Pediatric Musculoskeletal Ultrasound

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KEYWORDS

• Musculoskeletal • Ultrasound • Children • Congenital • Mass • Trauma • Vascular anomaly • Infection • Inflammation

KEY POINTS

- Ultrasonography (US) plays an invaluable role in the evaluation of pediatric musculoskeletal pathology because it has a variety of cost-effective applications but does not require sedation or expose children to ionizing radiation.
- US may be the only imaging modality required for diagnosing and monitoring many pediatric musculoskeletal pathologies and can direct further imaging if necessary.
- US is limited by user dependence and poor evaluation of bone marrow and deep structures.
- Well-established uses for pediatric musculoskeletal US (MSUS) include evaluation of the painful hip; diagnosis of congenital conditions, such as developmental dysplasia of the hip (DDH) and clubfoot; evaluation of soft tissue infection and superficial masses; and foreign body localization and characterization.

TECHNICAL CONSIDERATIONS

High-frequency (7.5–15 MHz) linear array transducers are most commonly used in pediatric MSUS and provide excellent spatial resolution of superficial structures and pathology.[1,2] For larger patients or deeper structures, lower-frequency curved or vector transducers enhance visualization. Color and power Doppler imaging provide information about blood flow, which is crucial in the assessment of soft tissue masses and inflammation. US also allows for dynamic real-time evaluation and plays a key role in guiding interventions.

Conventional sonographic assessment of small, complex body surfaces, such as fingers and toes, using US gel is challenging, especially in children. Although standoff pads may help image these regions, water bath immersion using a small field-of-view transducer is a novel MSUS technique that provides excellent visualization of superficial structures in the distal extremities. Using this technique,[3] the hand or foot is submerged in luke warm water and the US probe is placed in close proximity (but not touching) the anatomic region of interest (**Fig. 1**; **Fig. 15**A). In addition to providing better spatial resolution of superficial structures, the lack of direct contact between patient and transducer increases patient comfort, which is particularly helpful in cases of trauma or inflammation.[4]

When performing MSUS, the sonographer should be aware of the anisotropy artifact, which may falsely produce hypoechoic areas within structures containing anisotropic reflectors. These structures, such as the fibrillar tissues of tendons, ligaments, and, to a lesser degree, muscle, contain multiple parallel interfaces that interact with sound waves differently depending on the angle of insonation. The anisotropy artifact occurs when the

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Fig. 1. Water bath technique for distal extremities. Hand is submerged in a luke warm water bath. A high-frequency linear transducer is placed in close proximity—but not directly contacting—the anatomic region of interest.

US beam reaches the tendon or ligament obliquely instead of perpendicular to the structure's long axis, causing the US beam to be reflected away from the transducer (**Fig. 2**). Because a pathologic process may also cause abnormal hypoechogenicity, it is important to exclude anisotropy by focusing on the specific anatomic structure that is perpendicular to the US beam.[2,5]

Key points: technical considerations

- High-frequency (7.5–15 MHz) linear array transducers provide excellent spatial resolution of superficial structures and are most commonly used in pediatric MSUS.
- Doppler imaging is an essential component of the MSUS evaluation.
- Water bath immersion provides superior resolution of small, irregular body surfaces, such as fingers and toes.
- The anisotropy artifact occurs when the US beam is oriented obliquely, instead of perpendicular to, a ligament, tendon, or muscle, creating a hypoechoic area that can mimic pathology.

NORMAL ANATOMY

In contrast to radiography, cartilaginous structures within immature joints and epiphyses are well depicted by US. The chondral epiphysis appears speckled and homogenously hypoechoic to anechoic, is well visualized by US, and can serve as an acoustic window to evaluate deeper tissues. When present, an ossification center is seen as a central echogenic focus within the epiphysis that demonstrates posterior acoustic shadowing.[6] Similarly, ossified bone is a highly reflective surface with posterior shadowing that precludes evaluation of deeper structures, such as bone marrow, which is a relative limitation of MSUS.

As in adults, synovial membranes that line synovial joints, bursae, and tendon sheaths (tenosynovium) should be less than or equal to 1 mm to 2 mm in thickness if visualized sonographically.[2] Muscles appear uniformly hypoechoic with interspersed hyperechoic fibroadipose septa and fascia. Tendons and ligaments are uniformly hyperechoic with fibrillar internal echotexture (**Fig. 3**).

CONGENITAL/DEVELOPMENTAL

Developmental Dysplasia of the Hip

Developmental dysplasia of the hip (DDH) represents a spectrum of abnormalities associated with clinical hip instability and includes variable degrees of acetabular dysplasia, commonly accompanied by subluxation or dislocation of the capital femoral epiphysis.[7] The underlying pathophysiology of DDH is abnormal hip laxity that allows excessive mobility of the femoral head. A persistently malpositioned femoral head subsequently prevents normal acetabular development due to the absence of physiologic stresses necessary for proper growth.

Although most cases of DDH are idiopathic, risk factors include female gender, family history, oligohydramnios, and breech presentation.[7–9] DDH has a lower incidence in African American and premature infants and is more common in populations where infants are tightly bundled or swaddled, such as the Japanese and Native Americans.[7,9]

Early detection of DDH allows for timely and noninvasive treatment, because diagnosis after 6 months of age often requires surgical correction and has increased risk of long-term morbidity. Therefore, some form of neonatal DDH screening is common in many countries and typically involves physical examination maneuvers to provoke dislocation or subluxation (Ortolani and Barlow maneuvers) and/or imaging evaluation.[7]

Although the use of US in the setting of DDH is well established, routine US screening for DDH is not performed in the United States. Routine screening can increase the risk of overdiagnosis and treatment with abduction splinting, which carries a risk of iatrogenic avascular necrosis of the femoral head.[7,8,10] The American College of Radiology recommends screening US evaluation of infants with specific risk factors (**Box 1**).[10] Optimally, the US examination should occur after an infant reaches 4 to 6 weeks of age to decrease false-positive findings from physiologic, transient joint laxity.[8,9] Radiography is unreliable until 4 to