Musculoskeletal Ultrasound in Rheumatology

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In the past decade, there has seen a phenomenal growth in the research and application of musculoskeletal ultrasound (MSUS) in the understanding and management of rheumatic diseases. Ultrasound (US) is noninvasive and biologically safe. There is practically no contraindication for the technique. The portability of US machines makes them accessible for both out-patients and in-hospital patients including the critically ill. Utilisation of medical US is ubiquitous. In fact, one can hardly think of a clinical specialty involving direct patient care that does not include US as part of their diagnostic and therapeutic armamentarium. (Perhaps one notable exception is psychiatry for which all kinds of “sounds” have to be treated with a grain of suspicion!)

Musculoskeletal ultrasound is indeed a late comer!

History of musculoskeletal ultrasound

Though the first report of MSUS was published as early as in 1958, it was not until 1972 when Daniel G. McDonald described the first important clinical application of US to differentiate Baker’s cysts from thrombophlebitis. This remains an important use of the technique to date. The next milestone was the demonstration of ultrasonographic features of congenital dislocation of hip, which led to the first widespread application of MSUS. Technical difficulties in producing high resolution images needed for MSUS largely accounted for its laggard development.

The past two decades have seen revolutionary advances in imaging resolution, capabilities and cost of MSUS equipment. Advances in high-speed digital processing and transducer technology enabled the production of high-quality images of musculoskeletal structures. Visualisation of synovitis, tenosynovitis, rheumatoid erosions and demonstration of soft tissue hyperaemia in rheumatic diseases by ultrasonographic techniques opened up an unexplored and fascinating realm of musculoskeletal structures. Visualisation of synovitis, periarticular structures. Symptomatic areas can be easily located and confirmed with the patient during examination. Rapid side-to-side comparison can be done with ease. Diagnosis is instantaneous. Large number of joints in different regions of the body can be imaged swiftly and selectively within a single examination session.

US provides the best means for dynamic assessment of bone and tendon movement. Differential changes in various structures can readily be appreciated during active, resisted, and passive motion. US has multi-planar imaging capability currently only rivalled by magnetic resonance imaging (MRI), albeit more expensive. Its high repeatability and sensitivity to change offer the potential use in monitoring disease progression and evaluation of therapeutic efficacy of both local and systemic treatment.

Perhaps the greatest benefit of US in daily clinical practice lies in the guidance for diagnostic and therapeutic interventions. MSUS may be used to assist needle positioning to facilitate invasive rheumatological procedures such as aspiration of fluid, drainage of abscess, tissue biopsy and local injection of therapeutic agents. It is particularly useful when the fluid collections are very small, as in the case of tenosynovial effusion or when the inflammatory process occurs in deep-seated or otherwise inaccessible anatomical targets such as the hip. Sonographic guidance has been proven to increase the success rate of procedures and to help minimise the risk of damage to adjacent vital structures.

Study has shown that an experienced musculoskeletal radiologist and a rheumatologist with limited ultrasound training can achieve high interobserver agreement rates for identification of synovitis (91%) and bone erosions (87%) by means of standardised approach.

Indications for musculoskeletal ultrasound

MSUS is a versatile technique and the potential applications are myriad. This review will focus on the more widely accepted and proven indications.

Effusion

This is perhaps the commonest application of MSUS. US is superior to clinical examination in distinguishing effusion from synovial proliferation. Joint, tendon sheath and bursal effusion can be readily diagnosed on US and confirmed by guided aspiration (Figure 1).

Figure 1. Effusion (Eff) in suprapatellar pouch of a patient with rheumatoid knee effusion. The tip of the advancing needle is shown (arrow). The hyperechoic line represents the bony surface of the femur (F)
Synovitis
The presence of joint, bursal or tendon sheath effusion is an excellent indirect surrogate for synovial inflammation. MSUS also allows visualisation of synovial thickening, proliferation and villous formation. US is more sensitive than clinical examination to detect synovitis and to differentiate between inflammatory and non-inflammatory joint diseases.12 The introduction of power Doppler further enhances the ability to detect smaller degree of synovitis with reported accuracy close to that of dynamic MRI.12

Bony erosions
Early detection of bony erosions is pivotal in modern day management of arthritic conditions, notably rheumatoid arthritis (RA). MSUS can detect up to seven times more erosions than plain radiography in early RA.13

Tendons and ligaments
MSUS has risen to supremacy in the examination of tendon and ligamentous structures. US is superior to MRI in the detection of longitudinal split tendon tear and subluxed tendon and has the advantage of allowing dynamic tendon assessment.14 Focal tendinitis and calcific tendinitis can be detected by US. MSUS is an important tool in diagnosis of painful shoulder conditions, especially in rotator cuff tears.15 Enthesitis, inflammation of ligamentous insertion into bones, is a characteristic feature in spondyloarthropathies which is better detected by US than clinical examination.16

Peripheral nerves
In recent years MSUS has become a useful tool in diagnosing focal nerve compression such as the entrapment neuropathies. A prototypic example is carpal tunnel syndrome (CTS). Various US criteria for diagnosing CTS have been proposed17 and recently, a local study by Wong et al reported a sensitivity of 89% and a specificity of 83% for sonographic diagnosis of CTS.18

Interventional ultrasonography
Guidance for intervention (joint aspiration, synovial or soft tissue biopsy, joint or tendon sheath injection) is a major application of ultrasonography. US guided procedures can be performed under direct sonographic visualisation. Alternatively, the skin surface can be marked after determining the most appropriate entry point and the depth of the target area prior to the placement of the needle.19

Miscellaneous indications
MSUS has a multitude of developing and potential indications. US measurement of skin thickness is being evaluated as an objective outcome measure for systemic sclerosis. Differential diagnosis of skin and soft tissue infections including necrotising fasciitis20 can be assisted by US examination and guided aspiration (Figure 2). Characteristic ultrasonographic features are present in arteries of patients with Takayasu’s and giant cell arteritis though the role of US in the diagnosis of these conditions remains to be defined.21

Figure 2. Ultrasound of the thigh of a diabetic patient with severe limb pain. Note the irregularity of the fascia (F), abnormal fluid collection alongside the fascial planes (+) and diffuse thickening of the fascia (F) and subcutaneous tissue (SC). N ecroting fasciitis was confirmed on surgical exploration.

Equipment, techniques and training
A detailed description of the technics and techniques of MSUS is beyond the scope of this review but the key elements are highlighted below.

Equipment
The appropriate selection of equipment is critical in facilitating the introduction and training of MSUS. A fundamental issue in selection of sonographic instruments is to decide whether the machine is devoted for MSUS or if it is multi-purpose. Other important considerations include cost, image resolution and quality, transducer design, equipment size/portability and other optional features such as colour/power Doppler.

MSUS requires transducers with linear array. High frequency (7.5 - 20 MHz) transducers have better spatial resolution but shallower tissue penetration and are best used for demonstrating small and superficial structures like the hand joints. Lower frequency (<7.5 MHz) transducers sacrifice image quality for better penetration power and are preferable for larger and deeper structures such as the hip. A 7.5 MHz probe is a reasonable compromise for constrained budget. The size of the footprint (scan head) should match that of the examined joints to facilitate manoeuvring. Hence the choice of transducer will be affected by the type of examinations likely to be undertaken.

Newer US techniques including colour and power Doppler imaging provide colour maps of tissue corresponding to the degree of blood flow. Information regarding tissue vascularity is useful for distinguishing inflammatory and infectious changes from those that are non-inflammatory. The values of these techniques are still under evaluation and the additional cost has to be taken into consideration.1

Techniques and training
To obtain accurate information, patients have to be properly positioned. The targeted structures have to be scanned in predefined planes and orientations to allow meaningful interpretation and to enhance reproducibility. The European League Against Rheumatism (EULAR) has published a set of guidelines and protocols for standard scans in MSUS.22 Comprehensive description and illustrative images can be found in the official web site of EULAR (http://www.sameint. hugular ultrasound). The University of Michigan Health System (http://www.med.umich.edu/rad/muscskel/mskus) also provides free technical information and pictorial training guide in addition to a wide array of common pathologies. However, self learning is no substitute for structured and supervised training, which unfortunately, is still deficient in many countries and centres.23

Technical advances and future developments
Three- and Four-dimensional ultrasonography
Computing advances have allowed three-dimensional (3D) and four dimensional (3D in real time) US imaging. With continual refinement in image processing, the ultimate quest for virtual live anatomy may be attained with far-reaching impact.1

Acoustic microscopy
Continuous technological innovation in sonographic technology has made available very high frequency probes
one day we will find our internists carrying a new gadget in their already loaded white coat pockets - “The Musculoskeletonscope”.

Imagination is more important than knowledge. Albert Einstein

References