Sonography of Musculoskeletal Soft-Tissue Masses: Techniques, Pearls, and Pitfalls

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OBJECTIVE. The purpose of this article is to review the appropriate use of ultrasound in the workup of soft-tissue masses of the extremities. The normal sonographic appearance of superficial soft tissues, the importance of proper technique in image acquisition, and the characteristic sonographic appearance of certain masses and potential pitfalls are discussed.

CONCLUSION. Ultrasound is increasingly being used for the initial evaluation of soft-tissue masses of the extremities. Certain clinical and imaging findings allow diagnosis of selected soft-tissue masses; however, most imaging findings are nonspecific, and further evaluation is necessary. The many potential pitfalls can lead to adverse patient outcomes.

Keywords: extremities, musculoskeletal system, soft-tissue mass, sonography, ultrasound

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The role of ultrasound in the evaluation of soft-tissue masses traditionally has been limited to differentiating solid from cystic masses. In our experience, more cases of palpable soft-tissue masses are being referred for ultrasound as the initial imaging modality because of its availability, portability, and low cost. It is therefore imperative that general radiologists be familiar with the strengths and weaknesses of sonography and be aware of the many potential pitfalls so that they can avoid harm to patients that results from delayed diagnosis and misdiagnosis.

Ultrasound Evaluation of Soft-Tissue Masses

Different imaging modalities yield complementary information that can lead to diagnosis of a soft-tissue mass. The presence of a mass can be confirmed with sonography, and the mass can be characterized as solid or cystic. Sonography can also yield dynamic information, such as the compressibility and vascularity of a mass, and assist in imaging-guided intervention. In certain cases, the findings can lead to a diagnosis, but most patients need further evaluation with MRI, which yields detailed information about tissue composition. A few patients may need radiography or CT to determine the presence and pattern of mineralization.

Technique

Performance of real-time ultrasound by a radiologist is ideal for evaluation of soft-tissue masses. It facilitates acquisition of a detailed history, confident determination of anatomic location, evaluation with dynamic maneuvers, and easy comparison with the contralateral side and increases the visibility of radiologists with patients. However, increased study volume and remote reading may preclude radiologists from performing the examination. Proper training of sonographers and increased reliance on cine loops are essential.

The technique for image acquisition varies with the depth of the abnormality. Superficial masses should be examined with a high-frequency (12–17 MHz) linear transducer because of its high spatial resolution. Only light pressure should be applied to avoid compressing small vessels and missing flow. We favor use of a copious amount of gel rather than a standoff pad because the pad can be cumbersome and limit some dynamic maneuvers.

Deeper masses require the use of lower-frequency (5–9 MHz) curved-array transducers because of their better penetration and larger FOV. Applying more pressure to the transducer can be helpful for decreasing the distance between the mass and the probe, improving image quality.

Orthogonal static images can be used to determine the size, extent, morphologic features, and vascularity of a mass and should be part of the standard protocol for every examination [1]. Split-screen or extended FOV functions can be used to visualize the extent of masses occupying large anatomic seg-

ments [2]. Use of cine loops also facilitates complete evaluation of large masses and can be technically easier to obtain than extended FOV images. Both extended FOV images and cine clips can facilitate visualization of the anatomic origin of a mass, which can be missed on static images provided by a sonographer.

Important dynamic information can be obtained during real-time scanning, which can be essential for diagnosis. Dynamic evaluation can be used to determine symptoms of transection neuromas, noncompressibility of ganglia (Fig. S1) and swirling contents of complex cysts [3, 4]. (Figure S1, a cine clip, can be seen in the *AJR* electronic supplement to this article, available at www.ajronline.org.) In addition, dynamic information can aid in determining the tissue of origin of a mass. For example, because giant cell tumors of the tendon sheath arise from the tendon sheath and not the tendon, they do not move with flexion and extension of the digits [5].

Artifacts are commonly encountered at ultrasound, and identification of artifacts can lead to more accurate characterization of soft-tissue masses. Recognition of dirty shadowing and reverberation artifact, for example, can confirm the presence of air. Certain artifacts, however, can be misleading, and emphasis on proper technique can be essential in their elimination. For example, some simple cysts can appear complex or even solid because of internal echoes caused by multiple artifacts, including near field reverberation, beam thickness artifact, and excessive system gain [6, 7]. These can be eliminated by changing the scanning plane, adjusting the focal zone to the depth of interest, and adjusting the system gain.

Routine use of color Doppler imaging is essential for identifying solid and vascular masses. Proper technique is necessary to accurately visualize flow when present and to avoid falsely attributing flow to an imaging artifact. Low-velocity flow can be especially easy to miss. Techniques used for increasing sensitivity to low-velocity flow include use of power Doppler technique, decreasing the pulse repetition frequency, increasing the Doppler gain to a point just below that causing aliasing, using the highest-frequency transducer possible, and decreasing the wall filter [6]. Keeping the color box limited to the area of interest maintains a high frame rate, improving image quality [8]. Suspected flow should be confirmed with spectral analysis to avoid mischaracterizing transducer motion and twinkle artifact as flow.

Loizides et al. [9] reported the usefulness of contrast-enhanced ultrasound in the characterization of musculoskeletal masses. They described four perfusion pattern types: P1, nonenhancing mass or only rim enhancement of the surrounding pseudocapsule; P2, peripherally enhancing mass with nonenhancing central area; P3, diffusely enhancing mass with scattered nonenhancing areas and enhancement bridges, or both; and P4, completely homogeneously enhancing masses. All lesions with a P1 or P4 perfusion pattern were benign. However, both benign and malignant lesions can have either a P2 or a P3 perfusion pattern. More important, sulfur hexafluoride microbubbles, a second-generation blood-pool contrast agent, is not readily available at most institutions. Besides aiding in characterization of a soft-tissue mass, contrast-enhanced ultrasound can be used for biopsy guidance through identification of high-yield neoplastic foci. Final diagnosis requires tissue biopsy. Currently, ultrasound-guided core needle biopsy of musculoskeletal soft-tissue tumors is the technique of choice, after discussion and concurrence with the orthopedic oncologist, and has an overall diagnostic yield of 95%. The most important factor in achieving high diagnostic yield is expertise in identifying and targeting the viable tumor component [10].

Sonographic Appearance of Normal Soft-Tissue Structures

The sonographic appearance of normal soft-tissue structures has been described by Jacobson [3] and is reviewed in Table 1 and Figure 1. Ultrasound is poor for evaluating osseous structures because of the dense shadowing produced by the highly echogenic cortex. Evaluation of soft-tissue masses close to bones can also be limited because visualization of increased through-transmission may not be possible. In certain circumstances, angling the transducer away from the bone can improve visualization and facilitate visualization of posterior acoustic enhancement [11].

Lymph nodes are commonly encountered. Benign features include a characteristic reniform shape with a hypoechoic cortex and echogenic fatty hilum. Hilar flow can usually be visualized (Fig. 1). Increased cortical echogenicity, loss of reniform shape, and cortical flow suggest the presence of a pathologic entity.

Soft-Tissue Masses With Diagnostic Appearance at Ultrasound

Sonographic features, such as internal echogenicity, shape, and margination, are quite variable, even between similar histopathologic entities, and lack sufficient specificity for a definitive diagnosis. Findings that can be more reliably visualized are location within an anatomic compartment and relation to surrounding structures, both of which can suggest the anatomic origin of a mass. Ultrasound is ideally suited for this purpose because its spatial resolution is much greater than that of MRI [12]. Certain diagnoses can therefore be made with ultrasound on the basis of selected imaging features in characteristic locations (Table 2). This discussion includes both common (ganglia, Baker cysts, and peripheral nerve sheath tumors) and less common (Morel-Lavallée lesions, acromioclavicular joint cysts, and pseudoaneurysms) entities. They have been chosen to emphasize the importance of location and

TABLE 1: Sonographic Appearance of Normal Soft-Tissue and Osseous Structures

Structure	Sonographic Appearance
Epidermis, dermis	Hyperechoic
Hypodermis	Hypoechoic fat and hyperechoic fibrous septations
Tendon	Hyperechoic with fibrillary echotexture
Muscle	Hypoechoic
Bone and calcium	Hyperechoic with posterior acoustic shadowing
Fibrocartilage	Hyperechoic
Ligaments	Hyperechoic; striations more compact than with tendon
Peripheral nerve	Fascicular; nerve fascicles hypoechoic surrounded by hyperechoic connective tissue
Lymph node	Reniform hypoechoic structure with central echogenicity

Note—Data from [3].

relation to surrounding structures in diagnosis. Vascular malformations have a characteristic sonographic appearance and also are discussed. Other common lesions with characteristic sonographic appearances (e.g., Morton neuroma) are well described in the literature, are included in Table 2, and are not discussed further in this article.

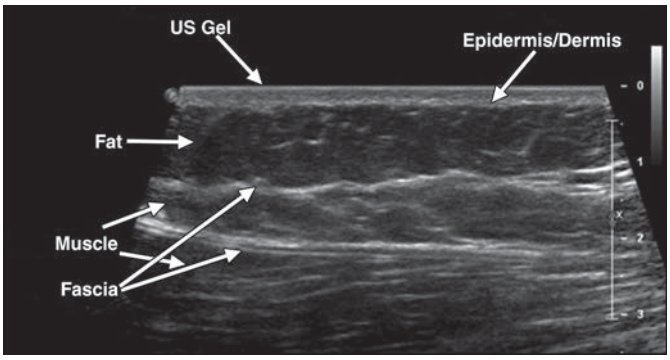
Ganglion

Ganglion is the most common mass of the hand and wrist [13]. The pathogenesis remains unclear, but at least 10% of ganglia are related to trauma [14]. The cyst is mucin filled, has a fibrous capsule, and occurs in association with a joint or tendon sheath. The dorsal wrist, near the dorsal scapholunate ligament, is the most common location (60–70% of cases) [15]. The radial aspect of the volar wrist is also a common site of involvement.

Ganglion has been classically described as a simple cyst characterized at ultrasound by smooth margins, lack of internal echogenicity, lack of flow, and increased through-transmission. Many reports in the literature suggest that most ganglia have a variable, complex appearance that includes thick walls, locules, and internal echogenicity [16, 17]. Visualization of internal vascularity is not expected. If seen, internal vascularity should suggest the presence of a solid mass or a collapsed ganglion [17].

TABLE 2: Soft-Tissue Masses With Characteristic Appearance Based on Location

Location	Cystic	Solid
Shoulder	Acromioclavicular joint cyst	Elastofibroma
	Paralabral cyst	
	Subacromial subdeltoid bursitis	
Elbow	Olecranon bursitis	Tumoral calcinosis
		Peripheral nerve sheath tumor
		Epitrochlear lymph node
Wrist, hand	Ganglion cyst	Peripheral nerve sheath tumor
		Giant cell tumor of the tendon sheath
		Glomus tumor
		Palmar fibromatosis
Hip, thigh	Morel-Lavallée lesion	Intramuscular myxoma
	Ischial, trochanteric, iliopsoas bursitis	Inguinal and femoral hernia
Symphysis pubis	Subpubic cartilaginous cyst	
Knee	Baker cyst	
	Parameniscal cyst	
	Joint effusion, synovitis	
	Morel-Lavallée lesion (prepatellar)	
	Prepatellar bursitis	
Ankle, foot	Ganglion cyst	Morton neuroma
		Peripheral nerve sheath tumor
		Plantar fibromatosis



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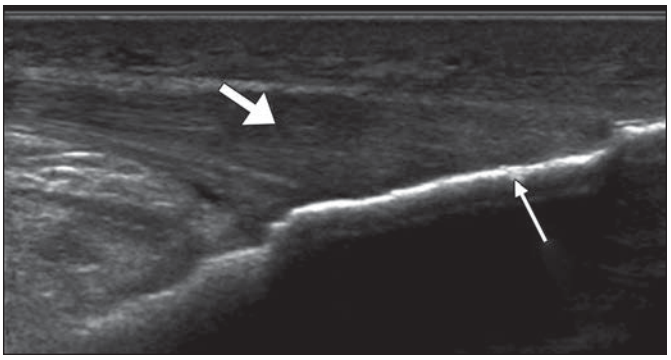

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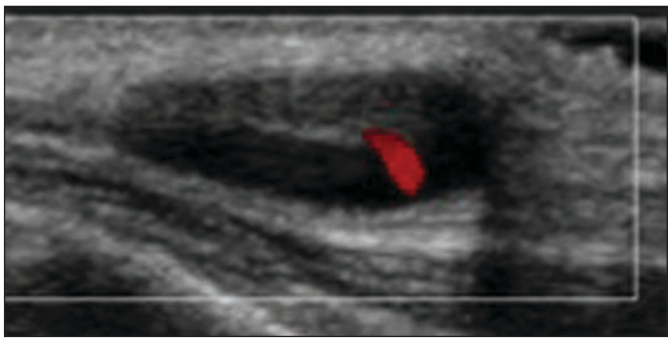

C

Fig. 1—27-year-old woman with normal superficial soft tissues.
A, Ultrasound image shows normal appearance of superficial soft tissues.
B, Ultrasound image shows normal appearance of bone (*thin arrow*) and patellar tendon (*thick arrow*) in knee.
C, Color Doppler image shows normal lymph node with fatty hilum and hilar flow.

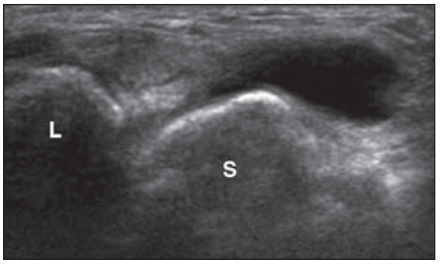

Fig. 2—38-year-old woman with ganglion of dorsal wrist. Gray-scale ultrasound image of wrist shows simple cyst arising from between scaphoid (S) and lunate (L) of dorsal wrist.

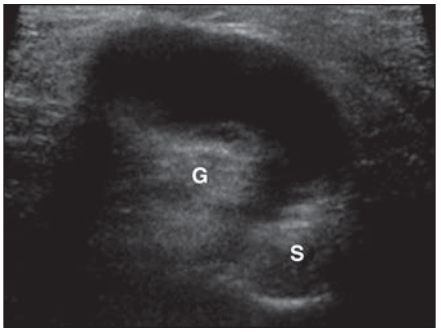

Fig. 3—67-year-old man with Baker cyst. Gray-scale ultrasound image of popliteal fossa shows cystic mass arising between tendons of medial head of gastrocnemius (G) and semimembranosus (S) muscles.

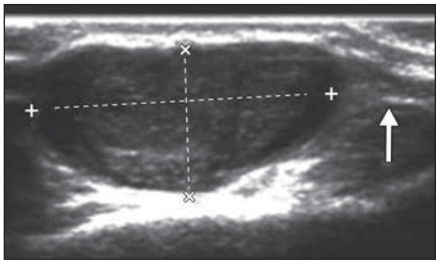

Fig. 4—27-year-old man with schwannoma of ankle. Gray-scale ultrasound image shows echogenic mass (*calipers*) with increased through-transmission. Entering or exiting nerve sign (*arrow*) confirms origin from peripheral nerve.

Because of the variable appearance of ganglia, the most important finding is association with a joint or tendon sheath, seen as a communication, or neck, indicating the anatomic origin of the mass (Fig. 2) and confirming the diagnosis of ganglion. However, this can be difficult to identify; it was seen in only 25–35% of cases in two series [16, 17]. Use of cine loops may facilitate visualization of this finding.

Ultrasound is an important tool in evaluating hand and wrist masses and has been found to be more accurate than clinical impression alone [17]. Differentiation of solid from cystic masses is essential information for the hand surgeon and although relatively easy with ultrasound can be difficult at physical examination. Solid masses are generally treated with surgical excision, but some cystic masses are managed more conservatively with aspiration and steroid injection. In the case of ganglion, identification of the neck of the ganglion is important for surgical planning, because it must be excised to lower the rate of recurrence.

Baker Cyst

A Baker cyst is located within the popliteal fossa posterior to the knee. It results from herniation of synovium through the small gap between the tendons of the semimembranosus muscle and of the medial head of the gastrocnemius muscle. Fluid gradually accumulates, and the cyst can enlarge and even rupture, causing pain. Complications include any process primarily involving the knee joint, such as synovial osteochondromatosis, hemorrhage, synovitis, and infection.

The sonographic appearance of a Baker cyst is an anechoic or hypoechoic mass in the medial aspect of the popliteal fossa. Septation and internal debris may be found. A Baker cyst lacks internal flow but may exhibit peripheral hyperemia in the presence of coexisting synovitis. The key to diagnosis is identification of the origin between the semimembranosus muscle and the medial head of the gastrocnemius muscle (Fig. 3).

Peripheral Nerve Sheath Tumor

Peripheral nerve sheath tumors are benign or malignant tumors of Schwann cell origin and include schwannomas, neurofibromas, and malignant peripheral nerve sheath tumors. They can arise from peripheral nerves throughout the body and commonly occur in the extremities. A solitary mass is the most common presentation, but multiple and plexiform neurofibromas occur in neurofibromatosis.

The typical sonographic appearance is a round or oval relatively homogeneous mass. A peripheral nerve sheath tumor is almost always hypoechoic relative to skeletal muscle and exhibits increased through-transmission, simulating a cystic mass, such as a ganglion, in the extremities [18]. Internal vascularity, however, is frequently visualized and can be used to differentiate the two [19]. The distinguishing imaging feature is continuity with a peripheral nerve, seen as a hypoechoic fascicular structure entering and exiting the mass (Fig. 4). Ultrasound has a unique advantage in depicting this feature because of its high spatial resolution, especially in the extremities, where masses and peripheral nerves can be quite small. Detection of a solid mass in the extremities, therefore, should prompt careful examination for this feature.

Differentiation between schwannoma, neurofibroma, and malignant peripheral nerve sheath tumor with ultrasound is often not possible because these lesions share many findings. An eccentrically located mass with respect to the entering nerve is specific but not sensitive for schwannoma [19]. The target sign, described as increased central and decreased peripheral echogenicity, is nonspecific and cannot be reliably visualized or used to differentiate schwannoma from neurofibroma [20]. Large size, ill-defined margin, rapid growth, and central necrosis raise suspicion of malignant peripheral nerve sheath tumor and merit further imaging with MRI.

Morel-Lavallée Lesion

Morel-Lavallée lesion is a posttraumatic closed degloving injury resulting from a shearing force applied across tissue planes. The result of the injury is a fluid collection consisting of blood, lymph, or fat lobules accumulating in a potential space between fascial planes. The characteristic location is over the greater trochanter, but the lesion can occur almost anywhere. The prepatellar soft tissue is another well-established location described in the literature [21]. Blood and lymphatic channels are disrupted, and the disruption can cause chronic or recurrent fluid collections and infection. Treatment options are variable, including conservative management, percutaneous aspiration, incision and drainage, sclerosis, and open débridement, and depend on symptoms and the presence of infection [22, 23].

The ultrasound manifestations of a Morel-Lavallée lesion are an anechoic or hypoechoic fluid collection that is typically compressible and lacks internal flow [24]. The lesion tends to be lobulate and slightly heterogeneous in the acute phase and gradually becomes closer to homogeneous and fusiform or flat [24]. The lesion may contain globules of echogenic fat (Fig. 5). The differential diagnosis in the acute phase includes hematoma, abscess, and fat necrosis and in the chronic phase includes neoplasm, seroma,

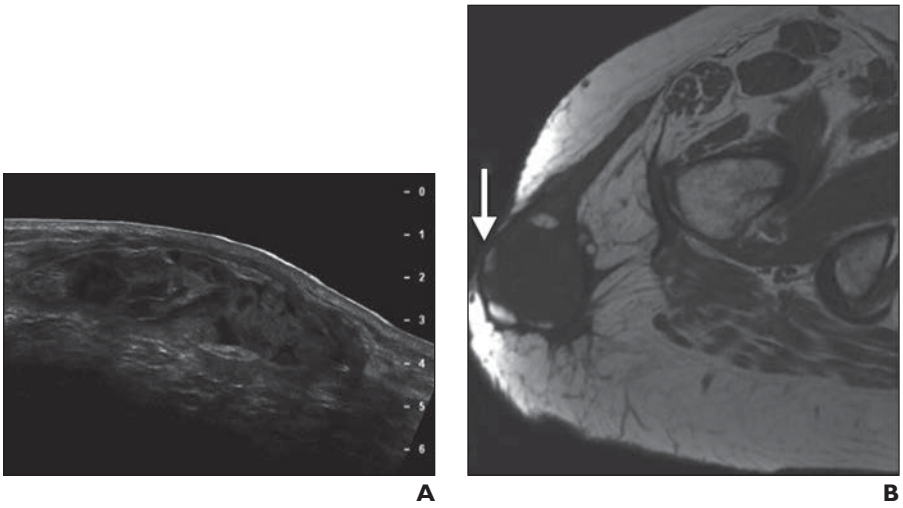

Fig. 5—73-year-old woman with Morel-Lavallée lesion of hip after fall.
A, Gray-scale sonographic image over greater trochanter shows fusiform hypoechoic mass with several central echogenic fat globules. Duplex Doppler image showed no internal flow (not shown).
B, Axial T1-weighted MR image shows fat globules within lesion (*arrow*).

and lymphocele. Characteristic locations between fascial planes in the hip and knee after acute or subacute trauma are the distinguishing features that lead to diagnosis.

Acromioclavicular Joint Cyst

Acromioclavicular joint cyst is a late manifestation of a chronic rotator cuff tear. Friction from the high-riding humeral head on the inferior acromioclavicular joint capsule results in tear of the inferior acromioclavicular ligament and superior herniation of glenohumeral joint fluid and synovium. Accumulation gradually leads to ballooning of the superior acromioclavicular joint capsule, resulting in a characteristic supraclavicular cystic mass.

The ultrasound appearance of an acromioclavicular joint cyst is an anechoic or hypoechoic cystic mass that may contain septations and debris (Fig. 6). Internal flow is lacking, though peripheral flow can occur in cases of coexisting synovitis. Although a cystic supraclavicular mass can be nonspecific, recognition of communication with the acromioclavicular joint through a narrow neck, termed the geyser sign, is the key to diagnosis and can be visualized through careful real-time examination and appropriate use of cine clips.

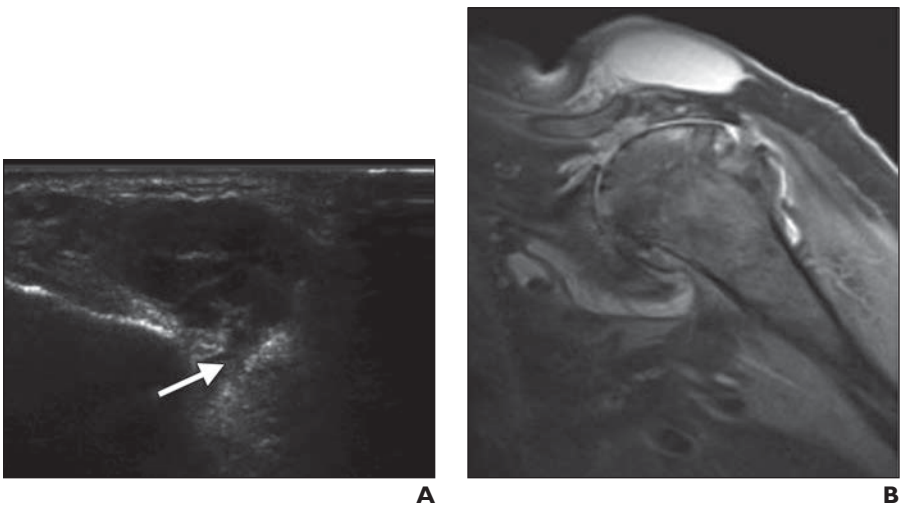

Fig. 6—89-year-old woman with acromioclavicular joint cyst.
A, Gray-scale ultrasound image shows hypoechoic mass arising from acromioclavicular joint. Communication with AC joint (*arrow*) seen with ultrasound confirms diagnosis. Duplex image confirmed no internal flow (not shown).
B, Coronal T2-weighted fat-saturated MR image shows chronic full-thickness rotator cuff tear predisposing to formation of acromioclavicular joint cyst.

Parameniscal and paralabral cysts in the knee and shoulder are similar pathologic processes, resulting from extraarticular accumulation of joint fluid and can be recognized at ultrasound on the basis of their characteristic locations. As is the case with acromioclavicular joint cyst, MRI, although not necessary to make the diagnosis, can be performed to confirm the underlying pathologic condition (i.e., rotator cuff, meniscal or labral tear) and exclude complications, such as acute suprascapular neuropathy, which is difficult to see with ultrasound (Fig. 7).

Pseudoaneurysm

Pseudoaneurysm is a contained arterial rupture that maintains its connection to the feeding artery. It can be iatrogenic or the result of infection or trauma. Thrombus formation and septations are common. Complications include rupture resulting in massive hemorrhage, embolization, and secondary infection.

Pseudoaneurysm appears as a hypoechoic or anechoic mass with increased through-transmission. Internal echogenicity, representing thrombus and septations may be seen. Ultrasound has unique advantages in depicting the distinguishing imaging features of pseudoaneurysm. High spatial resolution allows visualization of the relation to an adjacent artery, and use of color Doppler technique reveals the vascular nature of the mass. Doppler evaluation is useful in differentiating pseudoaneurysm from hematoma. Pseudoaneurysm has a yin-yang sign of swirling internal flow (Fig. 8) and a to-and-fro waveform at the neck representing pulsatile bidirectional flow [25].

Vascular Malformations

Vascular malformations include arteriovenous, capillary, venous, and lymphatic malformations and have characteristic sonographic appearances that should be sought at examination. Arteriovenous malformations entail abnormal connection between the artery and the adjacent vein. They consist of multiple dilated tortuous vascular channels that have both arterial and venous flow. Venous malformations are compressible, hypoechoic, heterogeneous masses. Occasionally, phleboliths are detected as echogenic, shadowing structures. Pulsed Doppler analysis reveals monophasic, low-velocity venous flow that can be visible at real-time exami-

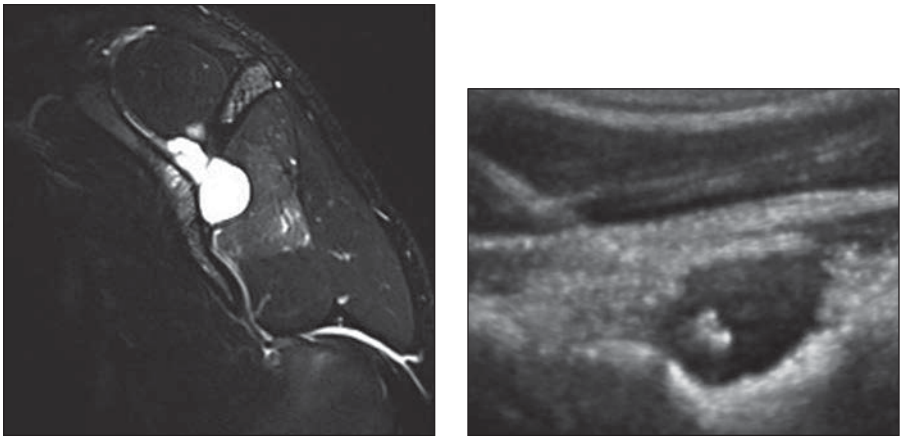

Fig. 7—32-year-old man with labral tear, paralabral cyst, and suprascapular neuropathy.
A, Oblique coronal T2-weighted MR image of shoulder shows paralabral cyst extending into spinoglenoid notch. Edema of infraspinatus muscle could not be visualized at ultrasound (not shown). Underlying labral tear also was present (not shown).
B, Gray-scale ultrasound image shows aspiration of paralabral cyst.

nation (Fig. S2) [26]. (Figure S2, a cine clip, can be seen in the *AJR* electronic supplement to this article, available at www.ajronline.org.) Peak venous flow and vessel density in arteriovenous malformations are higher than in venous malformations [27].

Potential Pitfalls at Sonographic Evaluation of Soft-Tissue Masses

Pitfall 1: Infected Fluid Cannot Be Differentiated From Noninfected Fluid

Ultrasound is reliable for visualizing joint effusions and abnormal fluid collections, which may be concerning for septic arthritis and abscess if infectious symptoms are present. Sonography can be particularly useful for identifying effusion in a patient with a metallic joint prosthesis because it lacks the limiting metallic artifact seen with CT and MRI [28]. Although modern imaging sequences facilitate identification of joint effusions associated with prostheses, sonography can be used for imaging-guided joint aspiration to assess for infection, loosening, and lesions associated with lymphocytic vasculitis.

Many sonographic findings are suggestive of infected fluid, including peripheral hyperemia, internal debris and septations, and accumulation of air (Figs. 9 and 10). In our experience, however, the absence of these findings does not exclude infection, and aspiration must be performed for fluid analysis. In addition, in the absence of internal air, sonography cannot be used to differentiate infection from inflammation (i.e., synovitis) or superimposed infection in inflammatory arthropathy. Imaging-guided aspiration is necessary to make a diagnosis.

Pitfall 2: Lipoma, the Most Common Soft-Tissue Neoplasm, Cannot Be Accurately Diagnosed

Lipoma is a benign proliferation of fat cells with variable amounts of fibrous tissue that primarily arises within the subcutaneous soft tissues, muscles, and even bones of the extremities. It is the most common soft-tissue neoplasm [29]. The classic sonographic appearance is a well-defined echogenic solid mass (Figs. 11 and 12). Results of multiple studies, however, have established the variable ultrasound appearance, which ranges from well- to ill-defined and anechoic to hyperechoic [2]. Echogenicity depends on cellularity and increases with the number of fat-water interfaces, which is quite variable for lipoma [30]. Because of the variable appearance, the accuracy of sonographic diagnosis is poor, ranging from 49% to 64% [31].

The specificity of the ultrasound findings of solid soft-tissue masses is limited, and any concerning features should prompt further evaluation. Concerning imaging findings include large size and the presence of detectable internal vascularity. Clinical features such as rapid growth and pain should also prompt further evaluation. MRI, if possible, should be the next step in imaging evaluation. CT and MRI findings suggestive of malignancy have been established [32]. In general, percutaneous biopsy should be performed only after consultation with an orthopedic oncologist. Excisional biopsy is the only method of definitive diagnosis.

Pitfall 3: Hematoma Cannot Be Reliably Differentiated From a Hemorrhagic Solid Soft-Tissue Neoplasm

Solid soft-tissue neoplasms are far less common than hematomas; however, mischaracter-

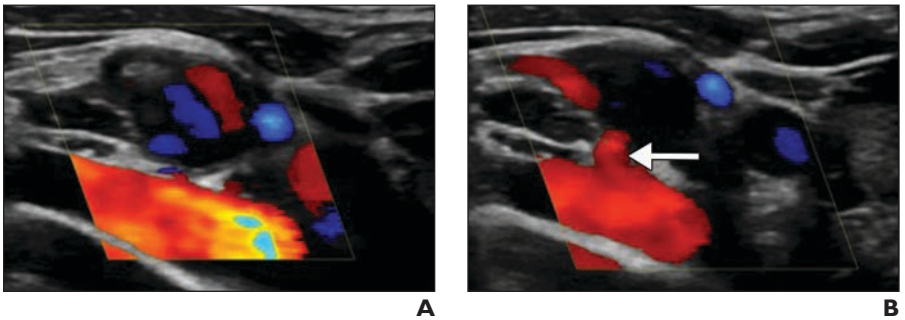

Fig. 8—8-year-old girl with subclavian artery pseudoaneurysm after arterial puncture.
A, Color Doppler image of subclavian artery shows hypoechoic mass with yin-yang sign indicating swirling internal flow.
B, Color Doppler image shows neck (*arrow*) connecting mass to subclavian artery. Bidirectional flow was confirmed with spectral Doppler(not shown).

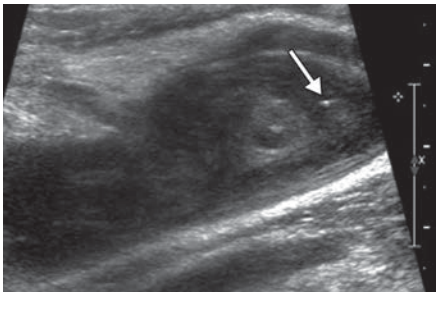

Fig. 9—58-year-old man with infected fluid collection due to septic arthritis and Baker cyst after recent knee arthroscopy. Gray-scale ultrasound image of popliteal fossa shows complex cystic mass with hyperechoic foci suggestive of gas bubbles (*arrow*). No calcified bodies were seen at radiography (not shown). Complexity and presence of air suggest infection.

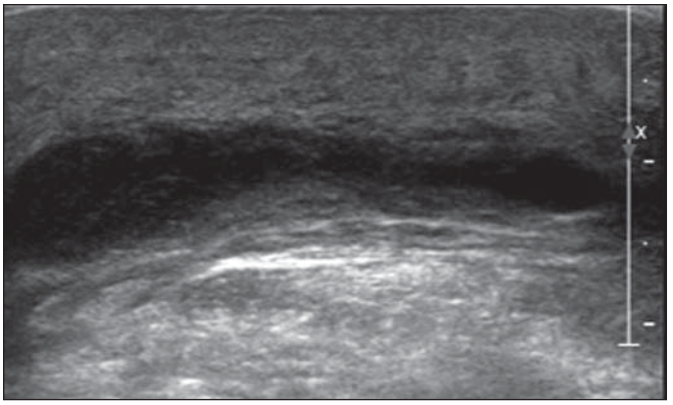

Fig. 10—19-year-old man with infected fluid collection due to infectious prepatellar bursitis. Gray-scale ultrasound image shows few internal echoes within prepatellar bursa. Minimal complexity may be secondary to synovitis or infection. Aspiration revealed infectious bursitis despite only minimal complexity of fluid.

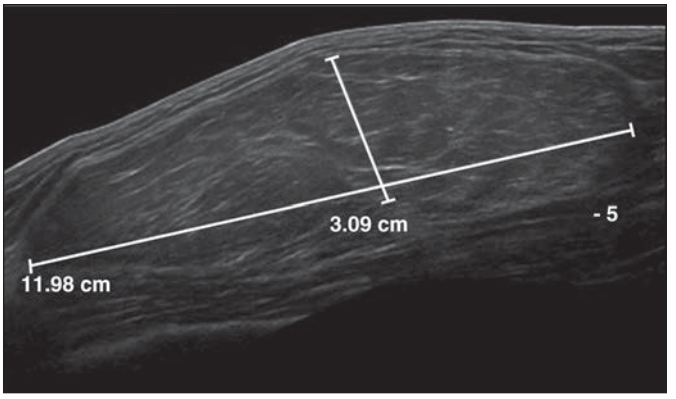

Fig. 11—39-year-old man with lipoma of upper arm. Extended FOV gray-scale sonographic image shows 12-cm uniform, well-circumscribed, hypoechoic mass. Possibility of malignancy was suggested because of size. Excision revealed benign lipoma.

ization as hematomas on the basis of the imaging findings can lead to disastrous outcomes. Risk factors for the development of hematoma include history of substantial trauma, recent surgery, bleeding diathesis, and anticoagulation therapy. The disorganized vasculature of soft-tissue neoplasms can result in spontaneous hemorrhage or bleeding after only minor trauma. Differentiation from benign hematoma can be difficult if the hemorrhagic component is large. Clinically, hemorrhagic neoplasms are usually painless, and hematomas usually present acutely with pain after trauma. Large hemorrhagic components have been reported in many types of soft-tissue sarcomas, including angiosarcoma, synovial sarcoma, epithelioid sarcoma, extraskeletal Ewing sarcoma, leiomyosarcoma, liposarcoma, rhabdomyosarcoma, and malignant fibrous histiocytoma [33]. Hemorrhagic components have been reported in 17% of epithelioid sarcomas found at MRI and 5% of malignant fibrous histiocytomas [34, 35].

The imaging appearance of hematoma varies with its age. Acute hematomas are generally well-defined and hypoechoic. As coagulation progresses and blood products are broken down, it appears more echogenic and heterogeneous [36]. As hematomas evolve, they often liquefy and present as anechoic fluid. Soft-tissue sarcomas are often very infiltrative and can therefore appear less well defined. Blood flow in hematomas may be peripheral. Therefore, the detection of intralesional flow should raise suspicion of a solid mass, and further imaging should be pursued (Fig. 13). MRI, because of its greater contrast resolution and its capability of depicting finely enhancing solid components, is preferred over CT and should be performed in all suspicious cases [37]. An important distinguishing feature is evolution over time; a hematoma should regress over weeks, whereas a sarcoma will persist or grow. Close follow-up imaging to visualize regression and resolution may be reasonable in low-risk cases.

There are many potential imaging and clinical pitfalls in differentiating hematoma from a hemorrhagic soft-tissue neoplasm. First, a history of trauma may be reported by patients with a soft-tissue neoplasm, leading to misdiagnosis of a hematoma. In the absence of a bleeding diathesis or anticoagulation therapy, large hematomas should result only after considerable trauma. Corroboration of the mechanism of injury is therefore imperative and should be done in all cases of suspected hematoma.

Second, some hematomas can mimic a hemorrhagic soft-tissue neoplasm by undergoing progressive growth more than 1 month after onset, termed a chronic expanding he-

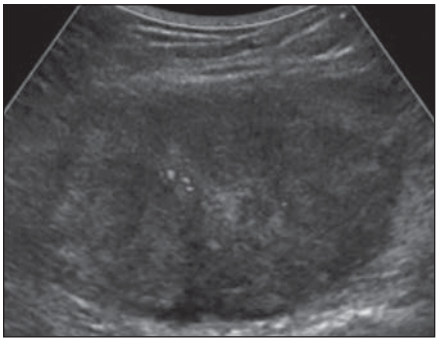

Fig. 12—63-year-old man with liposarcoma of thigh. Power Doppler sonographic image of thigh shows heterogeneous solid mass with internal flow, which suggests malignancy. Excision revealed liposarcoma.

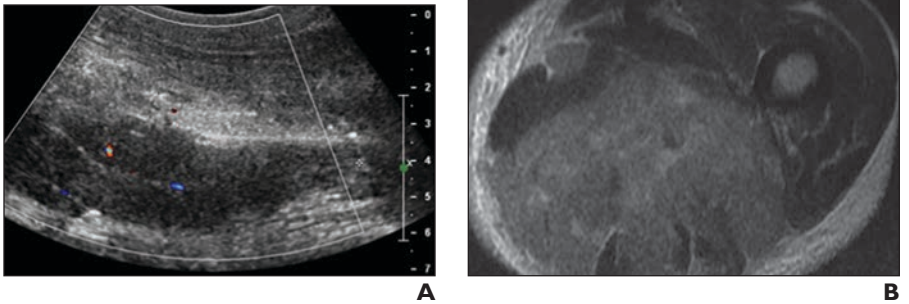

Fig. 13—74-year-old man with metastatic thigh lymphoma. Example of difficulty differentiating hematoma from hemorrhagic soft-tissue mass with ultrasound.
A, Color Doppler ultrasound image shows irregular hypoechoic deep thigh mass. Despite presence of internal vascularity, this was incorrectly identified as hematoma because of provided history of recent fall.
B, Axial T1-weighted gadolinium-enhanced MR image shows heterogeneously enhancing solid mass of posterior thigh confirmed to be metastatic lymphoma at pathologic examination.

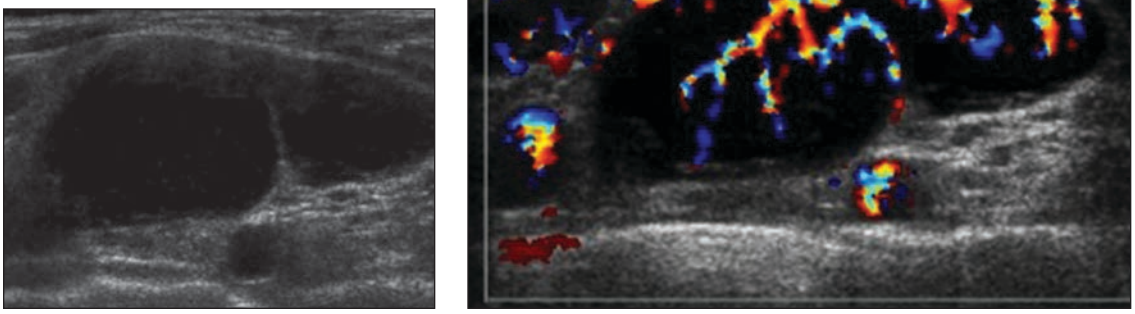

Fig. 14—64-year-old woman with supraclavicular lymphoma. Example of mischaracterization of solid masses as cystic.
A, Gray-scale sonographic image shows anechoic supraclavicular mass with increased through-transmission.
B, Duplex Doppler image shows internal vascularity, confirming solid mass. Without Doppler examination this mass may have been mischaracterized as cystic. Internal flow can also be difficult to show in small masses.

matoma [38]. History of remote trauma, prolonged duration of symptoms (sometimes over years), and involvement of more superficial fascial layers have been identified as potential differentiating features for this entity [39]. Despite the description in the literature, chronic expanding hematoma is relatively uncommon compared with conventional hematomas. Recognition of chronic expanding hematoma is important, but we believe the definitive diagnosis is not suggested by imaging findings alone. Tissue confirmation is ultimately necessary.

Last, aspiration biopsy can be unreliable in differentiating hemorrhagic neoplasm from hematoma because of the abundance of hematogenous cells. In one series of six hemorrhagic soft-tissue neoplasms [37], five (83%) yielded false-negative results. Open biopsy is needed for exclusion of malignancy in suspicious cases.

Pitfall 4: Some Solid Tumors Can Be Mischaracterized as Cystic

It is well established that one of the strengths of sonography is differentiating solid from cystic masses, which can limit the differential diagnosis of a palpable mass. Characteristic ultrasound findings of cysts are well described and reliable; however, some cystic masses may not have all of these findings, and certain solid masses share some of these features. In one series in the literature [8], solid tumors were mischaracterized as cystic in as many as 5% of cases. Mischaracterization was based on findings of low or absent echogenicity, increased through-transmission, and lack of internal vascularity within certain solid soft-tissue masses.

Internal echogenicity and increased through-transmission are both related to the transmission of sound. Uniformly cellular masses have a relative paucity of interfaces with different acoustic impedance and generally transmit sound well, resulting in both low internal echogenicity and increased through-transmission [40]. This has been well described in certain cellular masses, such as lymphoma (Fig. 14), melanoma, and peripheral nerve sheath tumors, and with fibrous tumors, and can lead to potential mischaracterization as cystic masses [5, 8, 19, 41, 42].

The presence of internal vascularity confirms the diagnosis of a solid mass or a mass of vascular origin. Visualization of this finding can be highly technique dependent. Detection of internal vascularity can also be difficult in small masses [43, 44].

We consider the classic findings of cystic masses to be reliable, but the absence of any of these findings should suggest the possibility of a solid mass, and further imaging should be performed. Proper technique and recognition of imaging artifacts are important as they are necessary to accurately visualize the findings used to differentiate solid and cystic masses.

Pitfall 5: Whether a Palpable Mass Is Truly of Soft-Tissue Origin or an Extraosseous Component of an Underlying Bone Lesion Can Be Difficult to Determine

Ultrasound is poor for evaluating bone and marrow because of the intensely echogenic cortex and dense shadowing. Differentiating the origin of a pathologic process close to bone can therefore be difficult (Figs. 15 and 16). Bone cortex should be a

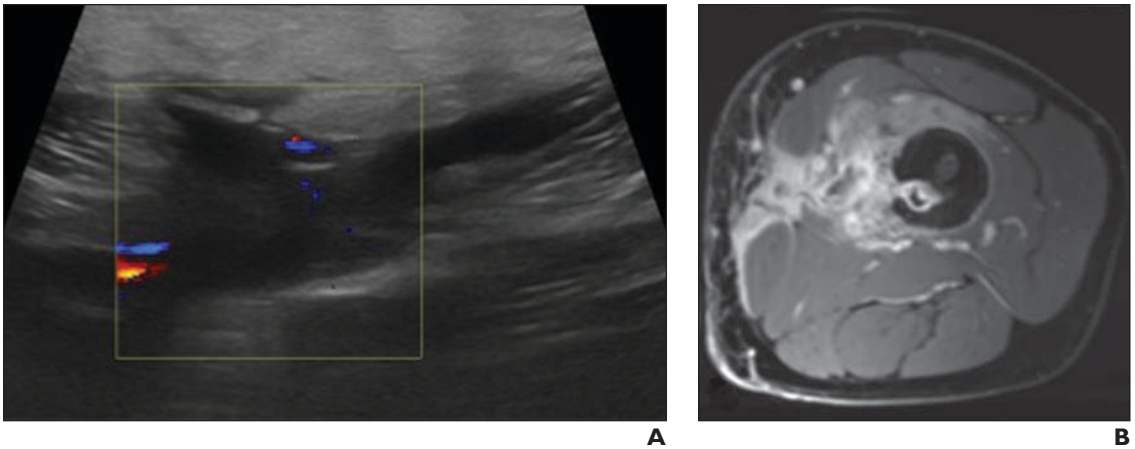

Fig. 15—35-year-old man with femoral osteomyelitis and associated soft tissue abscess.
A, Color Doppler image of deep thigh shows irregular hypoechoic mass with peripheral hyperemia.
B, Axial T1-weighted fat-saturated gadolinium-enhanced MR image of thigh shows underlying bone osteomyelitis with sequestrum. Underlying bone involvement could not be delineated with ultrasound.

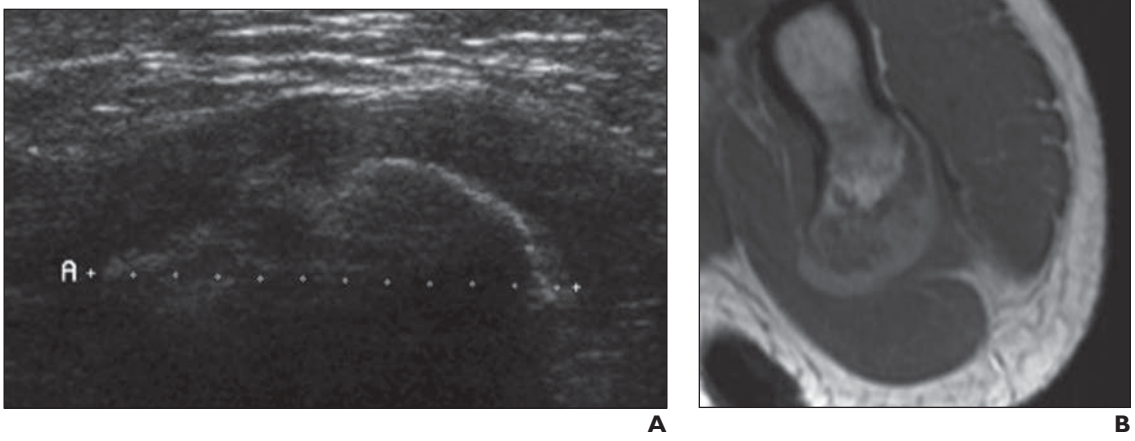

Fig. 16—54-year-old woman with soft-tissue mass.
A, Gray-scale ultrasound image of upper arm shows intensely echogenic mass (A) with dense shadowing.
B, Axial T1-weighted MR image shows echogenic mass to be osteochondroma of humerus.

well-defined echogenic line. Cortical step-off or disruption can be a clue to an underlying osseous lesion. Every effort should be made to visualize the extent of the lesion with real-time scanning, cine loops, or panoramic images. If the entire lesion cannot be visualized or if intimate association with a bony structure suggests underlying involvement, further evaluation with CT or MRI should be pursued.

Conclusion

Ultrasound is being increasingly used by ordering providers as the initial imaging modality for evaluation of palpable soft-tissue masses. Because of the dynamic nature of the examination, sonographic evaluation should ideally be performed personally by a radiologist to yield the most information. Emphasis on proper technique and recognition of artifact are essential for accurate characterization of masses.

Most soft-tissue masses have a nonspecific appearance at ultrasound and require further imaging. Anatomic location and relationship to surrounding structures are ideally evaluated with ultrasound, can be reliably visualized, and are generally more specific than other features, such as echogenicity, size, and margination. In combination with an appropriate clinical history and certain sonographic findings, a specific diagnosis can sometimes be made.

Initial contact with the patient through the ultrasound department provides an opportunity for the radiologist to guide proper management through appropriate referrals and recommendations for further imaging evaluation. To avoid adverse patient outcomes, it is imperative that the radiologist be familiar with the strengths and potential pitfalls of ultrasound when evaluating soft-tissue masses.

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