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Ultrasound of Soft Tissue Infections

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Abstract

Soft tissue infections are relatively common in clinical practice and some of them are considered as surgical emergencies which may be life-threatening. Infection may involve the subcutaneous fat, hypodermis, and superficial fascia causing cellulitis or extend to the muscle or deep fascia thus resulting in necrotizing fasciitis or pyomyositis. Synovial bursae or tendon sheathes can also be involved. The most frequently implicated agents are *Staphylococcus aureus* and *Streptococcus pyogenes* but specific infections such as tuberculosis or echinococcosis may also be observed. Ultrasound can be considered as a first line imaging modality for soft tissues infections after radiographs in localizing the process within a muscle (e.g. pyomyositis), a bursae or a synovial sheath. It may also be used to guide needle aspiration of an abnormal fluid collection. This article reviews ultrasound findings in soft tissue infections and emphasizes the role of ultrasound in the management of these conditions

Keywords: Ultrasonography; Soft tissue infection; Necrosis; Arthritis; Radiography

Introduction

Soft tissue infections are commonly encountered in clinical practice. Some of these conditions are considered as surgical emergencies with a high mortality rate. Clinical presentation is often not specific and imaging is needed to obtain a precise assessment of the disease. Radiographs remain the first imaging modality to perform when it comes to deal with this clinical array. On the other hand, ultrasound is a very useful tool to confirm the diagnosis and precise the extension of the disease. Ultrasound is also recommended to guide needle aspiration of a septic fluid collection [1]. This article reviews ultrasound findings in soft tissue infections and emphasizes the role of ultrasound in the management of these conditions.

Methods

Cellulitis

Cellulitis is a non-necrotizing infection of the skin and subcutaneous tissue, hypodermis, and superficial fascia without muscular or deep fascial involvement [2]. It may be due to some predisposing factors (vascular insufficiency, dermatitis, ulcerative skin lesions, wounds, burns, diabetes, malnutrition and immuno-deficiency and retained foreign bodies). The most frequently implicated agent is *Staphylococcus aureus* and *Streptococcus pyogenes* gaining access to the skin through a penetrating skin defect. Less commonly, it can be secondary to hematogenous spread or extension from an underlying deep. Clinical diagnosis is usually obvious: sudden onset of swelling, local erythema, warmth and tenderness with “orange peel” skin appearance typically associated with fever and general inflammatory closet.

The diagnosis is usually clinical; however, imaging is mainly indicated in case of severe systemic manifestations or rapidly progressing disease to rule out deep tissue extension and possible associated localized collections. Radiographs usually show nonspecific diffuse soft-tissue swelling and may detect radiopaque foreign bodies. Ultrasound typically shows a diffuse swelling with increased echogenicity of the subcutaneous fat tissue (Figure 1). A "dissected" or a “cobblestone” appearance of subcutaneous fat lobules may be observed surrounded by anechoic strands due to the inflammatory exudative reaction and associated with Increased vascular flow at color or power Doppler (Figure 2).

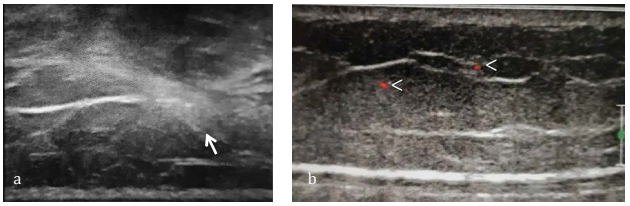

Figure 1: A 15-year-old boy with leg’s septic cellulitis. Ultrasound shows (a) increased echogenicity of the subcutaneous fat tissue (arrow) with (b) hyperhemia on power Doppler (arrowhead).

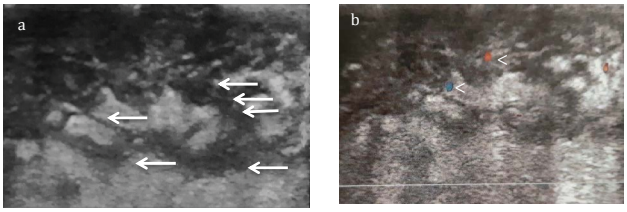

Figure 2: A 13-year-old girl with foot infectious cellulitis. Ultrasound shows a "dissected” appearance of subcutaneous fat lobules surrounded by anechoic strands with hyper vascularisation (arrowhead) in colour Doppler (b).

Ultrasound is the first line to differentiate cellulitis from venous thrombosis, although these conditions may coexist in some cases [2] Tayal et al. showed that ultrasound changes physician management in approximately half of patients with clinical cellulitis in the emergency department, by detection of occult abscess, prevention of invasive procedures, and guidance for further imaging or consultation [3]. Cellulitis is usually managed medically by antibiotics and controlling

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underlying metabolic abnormalities [2]. Unless an adequate treatment is settled, this infection may lead to thrombophlebitis, superficial abscesses, septicemia, or secondarily-infection with Gram-negative agents [4]. MR imaging may be the ideal tool to differentiate between necrotizing fasciitis and cellulitis [5].

Necrotizing fasciitis

Necrotizing fasciitis (NF) is a rare infection occurring mostly in immuno-compromised patients. This entity is different from cellulitis because of the associated tissue necrosis, the extensive behavior and lack of response to antimicrobial therapy alone, requiring urgent surgical treatment. Most cases are caused by polymicrobial infections with anaerobic gas-forming organisms and facultative aerobic agents. It most frequently occurs in the extremities, and has a predilection for the leg. NF is a surgical emergency. Mortality rate was reported to be 29% even when treated [2,6]. Early and accurate diagnosis is critical to ensure the necessary aggressive management needed to optimize outcomes. However, early recognition of this condition may be hampered by the uncommon nature of the disease and non-specificity of initial clinical signs in less fulminant cases, making the role of imaging important [7]. Reported risk factors for NF include age greater than 50 years, drug abuse, chronic debilitating comorbidities (e.g. diabetes mellitus, immunosuppression, obesity), and peripheral vascular disease [2]. Patients may present with cellulitis, vesicles, bullae, edema, crepitus, and erythema. Skin manifestations may be minimal compared to systemic findings (high fever, hypotension, and multi-organ failure). They also may complain of pain that seems out of proportion to the physical findings, which is a helpful clinical clue to differentiate NF from less serious conditions such as cellulitis or erysipelas ; as the infection progresses, their pain may decrease [6,7]. Imaging is only appropriate if it can be accessed urgently and must not be allowed to contribute to delayed surgical exploration.

Ultrasound may show a diffuse thickening of the subcutaneous tissue, a perifascial fluid, gas within the deep soft tissue, and a deep fascia with an “irregular” or “distorted” appearance. CT scan shows abnormal gas in the soft tissues and dissecting along fascial planes [8]. MRI is the most useful imaging modality in the diagnosis of necrotizing fasciitis. The presence of thick (>3 mm) hyperintense signal in the deep fascia (particularly intermuscular fascia) on fat-suppressed T2 weighted or short tau inversion-recovery images is an important marker for necrotizing fasciitis. Contrast enhancement of the thickened necrotic fascia can be variable [7,9].

Pyomyositis

Pyomyositis is usually caused by hematogenous spread and transient bacteremia rather than direct extension from an adjacent soft-tissue infection. It often results in deep intramuscular abscesses [10]. Living in tropical countries and immunodeficiency (HIV and intra-venous drug addiction) are predisposing factors. History of local trauma is found in 22-67% of cases. The main causative agent is *Staphylococcus aureus*. However, Gram-negative bacteria, anaerobes, mycobacteria, microsporidia, viruses, parasites, and fungi may be causative pathogens [2].

Three stages of pyomyositis have been described. The first stage, (invasive stage), is characterized by muscle edema and pain due to bacterial seeding. The second stage (suppurative phase), appears 10 to 21 days later; 90% of cases are diagnosed at this stage. It is characterized by intramuscular abscess formation and fever. The third stage, or late stage, is characterized by septicemia and multiorgan failure and carries a high mortality rate. A single muscle group is usually affected. Multiple-site involvement is present in up to 40% of cases. The muscles of the lower extremity are involved more frequently, with the quadriceps muscles being the most common site, followed by the gluteal and iliopsoas muscles [2]. Superficial abscesses are frequently complicating cellulitis. Ultrasound exam is of a great help when it comes to diagnosis and guidance of fine-needle aspiration. Differential diagnoses of pyomyositis are osteomyelitis and septic arthritis [11]. Careful analysis of adjacent bones and joints is required to confirm the muscular origin of the infection. Ultrasound pattern depends on the location and stage of the disease.

Different sonographic patterns may be found in pyomyositis: an echoic or hypoechoic collection, associated with an increase of transmitted sounds through it and well-defined or blurred margins. Septations or internal echoes (debris or gas) and comet-tail artefacts due the presence of gas may be present. Mobile suppurative material, fluid-fluid level may be found. The presence of “ultrasonographic fluctuation” (motion of particles induced by gentle pressure) should be sought to confirm the fluid nature of a non-anechoic mass. Peripheral hyperemia may be observed at Color Doppler imaging. Moreover, colour Doppler improves visibility of the needle tip and helps to avoid major vessels during interventional musculoskeletal procedures (Figure 3).

At invasive stage, there is an indurated localized muscle edema, with ill-defined hypo-echoic areas, which could be resolutive after antibiotic treatment. At suppurative stage, liquefaction is corresponding to abscess formation (Figure 4). The echogenicity of pus (fluid collection) may be increased, decreased or equal to surrounding tissues. It may require surgical drainage.

In pyomyositis, ultrasound is also helpful for detecting underlying abnormalities such as a foreign body, tumor or hematoma. Pyomyositis is a common complication of a penetrating foreign body ultrasound allows identification of the foreign bodies, assessment of precise location and relationship with adjacent structures such as tendons, nerves etc. [12] It may also guide percutaneous removal.

Ultrasound has been shown to be more effective than CT and MRI in the detection of superficial nonopaque soft tissue foreign bodies. However, it may be less accurate if the foreign bodies are located adjacent to bone or deep to subcutaneous gas [12]. Tuberculous abscess of skeletal muscle is uncommon, (1–2% of tuberculous cases) and usually occurs in immuno compromised patients [13].

Muscle may be involved by extension from bone, synovial lining of joints or tendon sheaths by direct inoculation and rarely by haematogenous dissemination [14]. The most common site is tuberculous psoas abscess resulting from extension of spondylitis. Tuberculous abscess wall usually shows a smooth appearance on

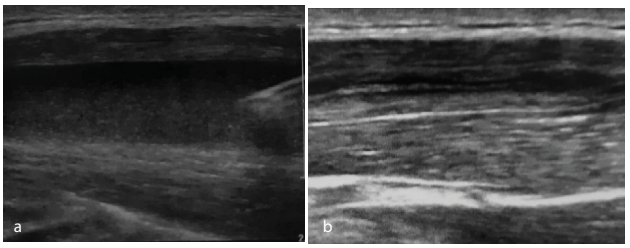

Figure 3: An 18-year-old boy with pyomyositis. Ultrasound shows an hypoechoic collection (a)which was evacuated under ultrasound guidance (b).

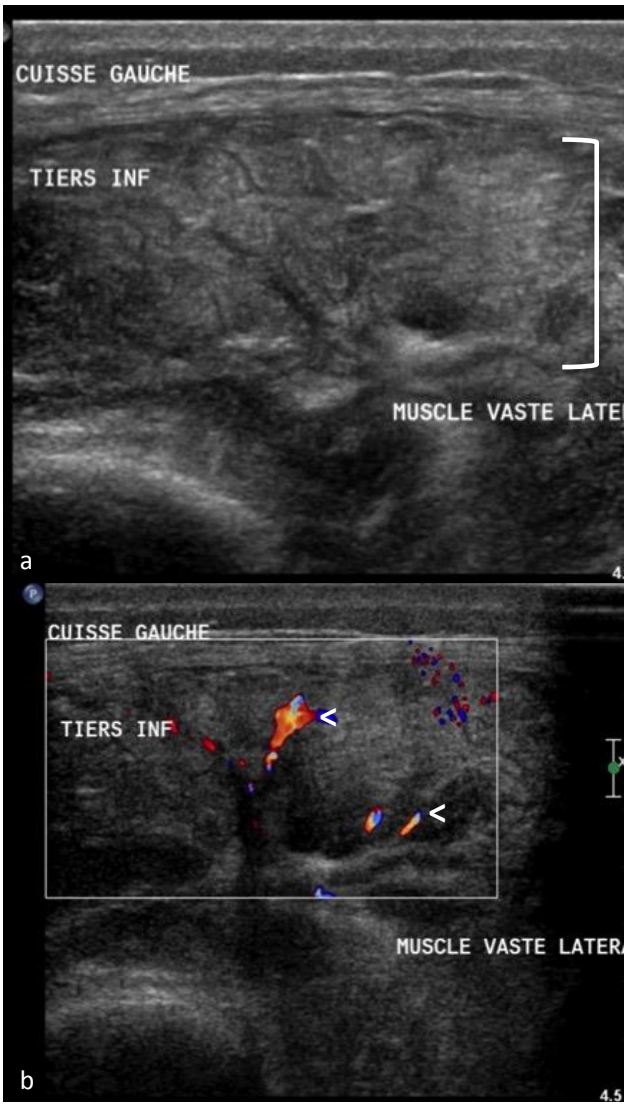

Figure 4: A 39-year-old man with thigh. Ultrasound shows soft tissue thickening (line) (a) and hyper vascularisation (arrowhead) in colour Doppler (b).

ultrasound or MRI. Fine calcifications may be observed in the abscess wall or into the abscess content. Biopsy and culture remains the gold standard for diagnostic confirmation [15]. A deep located abscess constitutes the main ultrasound's limitation. Deep located abscesses such as iliopsoas muscle abscess may require assessment with MRI or CT.

Septic bursitis

Septic bursitis refers to inflammation of the bursal cavities caused by bacterial inoculation of the synovial bursa [2]. Septic bursitis most commonly involves superficial bursae such as olecranon or prepatellar bursae, often by direct transcutaneous inoculation due to penetrating injury. Deep bursal infection by hematogenous route or direct extension from an adjacent joint is less common [2]. The most common pathogen is *Staphylococcus aureus*.

The patient usually presents with tenderness of the inflamed bursa with fever and local lymphadenopathy. Soft tissue swelling and/or erythema are more obvious in superficial bursitis. Radiographs usually show nonspecific soft-tissue fullness. Ultrasound shows a thickening of the bursae wall, an echoic or anechoic fluid accumulation into the bursa, and a Doppler hyperhemia. Ultrasound sometimes demonstrates echogenic shadowing foci, indicating gas bubbles [2]. Bursal fluid examination is mandatory for differential and etiological diagnosis. The advantage of ultrasound-guided aspiration is that the needle tip can be guided away from the bursal wall hypertrophy and towards small fluid collections; and ultrasound-guided aspiration prevents contamination of a normal joint [16]. CT can also demonstrate a thickened bursal wall, bursal distention with infected fluid and swelling of the adjacent soft tissues. MR imaging also shows thickened walls of the involved bursa which is typically distended by complex fluid containing internal debris and septa and surrounded by peribursal edema. Gas bubbles in the bursa can be seen as punctate foci of signal voids [2].

Signal abnormalities and/or enhancement of the overlying skin confirm the presence of an accompanying cellulitis. Bursal rice bodies can be observed with mycobacterial infections and other inflammatory and non-inflammatory processes. Except for gas, there is no other reliable sign to distinguish septic from non-septic bursitis [2].

Septic tenosynovitis

Tenosynovitis refers to inflammation of the synovial membrane surrounding a tendon. Infectious tenosynovitis is often due to inoculation or laceration and usually concerns fingers and toes flexors or contiguous spread from adjacent infections. Less commonly, it may result from hematogenous spread. The most common site of involvement in the musculoskeletal system is the hand and wrist most frequently implicated agents are *Staphylococcus aureus* and *Staphylococcus pyogenes*. Fungi, *Mycobacterium tuberculosis*, and non-tuberculous mycobacterial (NTM) infections are among the less common pathogens, particularly affecting immuno-compromised individuals [2]. A prompt assessment is mandatory to evict tendon necrosis. Radiographs are useful to eliminate adjacent arthritis or osteitis. Ultrasound shows thickening of tendon sheath associated to fluid effusion and Doppler hyperemia. Ultrasound may be useful to detect foreign bodies and guide their removal (Figure 5).

MR imaging shows fluid distending the tendon sheath that is associated with thickening of the synovial sheath and intense enhancement on post contrast images. Rice bodies can be observed with tuberculosis and atypical mycobacterial infections and may be confused with synovial chondromatosis [2]. Differential diagnosis is sarcoidosis and pigmented villonodular synovitis [17]. Antibiotics and surgical drainage are the keys of treatment. Infectious tenosynovitis is a surgical emergency, particularly in cases of acute bacterial flexor tenosynovitis of the hand. If left untreated, it may lead to osteomyelitis, tendon necrosis, or stenosing tenosynovitis [18]. Aspiration of synovial fluid or synovial biopsy is needed for definitive diagnosis [2].

Hydatidosis

Hydatidosis is a parasitic infection due to Echinococcus granulosus

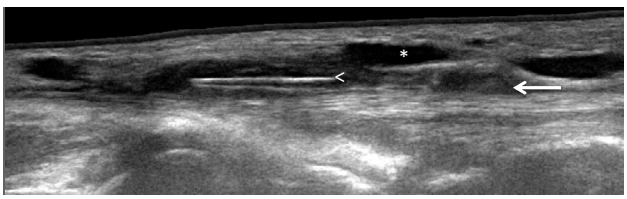

Figure 5: A 15-year-old boy with Septic tenosynovitis. Ultrasound shows thickening of tendon sheath (arrow), fluid effusion (asterisk) and hyperechoic foreign body (arrowhead).

larvae. The incidence of musculoskeletal echinococcis is about 1-5.4% among all cases of hydatid disease. Muscular echinococcosis may be primary or results from the spread cysts from other areas either spontaneously or after surgery. Cystic echinococcosis presents as a painless soft tissue mass with firm consistency. Ultrasound appearance of cystic echinococcosis is variable. It includes simple cysts (type I) cysts with detachment of the endocyst from the pericyst (type II), multivesicular cysts (type III) with honeycomb pattern as well as calcified cysts. Inhomogeneous muscle hydatidosis may have a nonspecific appearance that may simulate hematoma, abscess or necrotic soft tissue tumor (Figure 6). In case of atypical appearance or deep location, MRI is more accurate than ultrasound [19].

Mycetoma (Madura foot)

Mycetomas are inflammatory fungi-induced (eumycetomas) or bacterial-induced (actinomycetomas) pseudotumors. The main location is foot. The causal agents are mostly found on ground and thorny plants. The clinical pattern is an indolent chronic swelling and polyfistulized foot, with variable size and color grains issue. Diagnosis is obtained by direct examination of the pus, culture and histology. Radiographs and CT show cortical erosions, gaps, condensations and periosteal reactions. The confluence of these images could give an appearance of "bone lace". Ultrasound allows early diagnosis of this condition, before bone erosions appear on radiographs. It typically shows hypoechoic masses containing hyperechoic spots corresponding to fungal grains [19].

Cat-scratch disease

Cat scratch disease (CSD) is a human infectious disease caused by *Bartonella henselae*. It manifests mainly as acute regional lymphadenopathy and fever. Lymphadenopathy typically involves a single lymph node, frequently in the axillary and epitrochlear nodes (46%), head and neck (26%) and groin (17.5%). Ultrasonography shows hypoechoic lobular or oval mass with central hyperemia on power Doppler and a possible adjacent fluid collection. The nodes occasionally have hypoechoic regions representing areas of necrosis, and indeed, 10-30% of patients develop suppurative lymphadenitis (Figure 7). Asymmetrical shape and hyperechoic hilum seem to differentiate cat scratch disease from other aetiology including sarcoma, metastatic disease or lymphoma [20-22].

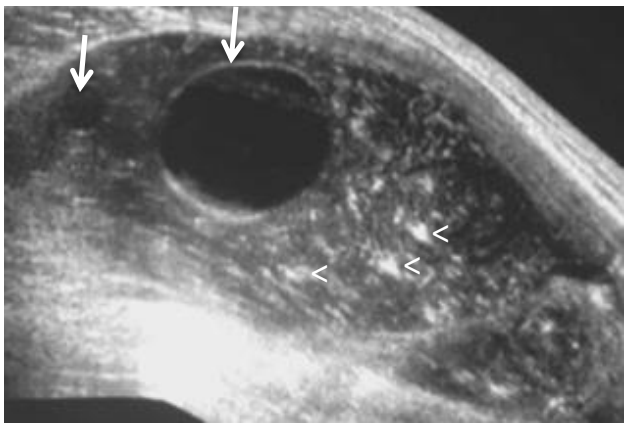

Figure 6: A 52-year-old man with soft tissue hydatidosis of the calf. Ultrasound shows multivesicular cyst: well-defined fluid collection with vesicles (arrow), calcifications and small echoes (arrowhead) corresponding to hydatid sand.

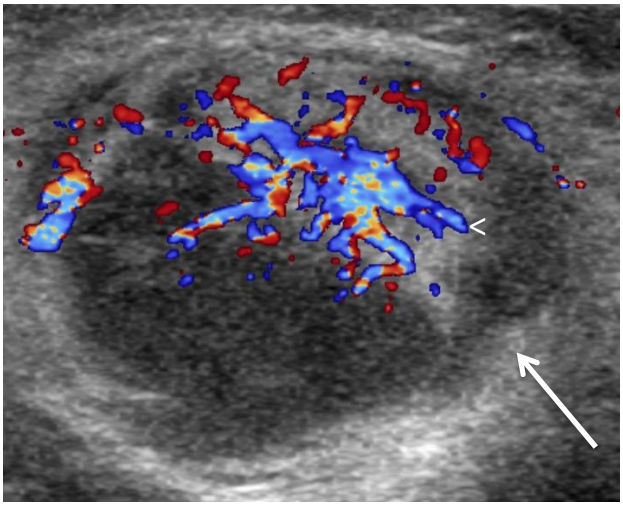

Figure 7: A 12-year-old boy with cat scratch disease. Ultrasound shows hypoechoic oval mass (arrow) with central hyperemia on power Doppler (arrowhead).

Conclusion

Ultrasound is an important tool in the diagnosis and the follow-up of soft tissue infections. In many cases (acute arthritis, cellulitis, septic tenosynovitis, superficial soft tissue abscess, cat scratch disease) ultrasound is sufficient for the diagnosis and helps to localize the site and the extent of the infection. In other cases (Necrotizing fasciitis, deep soft tissue abscesses), MRI or CT may be required. Ultrasound is also useful for treatment as it is used to guide aspiration or biopsy of septic collection, or to guide removal of foreign bodies.

Conflict of Interest

Authors declare no conflict interest

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