Targeted Musculoarticular Sonography in the Detection of Joint Effusions

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Abstract. This article describes an advanced application for an established technology, specifically the use of bedside sonography in the assessment of the acutely painful joint in the emergency department. The sonographic windows for each of the axial synovial joints are outlined, with a brief discussion of commonly encountered pathologic conditions. **Key words:** ultrasonography; bedside sonography; joint effusions; pain; imaging. ACADEMIC EMERGENCY MEDICINE 2001; 8:361–367

JOINT pain is a common complaint in the emergency department (ED), and identification of fluid within the joint space has important implications for both diagnosis and treatment. Clinical examination alone or attempted blind joint aspiration often fails to reliably detect the presence of a joint effusion,[1,2] and for this reason bedside sonography has a distinct clinical utility for emergency physicians. Joint sonography has several advantages over magnetic resonance imaging (MRI) and computed tomography (CT), including lower cost, wide availability, rapid side-to-side anatomic comparison, and better characterization of fluid.[3] In addition, ultrasound exams can be repeated without radiation risks, patients unsuitable for MRI and/or CT can be evaluated, and no sedation is required for pediatric patients.[3]

Ultrasound has proven accuracy in the identification and characterization of joint effusions.[4,5] Using a high-frequency probe, as little as 1 mL of intraarticular fluid can be reliably seen.[2] Conversely, a sonogram demonstrating no effusion usually indicates that the source of pain lies outside of the joint (periarticular).[6] The purpose of this discussion is to detail the sonoanatomy and sonographic characteristics of the large synovial joints in the detection of intraarticular effusions. It is assumed that the reader has a basic understanding of the principles of ultrasound.

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SONOGRAPHIC CHARACTERISTICS OF EFFUSIONS

The main categories of effusions that are encountered when performing bedside sonography are: 1) noninflammatory, 2) posttraumatic hemarthrosis, 3) inflammatory, and 4) septic. Simple, noninflammatory joint effusions are typically anechoic or hypoechoic in appearance. An example of a simple effusion is that seen in transient synovitis[2] or a result of gravitational forces with fluid seen in the ankle. Acute traumatic effusions appear as hypoechoic space within the joint and can be difficult to distinguish from a simple effusion, particularly in the case of chronic effusions. When the effusion is complicated by the presence of either free-floating clot or fat lobules, the appearance is heterogeneous with echogenic particles or fronds floating within the relatively hypoechoic joint space.

Lipohemarthrosis has a unique sonographic appearance due to the layering of blood and fat; there is a two-layer effusion with the superior layer being fat and the inferior layer being blood. This layered appearance may be best seen in the patient who hasn't been moving the joint to a large extent prior to the ultrasound exam. In septic arthritis, the fluid frequently has a hypoechoic appearance with internal echoes (particulate appearance). The effusions associated with chronic inflammatory arthritic conditions, such as rheumatoid arthritis (RA), are often difficult to differentiate from acute infective arthritis. One sonographic sign of infection in a rheumatoid joint is a marked increase in intraarticular fluid without a concomitant increase in synovial thickness. The amount of joint effusion is proportionate to the amount of synovial thickening with flaring of RA.[6] However, septic arthritis cannot be ruled out based solely on the sonographic appearance.[2,7]

Synovial hypertrophy, or pannus, is most commonly seen in inflammatory arthritis, but can also

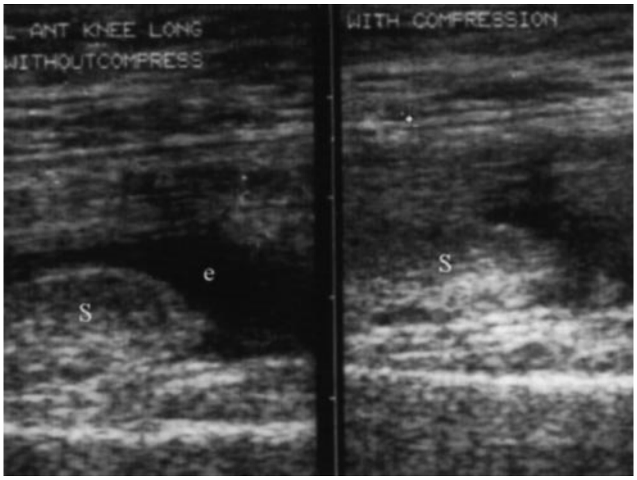

Figure 1. Longitudinal view of the suprapatellar bursa with and without compression. A synovial polyp (S) and an effusion (e) are noted on the left (without compression). Upon graded compression with the transducer, the synovium (S) remains a comparable size (*right panel*).

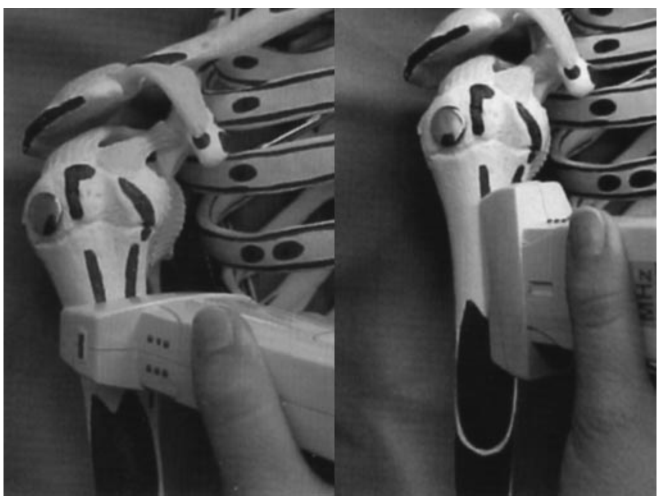

Figure 2. Transducer position for the transverse view (*left*) and the longitudinal view (*right*) over the normal anatomic position of the biceps tendon.

be found in chronic infections (tuberculosis, brucellosis, Lyme disease, or fungal infection).[6] Pannus has a sonographic appearance similar to clot or septic fluid (particulate). One way to identify pannus is to compress the joint under sonographic visualization—fluid and clot are displaced with joint compression; synovial pannus cannot be completely compressed (Fig. 1).

TECHNIQUE

The most commonly used probe for joint space assessment is a linear-array probe (5–12 MHz). The hip and shoulder are deeper joints and may be best visualized with a lower-frequency linear probe (5–7.5 MHz). Large joints are imaged using a variety of sonographic windows. It is helpful to move the joint under direct sonographic guidance (dynamic sonography) to aid in identification of intra- and periarticular structures. Graded compression of the joint is extremely useful in differentiating fluid (or clot) from tissue or cartilage. The affected joint should always be compared with the contralateral (normal) side by use of the multi-image function on the ultrasound machine. The sonoanatomy of the axial joints and specific scanning techniques are described below for each individual joint.

The Shoulder. The most common causes of shoulder pain are traumatic injuries, overuse syndromes, and degenerative or calcific arthritis. The shoulder is involved in approximately 15% of hemophilic arthritis as well as 3% to 12% of all cases of septic arthritis.[8] Evaluation of the shoulder is currently the most common application of joint ultrasound.[3] Ultrasound is helpful in identifying fluid within the glenohumeral joint and tendon sheaths, and can reveal tears and calcifications of the tendons of the rotator cuff. The presence of a joint effusion in combination with fluid in the subacromial-subdeltoid (SA/SD) bursa is highly specific (99%) and has a high positive predictive value (95%) for rotator cuff tears.[9] Fluid found solely in the synovial sheath of the long head of the biceps tendon is indicative of biceps tendinitis. Sonography is also very sensitive for detection of focal calcific deposits in the rotator cuff tendons and subacromial bursa, which are common sources of acute shoulder pain.[10]

The shoulder joint can be imaged from two sonographic windows: the anterior and posterior views. The anterior window consists of longitudinal and transverse scans of the long head of the biceps tendon (Fig. 2). The long head of the biceps tendon has a synovial sheath that is an extracapsular extension of the joint synovium (Fig. 3). Consequently, fluid within the joint is often demonstrated within the synovial sheath surrounding the biceps tendon (Fig. 4). Compression with the transducer aids in differentiating synovial proliferation from fluid in the biceps tendon sheath as previously discussed. For positioning, the patient can be sitting with the elbow adducted and the hand positioned palm up. An alternate scanning position is having the patient lie on a gurney in a supine position with the shoulder in a neutral position and the patient's hand resting on the chest.[11]

The posterior window is obtained by means of a transverse scan at the level of the infraspinatus tendon (Fig. 5). Using a lower frequency (5 MHz) may be helpful, as the joint is deep. The patient should try to place his or her hand on the side of the affected shoulder onto the opposite shoulder to essentially open up the joint space. Fluid accumulates in the posterior recess due to capsular thinning with minimal adjacent structures to prohibit distention.[12] A definite sign of an effusion is elevation of the infraspinatus tendon more than 2 mm from the posterior glenoid labrum (Fig. 6).[6]

The Hip. Ultrasound is the imaging modality of choice for detection of fluid collections around the hip. The etiologies of joint effusions involving the hip are abundant. The most common causes in adults are osteoarthritis and osteonecrosis (avascular necrosis).[6] The most common synovial disease involving the hip joint in adults is RA. Acute hip pain in children is a common complaint, and

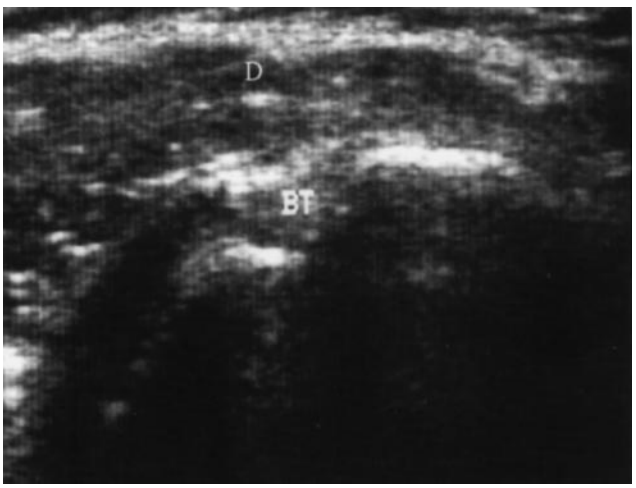

Figure 3. A transverse interior view of the normal tendon of the long head of the biceps (BT) seated within the bicipital groove. The biceps tendon is hyperechoic and oval. The deltoid (D) muscle is seen over the tendon.

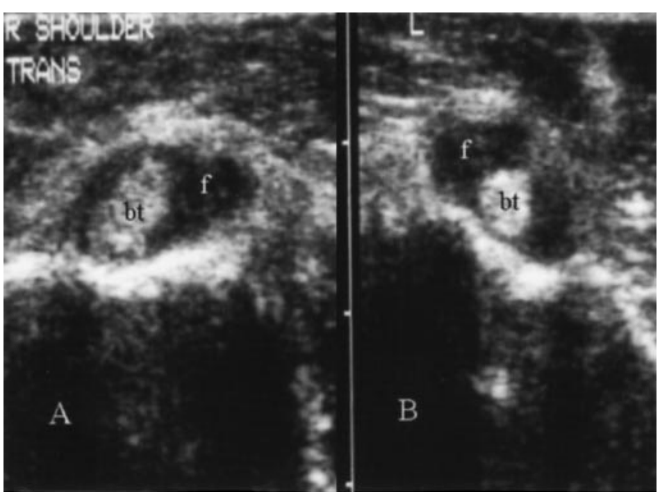

Figure 4. Transverse scan of the anterior shoulder representing fluid (f) within the biceps tendon (bt) sheath of both shoulders. The biceps tendon in **A** is larger and appears relatively hypoechoic compared with the opposite shoulder (**B**).

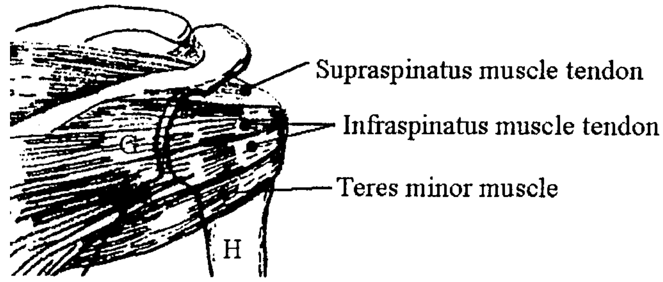

Figure 5. The posterior window of the shoulder outlining the glenohumeral joint and the overlying musculature. The transducer should be placed in a transverse position at the level of the infraspinatus tendon. G = glenoid cavity; H = humerus.

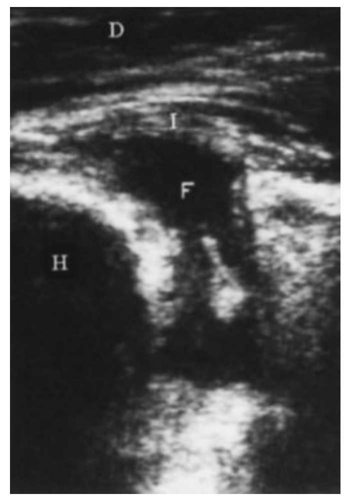

Figure 6. A transverse view of the posterior window revealing a large amount of fluid (F) in the recess. The infraspinatus muscle (I) is bulging over the fluid. The humeral head (H) has an irregular, erosive contour. D = deltoid muscle.

demonstration of fluid within the joint space can narrow the differential diagnosis and guide diagnostic arthrocentesis.[13,14]

The anterior approach provides the best assessment of capsular distention and joint effusion. This window consists of an oblique sagittal plane with the transducer parallel to the long axis of the femoral neck (Fig. 7). Effusions of the hip preferentially accumulate in the anterior aspect adjacent to the femoral neck and not the femoral head.[13] The patient should be positioned with slight hip flexion and internal rotation. Extension and external rotation of the leg tighten the joint capsule, causing fluid to be displaced posteriorly.[13] Using a lower frequency (5–7.5 MHz) may be helpful, as this joint is relatively deep in adults. The contralateral hip is always scanned for comparison. The articular cartilage is a thin, hypoechoic stripe over the femoral head and should not be confused with

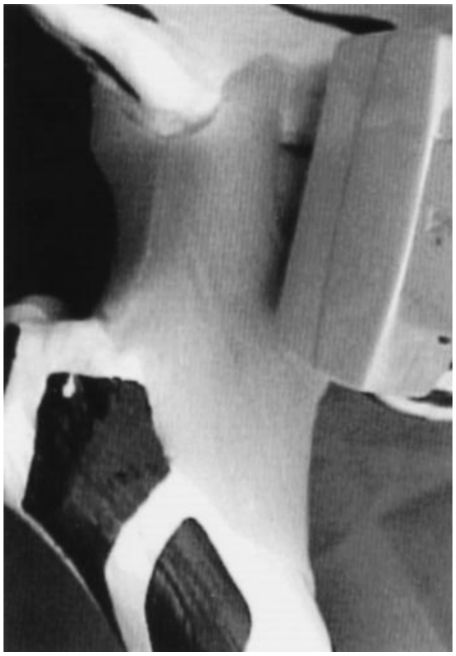

Figure 7. The anterior window of the hip in an oblique, sagittal plane. The transducer should be placed parallel to the long axis of the femoral neck.

an effusion. The joint capsule is a thick hyperechoic band-like structure over the femoral head and neck. For adults, an effusion exists if fluid is seen extending along the *entire* length of the capsule and measures more than 5 mm (Fig. 8).[15] An effusion in children is present with a capsulosynovial thickness of more than 5 mm (or 2-mm difference from the contralateral hip).[16]

The Knee. Effusions of the knee may be difficult to appreciate on physical exam alone, particularly when the patient is obese, has a preexisting chronic inflammatory arthritis that distorts the normal anatomy, or has pain severe enough to limit the exam. The suprapatellar bursa communicates with the knee joint, and fluid in this bursa (or recess) is representative of an intraarticular process. This bursa extends approximately 6 cm above the patella.

The anterior views of the knee begin with a longitudinal scan above the patella, which is the bony landmark for imaging the suprapatellar bursa (Fig. 9). The patient should be supine with the knee in flexion (approximately 20 degrees). A roll should be placed under the knee to provide a comfortable examination in flexion. The suprapatellar bursa is just deep to the quadriceps tendon. The medial and lateral recesses of the knee (extensions of the suprapatellar bursa) are then viewed in longitudinal and transverse orientation. In a normal joint, the bursa is a thin hypoechoic line no more than 2 mm thick located between the suprapatellar and prefemoral fat pads (Fig. 10). Compression of the lateral recesses while imaging should not cause bursal distention.[6]

A montage image can be used to visualize the bursa down to the patella by using the side-by-side or multiscreen function on the ultrasound console (Fig. 11). The posterior approach is performed with the patient in the prone position. The medial popliteal fossa is viewed in the longitudinal and transverse orientation. It is scanned for the presence of fluid in the bursa between the semimembranosus and medial gastrocnemius muscles (Baker's cyst). This bursa also communicates with the knee joint.

One cadaver study using MRI noted that when 4 mL of fluid was injected into the joint, the an-

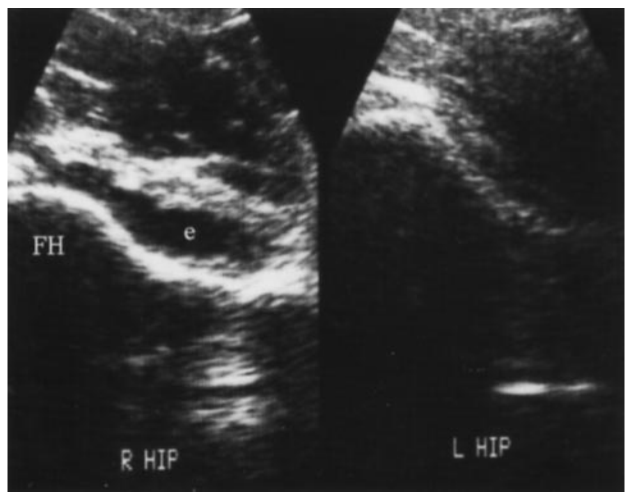

Figure 8. Bilateral hips with an effusion (e) present in the right hip adjacent to the femoral head (FH). The thick hyperechoic, band-like structure overlying the effusion is the joint capsule. This effusion extends along the entire length of the capsule.

Figure 9. Probe replacement for the anterior window of the knee. The patella is the bony landmark for imaging the suprapatellar bursa, which lies just deep to the quadriceps tendon.

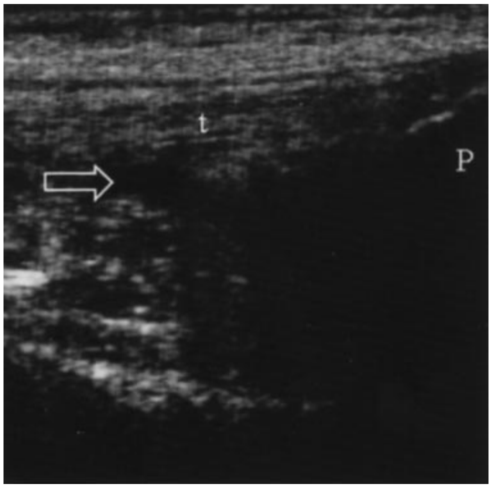

Figure 10. A longitudinal view of the normal anterior knee demonstrating the patella (P), the quadriceps tendon (t), and a small amount of fluid (*arrow*) in the suprapatellar bursa. Tendons are hyperechoic however; the tendon (t) as shown is hypoechoic, representing anisotropy.

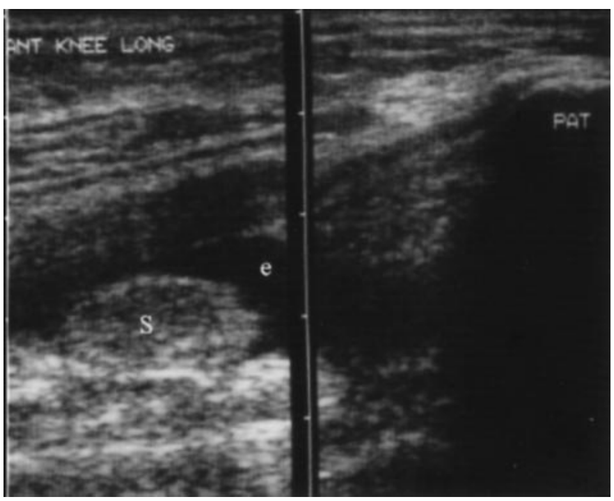

Figure 11. A longitudinal view of the anterior knee demonstrating an effusion (e) in the suprapatellar bursa with a synovial polyp (S). The patella (PAT) can be seen. This side-by-side view of montage extends the field of view. (Also see Figure 1).

teroposterior (AP) diameter of the suprapatellar recess was 4 mm at the widest aspect.[17] Likewise, with 15 mL of fluid in the joint, the AP diameter was 16–20 mm, and it was 18–20 mm with 20 mL. Demonstration of fluid in the superficial bursa (extraarticular) and the lack of fluid in the suprapatellar bursa (intraarticular) can differentiate prepatellar bursitis from a joint effusion on sonography.

If fluid is not seen within the knee joint but is demonstrated adjacent to the suprapatellar region, a muscle rupture may be present. The most common site for muscle rupture secondary to a distracting injury involves the rectus femoris.[6] The gap between the muscles outlined by fluid can often be demonstrated.

The Ankle, Elbow, and Wrist. The ankle can be imaged to determine the presence of fluid by means of an anterior or posterior approach. The anterior tibiotalar recess is viewed in a longitudinal plane along the long axis of the tibia with the foot in dorsiflexion (Fig. 12). The posterior tibiotalar recess uses the Achilles tendon as a sonographic window in a midsagittal plane with the patient in a prone position and foot dorsiflexed. The posterior recess is deeper by comparison with the anterior, and a 5-MHz transducer may be needed. An effusion is present when hypoechoic fluid is noted to displace the capsule anteriorly (more than 3 mm) (Fig. 13).[18] Unfortunately, fluid in the an-

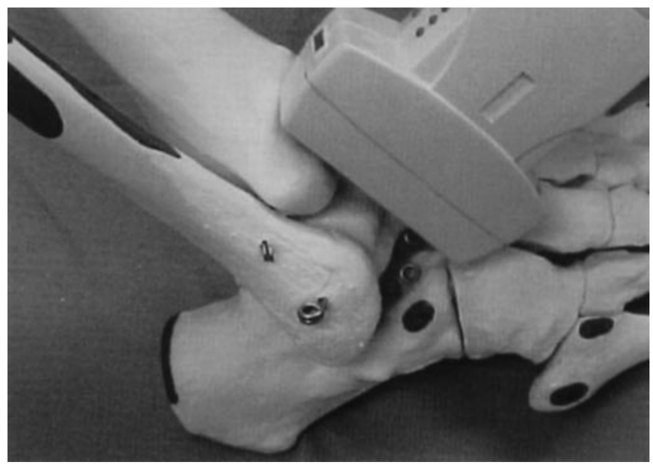

Figure 12. The anterior tibiotalar recess is approached in a longitudinal plane along the long axis of the tibia. The foot should be dorsiflexed.

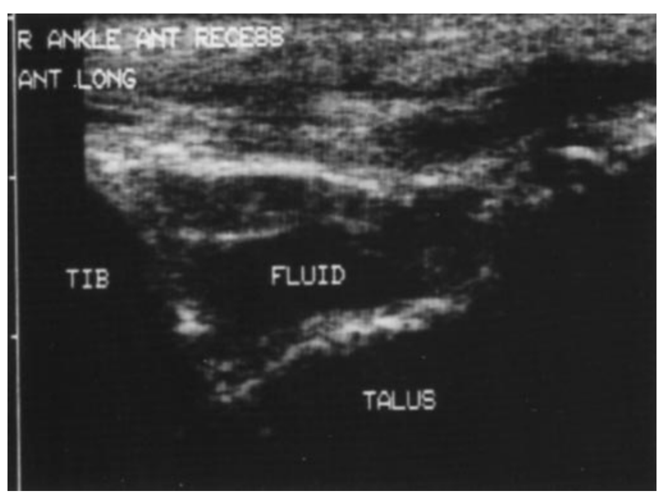

Figure 13. The anterior window of the ankle with the probe is longitudinal to the tibia (TIB) at the articulation of the talus and the tibia. Fluid is readily seen in the anterior tibiotalar recess.

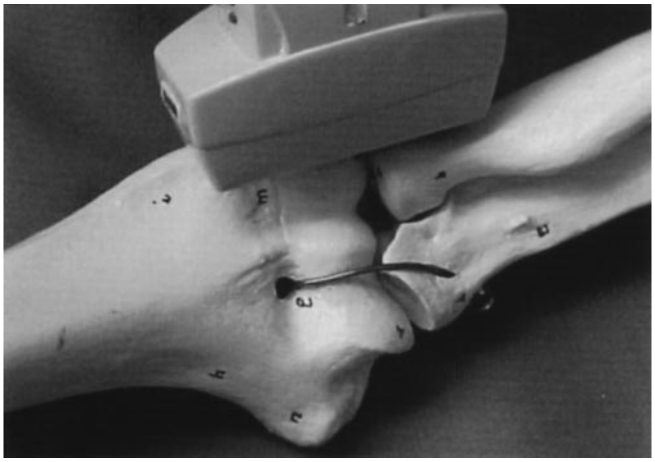

Figure 14. The anterior window for the elbow consists of a longitudinal plane. The arm should be held in slight flexion. The radial head and capitellum are in alignment.

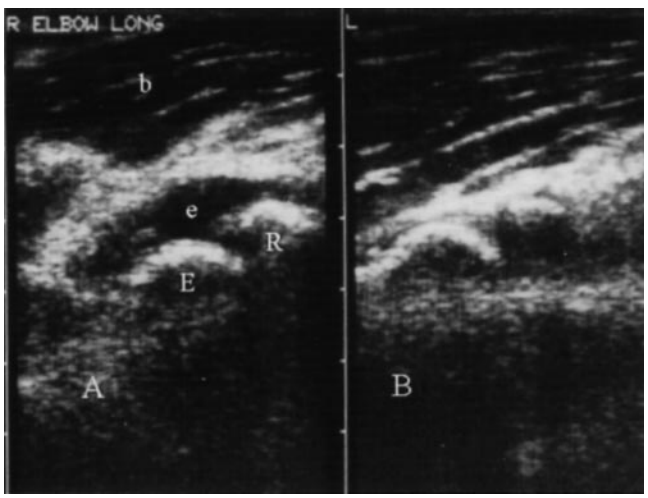

Figure 15. (**A**) This longitudinal view with an anatomic comparison demonstrates an effusion (e) above the radius (R) and lateral epicondyle (E). The brachialis muscle is noted in addition (b). This patient had an aspiration revealing a septic effusion. (**B**) An anatomic comparison.

terior tibiotalar recess and tendon sheaths of the ankle is a common finding in asymptomatic joints, and neither the amount nor the sonographic appearance reliably identifies pathologic effusions.[19] However, fluid in the posterior recess is not seen in asymptomatic volunteers with ultrasound and usually indicates pathology.[20]

The anterior recess of the elbow joint is imaged with slight flexion of the arm with the transducer in the longitudinal plane (long axis of the arm) (Fig. 14). The radial head and the capitellum are aligned with the hyperechoic joint capsule bridging between the bones. The capsule is displaced anteriorly in the presence of an effusion (Fig. 15). A small amount of fluid (1–2 mm) can be normally seen. The posterior recess (olecranon fossa) can be imaged with the elbow in 90 degrees of flexion (palm on table). The fat pad is displaced posteriorly when an effusion is present (Fig. 16).

Ultrasound of the wrist can be challenging in view of the complex anatomy. The window for fluid in the wrist joint is the prestyloid recess in the dorsal approach (Fig. 17). Radial deviation of the hand may assist in opening up the prestyloid recess.

PITFALLS

The single most important artifact in musculoar-

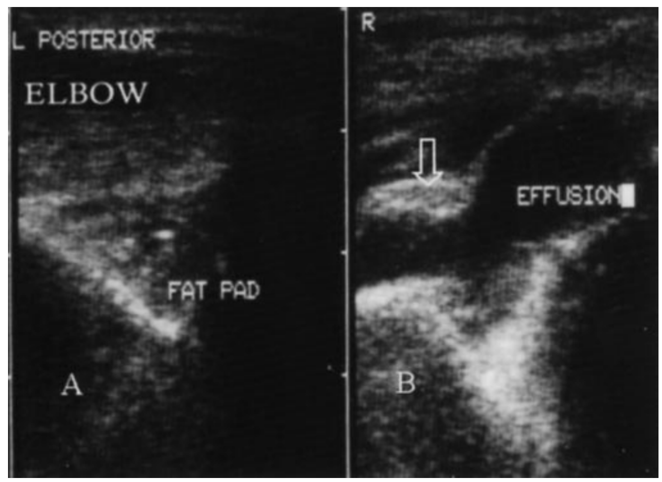

Figure 16. The posterior window of the normal elbow depicting the fat pad (**A**) in the olecranon fossa. With an effusion (**B**), the fat is displaced posteriorly (*arrow*). This represents the sail sign seen on radiographs in occult fractures of the elbow.

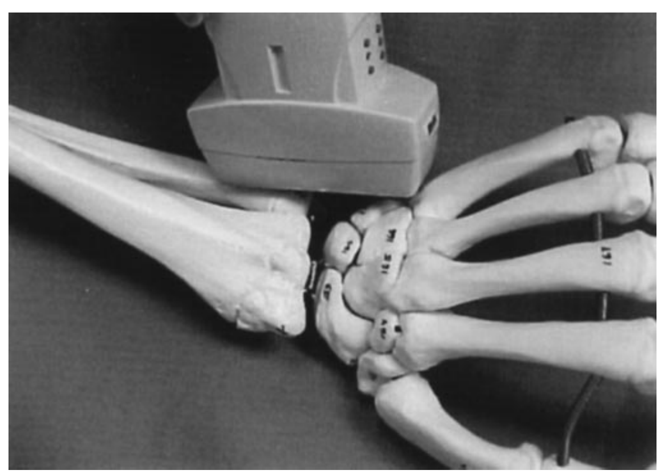

Figure 17. The window for fluid in the wrist joint is the prestyloid recess in the dorsal, longitudinal approach. Radial deviation would aid in opening the window for sonographic examination.

ticular sonography is anisotropy. An anisotropic reflector displays different sonographic appearances depending on the direction of measurement, and is usually most problematic when imaging tendons at their insertion (Fig. 10). The ultrasound beam must be strictly perpendicular to the structure being examined to minimize loss of reflectivity and increased scatter causing artifactual decreased echogenicity. Varying the examination angle is helpful in differentiating artifact from pathology. The relatively hypoechoic appearance of a periarticular muscle or tendon can be confused with fluid (effusion). When the effusion is adjacent to bone, the striking difference in sonographic appearances of fluid and bone minimizes the risk of errors due to artifact.

Another potential pitfall in imaging the large joints involves a lack of knowledge of the sonoanatomy. Movement of associated structures by the patient can be helpful in identifying anatomic structures, and it is imperative to use bilateral comparison to minimize error. In cases where there are bilateral abnormalities, measurement of the effusion with correlation to the suggested guidelines is helpful. It is not uncommon to see a small amount of fluid present in a normal joint, and caution should be used to avoid overinterpretation of sonographic findings. This is particularly problematic with ankle sonography.

Another pitfall is confusing the hypoechoic articular cartilage with fluid. This is particularly important in infants less than 1 year of age.[7] Using graded compression to distinguish fluid (which is compressible) from cartilage (which is not) and bilateral comparison can help in differentiation. Finally, applying gentle transducer pressure allows better visualization of superficial (near-field) structures. For example, excessive transducer pressure may compress small amounts of fluid seen in a painful knee due to prepatellar bursitis and limit the diagnostic yield of the ultrasound exam.

CONCLUSIONS

Sonographic imaging of joints for the presence of an effusion is more accurate and reproducible than clinical examination.[1] It provides clues as to the nature of the effusion, differentiates intra- from extraarticular processes, and shows promise for improving procedural success rates. In addition, sonography differentiates synovial thickening from intraarticular effusions. Future research in this area includes establishing learning curves for detection of effusions, determining the impact on procedural success rates, and examining the presence of an effusion and SA/SD bursal fluid as predictive indicators of rotator cuff injuries in an emergency setting, as well as integration into clinical decision rules.

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