Evaluation of Hip Pain and Management of Toxic Synovitis in the Ultrasound Era

Prisca Takundwa, MD, Lei Chen, MD, MHS, and Rabia N. Malik, MD

Abstract: The cause of acute onset hip pain in children can be difficult to determine. Once trauma is excluded, the workup revolves around determining whether there is a hip effusion and eliminating orthopedic emergencies. Point-of-care-ultrasound can be used as an adjunct in the workup. In this article, we review (1) differential diagnosis of hip pain, with a focus on toxic synovitis; (2) the evaluation of a hip for the presence of effusion, including the point-of-care ultrasound technique; and (3) the management of toxic synovitis.

Key Words: hip, ultrasound, toxic synovitis, joint effusion

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TARGET AUDIENCE

This review article is intended for health care providers working in the emergency department, urgent care centers, hospital settings, and outpatient settings providing care to the pediatric population.

LEARNING OBJECTIVES

After completing this article, the reader should be better able to:

1. Identify the challenges in differentiating toxic synovitis from septic arthritis.
2. Describe the role and utility of ultrasound in assessment of hip pain, particularly in evaluation of possible joint effusion.
3. Assess bedside ultrasound techniques when evaluating for a hip effusion.

Hip pain in a pediatric patient has traditionally been a diagnostic challenge. This is because of the sometimes nonspecific presentation of the pain, extensive differential diagnoses, as well as confounders, such as referred pain from other sites, like the abdomen, knee, and back. Overall, age is a major factor in assessing the etiology of hip pain. Evolving skeletal maturity makes specific hip pathologies and injury patterns more common in different age groups.[1] Traditionally, the workup may be guided by various algorithms or the use of prediction rules. These include age-specific algorithms, suspected etiology algorithms, and even imaging algorithms.[2,3]

In the United States and Canada, point-of-care ultrasound (POCUS) has become a standard part of training for pediatric emergency medicine physicians in the past decade. With the increased availability of equipment and training in POCUS, there is a need to thoughtfully incorporate the modality to clinical decision making. The aim of this article is to review how ultrasound (US) has changed the evaluation of hip pain in children, given the many possible diagnoses, with a focus on toxic synovitis.

The differential diagnosis for hip pain in a pediatric patient can be separated into broad categories, such as infectious, traumatic, inflammatory, developmental, and neoplastic. Within each of these categories, common causes include, but are not limited to, those shown in Table 1.

Toxic synovitis (TS) or transient synovitis is a common cause of hip pain in the pediatric population accounting for about 0.4% to 0.9% of pediatric emergency department visits.[5] Overall, it is estimated that about 3% of children get toxic synovitis, with a recurrence rate between 4% and 17%.[5–7] Toxic synovitis is a self-limiting inflammatory condition that is more predominant in men than in women (2:1). It has a peak incidence at the ages of 6 to 8 years.[5,8] Symptoms can present as unilateral, bilateral, or sometimes unilateral progressing to bilateral findings. These include hip pain, often associated with reduced hip range of motion, and a limp. If patients can localize pain, it is usually in the groin, anterior thigh, or medial knee.[2,9] The patient often refuses to bear weight or to walk. Fever, if present, is low grade (<38°C).

Because of the significant overlap in presentations of TS and other hip pathologies, it is essential to have a systematic approach to making the diagnosis. Of foremost importance is distinguishing TS from septic arthritis (SA) as the latter is a true emergency. Undiagnosed SA or delay in diagnosis can result in devastating outcomes, such as cartilage destruction, and long term sequelae, such as coxa magna.[5,6,10] Numerous clinical diagnostic tools/algorithms have been created, reviewed, and validated to aid early diagnosis of SA and to distinguish it from other hip conditions, such as TS.[6,7,10,11] Our review will focus on the use of imaging, particularly the use of US, as a diagnostic adjunct in assessing for TS.

PATHOPHYSIOLOGY

The etiology of TS remains unclear. There are several hypotheses that presume a yet-to-be-identified viral agent. Toxic synovitis is usually preceded by an upper respiratory viral infection.[5] Other proposed etiologies include trauma involving the hip joint and an association with a predisposition to allergic reactions.[5] Toxic synovitis causes transient hip pain that is often, but not always, accompanied by a hip effusion. A reactive effusion in the hip joint capsule in TS is thought to be the cause of hip pain and limited range of motion.[8]

EVALUATION

Following a thorough history and physical examination, depending on clinical presentation and indication, the initial laboratory studies obtained to distinguish TS from SA are complete blood count, erythrocyte sedimentation rate, +/− C-reactive protein, blood cultures. Kocher et al[11] suggest that in a patient who is nonweight bearing who has white blood count greater than 12×10^9 cells/L, erythrocyte sedimentation rate >40 mm/h, fever >38.5°C, there is a high positive predictive value (93%–99%, depending on number of predictors present) for SA.

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TABLE 1. Causes of Acute Hip Pain in a Pediatric Patient [Adapted From Fleisher & Ludwig[4]]

Infectious	Inflammatory	Mechanical	Neoplastic	Developmental	Other
SA	TS	SCFE	Osteoid sarcoma	DDH	VOC pain from sickle cell disease
Lyme arthritis	Systemic arthritis	LCP	Leukemia	Toddler's fracture	NAT
Osteomyelitis	Idiopathic chondrolysis of hip	Stress fracture	Solid tumors	NAT	
Pyomyositis		Trochanteric bursitis			
Psoas abscess		NAT			
Appendicitis—referred					

DDH indicates developmental dysplasia of the hip; VOC, vaso-occlusive crisis; NAT, nonaccidental trauma.

A subsequent internal validation by Kocher et al showed a lower positive predictive value of the algorithm. Other institutions have been unable to replicate the high prediction values.[7,10] This may be because of the different prevalence of SA in different geographical regions, and, hence, different institutions. There are other prediction tools that include the use of C-reactive protein to rule out SA.[12] Once the appropriate clinical tool or criteria have been used, and a diagnosis has not been reached, the next step in hip pain evaluation is often the selection of the appropriate imaging.

Ultrasound evaluation for hip pain is ideal in the pediatric population. Ultrasound has the advantage of avoiding ionizing radiation and obviating sedation typically required for magnetic resonance imaging (MRI). The ability to obtain real time evaluations also makes it invaluable.[3] Ultrasound has seen an increase in use since the 2000s, partly because of the advancement in US technology from 2-D gray scale ultrasonography to Doppler US starting around 1998.[5] Increase in access to US, ease of portability, and increased training has also led to use of POCUS to evaluate the hip instead of relying on radiography, computed tomography, MRI, or bone scans.

Plain radiographs may be useful in patients with unexplained limp and/or hip pain. Usually, there are no radiographic anomalies early in the course of TS or SA. In some instances, however, clinical history suggests possible avascular necrosis of the femoral head (history of sickle cell disease, for instance) necessitating radiographs. Occasionally, soft tissue densities or very subtle widening of the hip joint to suggest an effusion on radiographs has been reported, but these findings are not useful in distinguishing TS from SA.[5,6] The cost and radiation exposure risk make computed tomography undesirable, whereas MRI typically necessitates use of sedation in the pediatric population.[3] Magnetic resonance imaging, however, is helpful in differentiating TS from SA in patients with equivocal clinical and/or US findings.[7] For all of these reasons, US has become the primary initial imaging option after thorough history, physical examination and/or laboratory.

ULTRASOUND TECHNIQUE

Ultrasound has high sensitivity for detecting joint effusions, which makes it valuable in ruling out emergent diagnoses, such as SA.[13] Additionally, early erosion changes associated with femur metaphysis suggestive of osteoarthritis can be detected on US. Femur metaphysis changes can be suggestive of an infection, whereas femur epiphysis changes can hint at early Legg-Calve-Perthes (LCP) disease.[2]

Imaging for joint effusion is typically focused on the anterior joint capsule. The anterior joint capsule is made of 2 layers (anterior and posterior) and in the absence of an effusion, it is these 2 layers that give the "stripe" sign on US when they interface.[9,14] Optimal images are obtained when the patient is supine with legs extended, femur slightly externally rotated. High-frequency linear transducers are used. First sagittal views are obtained (Fig. 1 and Fig. 2).

Slight hip abduction can be helpful in capsular surface view and it also may be the most comfortable position for a patient in pain (Fig. 2). Holding the hip joint in a flexed, abducted and externally rotated position achieves the largest hip joint intracapsular volume[7,14] and relieves pressure from the effusion. The transducer should be placed parallel to the femoral neck. Centering the probe on the epiphysis gives a view of the femoral neck, growth plate and part of the acetabulum.[15] In a normal hip joint, the joint capsule will be seen as a hyperechoic band running above the femoral head and the proximal femoral neck.[16] Examination of the femoral head is also useful in assessing for hip pathology because it may be helpful in other diagnoses, such as LCP and slipped capital femoral epiphysis (SCFE).[14] Imaging of both hips for comparison is recommended. Color Doppler may give additional information, such as synovial fluid hyperemia.[17]

The presence of an effusion in the hip joint capsule typically causes the capsular appearance to change from a concave contour to convex contour[3,13,17] and comparison with contralateral side is instructive (Figs. 3 and 4). A joint capsular space that is at least 2 mm greater than contralateral asymptomatic side (measuring from inner margin of the capsule or posterior surface of iliopsoas muscle to femoral neck cortex) indicates an abnormal joint effusion.[13,15] Other alternative criteria measure the full effusion thickness, and

FIGURE 1. POCUS sagittal view with hip in neutral position.

FIGURE 2. POCUS sagittal view with hip slightly abducted and externally rotated.

use greater than 5 mm as diagnostic for an abnormal hip effusion in a child.[3,18] The appearance of the effusion can also range from simple, seen as hypoechoic, to complex, seen as multiple densities on US. An important pitfall to avoid is mistaking the cartilaginous femoral head for an effusion as this can appear hypoechoic on US.[3] Obtaining views at the level of the femoral neck helps avoid this pitfall. Incidental hip effusion found in the contralateral asymptomatic hip usually suggests a diagnosis of TS rather than SA.

MANAGEMENT

If US shows a hip effusion and laboratory evaluation suggests ongoing systemic inflammation, aspiration of the fluid should be performed to distinguish purulent from nonpurulent effusions. Definitive diagnosis of SA is obtained by evaluating the aspirate for cell count, Gram stain, and culture. A diagnosis of TS is probable in the absence of findings suggestive of other etiologies that can also cause effusions, such as trauma. Aspiration of fluid in TS can offer some symptomatic relief but is not routine part of management. Treatment of TS consists of anti-inflammatory medication and rest for symptomatic relief.[8]

Patients with a diagnosis of TS are typically discharged home from the emergency department, pediatric clinic, or office as it is a self-limiting diagnosis.[5,7,8] In one systematic review study, the clinical course of TS was assessed with the majority of patients diagnosed with TS recovering within 2 weeks. However, in the same study, a high recurrence rate was noted (up to 26%) with a recommendation to continue following patients with TS for up to 6 months.[8] Close follow up after discharge with clear return instructions are important. There are reported rare cases of TS that progress to LCP.[8] Furthermore, SA can be missed early in the disease course as the joint effusion may be absent. Therefore, clinicians should have a low threshold to repeat the hip US in cases of diagnostic uncertainty.

DISCUSSION

The use of US to evaluate children with hip pain has become routine in the last decade. With increased availability of POCUS, understanding when and how to incorporate US into the workup for hip pain is vital. Dubois-Ferriere et al[19] conducted a retrospective study following children with nontraumatic hip pain that were later diagnosed with TS. Their findings suggest that as long as a patient has symptom improvement and resolution, there is no need for further laboratory or imaging to confirm resolution of TS at follow up visits.[19]

Special considerations should be given to geographical location where there is Lyme arthritis. Although Lyme disease

FIGURE 3. POCUS of a normal hip joint.

typically causes arthritis of the knee, there are some case reports of hip arthritis.[20] Bachur et al[21] investigated predictors of Lyme disease among children with suspected TS in a Lyme endemic region. Their study showed only 5% of children who presented with acute, nontraumatic hip pain had Lyme infection, concluding that routine testing for Lyme disease in children suspected of TS is not recommended. It is important to keep in mind, however, that laboratory evaluations of the joint effusions and serum of SA and Lyme arthritis have overlap significantly. In those circumstances sending Lyme studies for patients in Lyme endemic regions is wise. This exemplifies the importance of a systematic approach to acute hip pain in a pediatric patient based on local epidemiology, instead of using "standard" labs and imaging algorithms as a panacea.

Although plain radiography has limited use in the diagnosis of TS, in practice it is often the first line of investigation after history and physical examination in a patient with acute hip pain, inability to bear weight or limping. Toddlers with tibial fractures can present with limp and questionable hip discomfort. Our recommendation would be to obtain radiographs to rule out traumatic causes of hip pain, as well as other diagnoses, such as LCP and SCFE.

Ultrasound for hip effusion is very sensitive. The absence of an effusion rules out SA, unless it is very early in the disease process. As a corollary, US has low specificity as effusion can be seen

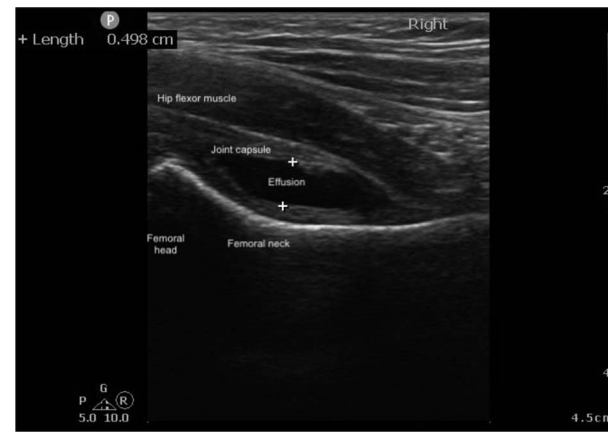
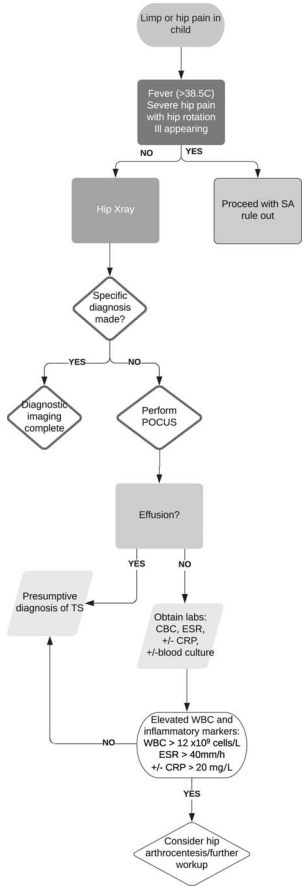


FIGURE 4. POCUS of a hip joint with an effusion.

in SA, TS, as well as Lyme arthritis.[13] Furthermore, absence of an effusion on US does not rule out TS. Ultrasound generally is not very sensitive in assessing bone morphology. On the other hand, once a joint effusion is present, US is extremely useful as a real-time guide in performing arthrocentesis.

The increased availability of POCUS allows emergency medicine providers to perform bedside US of the hip.[22] This could be useful in triaging patients with presentations concerning for septic joint and reduce the time to diagnosis and management, akin to the use of FAST in trauma. It may also be useful in centers with limited radiology availability. There is little data on the training necessary to be able to perform and interpret POCUS of the hip with sufficient quality.[22,23] In one prospective study, Vieira and Levy[22] compared the ability of minimally trained emergency department physicians to correctly identify hip effusions using POCUS compared with radiology performed US. Results showed that bedside US had a sensitivity of 80% and specificity of 98% for identifying effusions in all of the hips evaluated (symptomatic and contralateral). If the goal is to use POCUS as a screening test, then higher sensitivities would be necessary. In cases of negative POCUS, confirmation studies with a formal US may still be necessary because of the potential for missing a septic joint.[18] On the other hand, as the test threshold for POCUS is lowered, another open question is whether more widespread use would lead to more arthrocentesis. We propose the following algorithm as an aid in deciding the role of imaging in evaluating hip pain for toxic synovitis.



SUMMARY

In cases of suspected toxic synovitis of the hip the need for imaging and the appropriate modality are guided by careful and thorough history and physical examination followed by judicious use of clinical algorithms. If imaging is indicated, US offers many advantages. Point-of-care ultrasound can be performed expeditiously without significant risk and discomfort to the patient. Point-of-care ultrasound has high specificity for joint effusion. It can be used to guide arthrocentesis if indicated.

Toxic synovitis is a clinical diagnosis. If a patient is clinically well, afebrile with an examination consistent with toxic synovitis, it is appropriate not to image provided there is close follow up with clear and explicit return instructions. Cases that are concerning include those with atypical features, such as sick-appearance, persistent fever, or other concerning history and physical features. These may include co-morbidity as immune deficiencies including sickle cell disease. Local epidemiology, such as the presence of Lyme disease, should be considered in the workup. Diagnostics should aim to rule out orthopedic emergencies, such as SA and osteomyelitis by obtaining laboratory studies +/− imaging. Septic arthritis may present without a joint effusion early in its course, therefore, repeat US may be necessary in cases of diagnostic uncertainty.

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CME EXAMINATION
January 2021

Please mark your answers on the ANSWER SHEET.

Evaluation of Hip Pain and Management of Toxic Synovitis in Ultrasound Era, *Takundwa et al*

1. A diagnosis of toxic synovitis can be made once:
   a. There is an effusion on ultrasound
   b. Inflammatory markers are within normal range
   c. Hip aspirate has been sent for testing
   d. There is transient hip pain with or without an effusion

2. Evaluation of septic arthritis includes all of the following except:
   a. Inflammatory markers
   b. History and examination
   c. Hip aspirate
   d. Hip US
   e. Hip XR

3. What is the optimal positioning of the lower extremity for POCUS:
   a. Leg in neutral position
   b. Leg slightly abducted and flexed
   c. Leg internally rotated
   d. None of the above

4. On US, a hip effusion is defined as:
   a. A joint capsular space that is >5 mm greater than contralateral side
   b. Measurement of the full effusion thickness is >5 mm
   c. A joint capsular space that is concave in shape
   d. Any fluid in the joint capsule

5. Management of toxic synovitis includes:
   a. Aspiration of hip effusion
   b. IV antibiotics
   c. NSAIDS
   d. Follow-up imaging

ANSWER SHEET FOR THE *PEDIATRIC EMERGENCY CARE* CME PROGRAM EXAM

January 2021

Please answer the questions on page 39 by filling in the appropriate circles on the answer sheet below. Please mark the one best answer and fill in the circle until the letter is no longer visible. To process your exam, you must also provide the following information:

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1. (A) (B) (C) (D) (E)
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5. (A) (B) (C) (D) (E)

Your completion of this activity includes evaluating them. Please respond to the following questions below.

Please rate this activity (1 - minimally, 5 - completely)	1	2	3	4	5
Was effective in meeting the educational objectives	○	○	○	○	○
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Please rate your ability to achieve the following objectives, both before this activity and after it::
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	Pre					Post				
	1	2	3	4	5	1	2	3	4	5
1. Identify the challenges in differentiating toxic synovitis from septic arthritis.	○	○	○	○	○	○	○	○	○	○
2. Describe the role and utility of ultrasound in assessment of hip pain, particularly in evaluation of possible joint effusion.	○	○	○	○	○	○	○	○	○	○
3. Assess bedside ultrasound techniques when evaluating for a hip effusion.	○	○	○	○	○	○	○	○	○	○

How many of your patients are likely to be impacted by what you learned from these activities?

○ <20% ○ 20%–40% ○ 40%–60% ○ 60%–80% ○ >80%

Do you expect that these activities will help you improve your skill or judgment within the next 6 months? (1 - definitely will not change, 5 - definitely will change)	1	2	3	4	5
	○	○	○	○	○

How will you apply what you learned from these activities (mark all that apply):

In diagnosing patients ○
In monitoring patients ○
In educating students and colleagues ○
As part of a quality or peformance improvement project ○
For maintenance of board certification ○
To consider enrolling patients in clinical trials ○
In making treatment decisions ○
As a foundation to learn more ○
In educating patients and their caregivers ○
To confirm current practice ○
For maintenance of licensure ○

Other _____

Please list at least one strategy you learned from this activity that you will apply in practice:

Please list at least one (1) change you will make to your practice as a result of this activity:

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	○	○

If yes, please explain:

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