Vieira et al performed a prospective study that demonstrated POC ultrasound on symptomatic pediatric hips carried a sensitivity of 85% and specificity of 93% for the identification of an effusion. When emergency physicians reported high confidence in their ultrasound accuracy, the test results improved with a reported sensitivity of 90% and specificity of 100%.⁸ Cruz et al subsequently demonstrated a similar sensitivity of 85% and specificity of 98% among a cohort of trained pediatric emergency physicians in a large study of POC hip ultrasonography cases.¹³ Arthrocentesis of the hip joint has also been performed safely and successfully by the emergency physician.^{6,10-12} Berona et al performed a cadaver study, wherein emergency physicians achieved a 100% success rate in the performance of ultrasound-guided hip arthrocentesis.²⁷

Given the readily available nature of POC ultrasound in EDs and the ease in learning this modality,¹³ POC hip ultrasound can provide a powerful tool to the practicing emergency physician. There is an inherent advantage of having this skillset in the emergency physician's armamentarium, as the examination itself is quick to perform and does not involve ionizing radiation or the need for sedation. The emergency physician also has the advantage of contemporaneously performing and interpreting the ultrasound study as opposed to waiting for the patient to be sent to the radiology suite for image acquisition by a technician and a subsequent interpretation by a radiologist. In the current study, we selected the end time point for emergency physician-performed hip ultrasound studies as the time of image acquisition, whereas the end time point for the RP studies was set at time of first imaging interpretation (often by the radiology resident). These time points were selected as we felt this was most closely congruent with actual emergency physician practice. As with many POC ultrasound studies, emergency physicians performing the POC hip ultrasound will interpret the imaging at the same time as they are actually performing the ultrasound. Given this, we felt that the end time point to utilize for a emergency physician-performed hip ultrasound to be resulted is when the images themselves were actually acquired, whereas the end

time point for the RP hip ultrasound to be resulted is most accurately reflected as the time when the first radiologist interpretation is posted.

Importantly, our experience also demonstrates that the time to arthrocentesis is shorter for those patients undergoing emergency physician-performed hip arthrocentesis. As the results of an arthrocentesis are often relied upon to distinguish between septic arthritis and non-infectious alternate diagnoses, the time at which the joint fluid is acquired can be important in determining the time to antibiotic administration and definitive operative intervention. Six out of 10 of our ED-performed arthrocentesis patients went on to operative intervention by the orthopedics team. All of these interventions occurred expeditiously without additional imaging or testing in the ED. The time to operative intervention was quicker among these 6, as opposed to the patients who underwent operative intervention following RP hip arthrocentesis. Although our data set was too small to allow for the evaluation of improvement in clinical outcomes, we did note a potential trend toward a reduced time to operative intervention in the cohort undergoing emergency physician-performed hip sonography and arthrocentesis.

Our study highlights the potential for emergency physician-performed hip sonography and arthrocentesis to provide benefit in these selected patients through improved times to key diagnostics and definitive testing. An additional advantage in the pediatric arena is that because emergency physician-performed hip arthrocentesis occurs in the ED, the emergency physician can also provide the procedural sedation needed for a safely performed procedure. This was the case in each of our pediatric arthrocentesis cases in the present study. Finally, although the median time was lower in ED arrival to disposition time between patients who received emergency physician hip ultrasound versus RP hip ultrasound, that difference was not found to be statistically significant.

In summary, SA is an important diagnosis to make in a timely manner for the emergency physician, as poor outcomes are associated with increased time to intervention. POC hip ultrasound and arthrocentesis provide the emergency physician with a potential tool to expedite the evaluation and diagnosis of this patient cohort. Although our total patient number was limited, we found a statistically significant time reduction in both the time to ultrasound result and time to arthrocentesis when POC ultrasound was employed in the care of these patients.

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AUTHOR BIOGRAPHY



Christopher Thom, MD, RDMS, is Assistant Professor of Emergency Medicine, Assistant Program Director, Emergency Medicine Residency Program, and Director, Ultrasound Fellowship at the University of Virginia.

How to cite this article: Thom C, Ahmed A, Kongkatong M, Moak J. Point-of-care hip ultrasound leads to expedited results in emergency department patients with suspected septic arthritis. *JACEP Open*. 2020;1:512–520. <https://doi.org/10.1002/emp2.12167>

APPENDIX A:

MRN: _____ Name: _____ Date: _____

Age: _____ Chart diagnosis: _____

Attending Physician: _____ Resident physician: _____

Time data:

Emergency Physician Hip Ultrasound Performed (YES/NO): _____

Radiology Hip Ultrasound Performed (YES/NO): _____

Emergency Physician Hip Arthrocentesis Performed (YES/NO): _____

Radiology Hip Arthrocentesis Performed (YES/NO): _____

Documented suspicion for septic hip arthritis (YES/NO): _____

Time of first ED physician contact (resident or attending): _____

Time of first radiology hip ultrasound result (prelim or final): _____

Time of first saved image of emergency physician Hip ultrasound image: _____

Start time for radiology arthrocentesis: _____

Start time for emergency physician arthrocentesis: _____

Time elapsed from first physician contact to ultrasound (emergency physician or RP): _____

Time elapsed from first physician contact to arthrocentesis (emergency physician or RP): _____

Time elapsed from first ED physician contact to OR start (if applicable): _____

Total Patient Disposition Time: _____

Patient Characteristics:

Pediatrics (YES/NO): _____

Adult (YES/NO): _____

Ambulatory Status in ED (YES/NO): _____

WBC: _____

Erythrocyte Sedimentation Rate: _____

CRP: _____

Highest Temperature in ED: _____

APPENDIX B: –International Classification of Diseases Tenth Edition code query results for study period

	Total patients queried in EPIC Electronic Health Record	Patients meeting study criteria ^a
Transient synovitis (M67.30)	19	11
Transient synovitis of hip (M67.359)	2	1
Transient synovitis of hip, left (M67.352)	4	4
Transient synovitis of hip, right (M67.351)	8	6
Transient synovitis of hip, unspecified laterality (M67.359)	0	0
Right hip joint effusion (M25.451)	3	2
Pyogenic arthritis of hip and septic hip (M00.9)	24	18
Pyogenic bacterial arthritis of hip (M00.859)	0	0
Pyogenic bacterial arthritis of hip, left (M00.852)	0	0
Pyogenic bacterial arthritis of hip, right (M00.851)	0	0
Left hip joint effusion (M25.452)	3	3
Effusion of hip joint (M25.459)	1	1
S/P arthrocentesis (Z98.890)	0	0
Positive culture of synovial fluid obtained by arthro (R89.5)	0	0
Total Patients:	64	46

^aPatient met initial study inclusion if they had an ultrasound or arthrocentesis performed and there was a documented suspicion for septic arthritis in the Emergency Department physician note.