Musculoskeletal Ultrasound for Rheumatologists

Ka-Lai Lee

Abstract: In the past two decades, musculoskeletal ultrasonography has become an important imaging modality in rheumatology. Musculoskeletal ultrasonography, some considered it to be the rheumatologist's stethoscope, is now routinely used by an increasing number of rheumatologists throughout Europe for proven clinical indications in diagnosis, disease monitoring and intervention.

Keywords: Musculoskeletal ultrasonography, Rheumatology

Introduction

The application of ultrasound imaging in medical field is now regarded as an indispensable tool, was pioneered in surgery and obstetrics in the late 1950s and early 1960s. The first report of musculoskeletal ultrasonography (MSUS) was published in 1958 by Dussik et al who measured the acoustic attenuation of articular and periarticular tissues including skin, adipose tissue, muscle, tendon articular capsule, articular cartilage and bone. However, the first clinical application of MSUS in differentiating Baker's cyst from thrombophlebitis was only reported in 1972.

The Development of Musculoskeletal Ultrasound

Musculoskeletal ultrasonography began with the demonstration of synovitis of the knee in rheumatoid arthritis in 1978. Its initial use was limited to investigating larger joints and soft tissue structures. In the early 1980s, technical advances in ultrasound had led to higher-resolution imaging of musculoskeletal structure and allowed assess to the smaller joints, detection of bone erosions, synovitis, tendon disease, and enthesopathy. Combined with a better understanding of the rheumatic disease, multiplanar imaging of articular structures in real time, low running costs, absence of radiation and excellent patient acceptability, MSUS now become an ideal tool for rheumatologists. In Germany, MSUS has already intergraded into their clinical practice, just like the extension of the clinical examination. Moreover, MSUS is now a standard part of the rheumatology training curriculum in Germany and Italy.

Indications of MSUS in Rheumatologists

Musculoskeletal ultrasonography aids the early diagnosis of rheumatoid arthritis (RA) by demonstration the bony erosions which may not be present in X-ray in early disease. It can be used for assessment of the disease activities by the presence of power Doppler signal, monitoring of disease progression, treatment response, research work, needle guidance in aspiration and injection. It also helps in diagnosing other connective tissue disease.

MSUS Technical Equipments

Transducer and Frequency of the Ultrasound Wave

Transducer is an essential element of ultrasound equipment which is responsible for the generation of ultrasound beam and the detection of returning echoes. Ultrasound waves are longitudinal, mechanical waves which are above the hearing frequency range of the human ear (>20 kHz). Diagnostic musculoskeletal systems need much higher frequencies, ranging from 3-18 MHz. The higher the frequency, the greater...
the axial and the lateral resolution of image, but at the cost of reduced tissue penetration. Therefore, a higher-frequency transducer is best used for superficial structures, such as the small joints of the hand and feet (7.5-20 MHz), and a low frequency transducer is used for deeper joints, such as the hip or shoulder (<7.5 MHz). Smaller size of transducers allows better access to the small joints of the hands and feet with adequate angulation to reduce the chance of artifact (Figure 1).

**Grey-scale Imaging**

The ultrasound imaging is blank and white. Each white dot on the monitor indicates a reflected sound wave. Fluid, therefore, is black as it is a good transmitter of sound, and bone and soft tissue are varying degrees of white.

**Power Doppler**

Power Doppler is useful in the detection of vascularity by visualized the low-velocity of blood cells within a vessel especially the synovium tissue within a joint. It has a practical value in distinguishing inflammatory and infectious musculoskeletal fluid collections from those that are non-inflammatory. However, the interpretation of power Doppler is highly dependent on the quality of the ultrasound machine, the experience of the examiner and the technical conditions of the examination, e.g. the temperature of the examination room. Although power Doppler is an exciting technique for the diagnosis and quantification of inflammatory musculoskeletal disease but further validation is required before it could be used as a universal assessment and monitoring of the disease activities. Figure 2 demonstrates the presence of power Doppler signals in a metacarpal pharyngeal joint.

**Ultrasound Detectable Pathologies**

**Bone Erosions**

Bone erosion found in MSUS is defined as an intraarticular discontinuity of the bone surface that is visible in 2 perpendicular planes (Figure 3). The detection of joint erosion on plain radiography is a key diagnostic criterion and outcome.
measure in RA, however, the sensitivity of picking up bone erosion by X-ray in early rheumatoid arthritis is low. Wakefield et al showed that MUSU is capable of detecting up to seven times more erosions than plain radiography in early RA. Early detection of bone erosion using other modalities including musculoskeletal ultrasound or MRI is of paramount importance in early diagnosis and treatment. Thus, it has been proposed that MSUS detection of erosion should be included in the diagnostic criteria of RA.

**Joint Effusion**

Joint effusion is defined as an abnormal hypoechoic or anechoic intraarticular material that is displaceable and compressible, but does not exhibit Doppler signal. The detection of a fluid collection in joints is a useful sign of inflammation. High resolution MSUS is superior to clinical examination in the detection of minute amounts of joint effusion in asymptomatic patient. However, MSUS is not able to accurately differentiate whether a fluid collection is inflammatory, infectious or haematogenous. Figure 4 below shows a significant amount of joint effusion inside the metatarsalpharyngeal joint.

**Synovitis (Synovial Hypertrophy)**

Synovial hypertrophy is defined as abnormal hypoechoic intraarticular tissue that is nondisplaceable and poorly compressible, which may exhibit power Doppler signal. Presence of synovitis on ultrasound imaging usually signifies inflammation. However, in the absence of joint effusion, synovitis could be difficult to detect, especially when the synovial thickening is minimal. In an asymptomatic joint, the detection of subclinical synovitis by MSUS may lead to a re-evaluation of the clinical classification of arthritis as oligoarticular or polyarticular. Figure 5 demonstrates the ultrasound imaging of an active synovitis involving a metacarpalpharyngeal joint.

**Tenosynovitis**

Tenosynovitis is defined as a hypoechoic or anechoic thickened tissue with or without fluid within the tendon sheath.
Musculoskeletal Ultrasonography

seen in 2 perpendicular planes, which may exhibit Doppler signal. MSUS is superior to MRI in the detection of longitudinal split tendon tear, subluxed tendon and snapping tendon; it also has the advantage of allowing dynamic tendon examinations although subtle changes may be missed or misinterpreted due to anisotropy. Figure 6 demonstrates the scanning of Achilles tendon.

Peripheral Neuropathy

MSUS easily identifies the nerve from tendons as it is hyperechoic and speckled in transverse section. Nerve does not demonstrate anisotropy and has a hypoechoic fascicular pattern in longitudinal section (Figure 7). Carpal tunnel syndrome is the most common peripheral nerve problem which could be identified by measuring the median nerve cross-sectional diameter at the tunnel inlet, an area >0.098 cm² signify neuropathy with sensitivity and specificity of 89% and 83% respectively. Additional information on the cause of nerve compression in carpal tunnel may be obtained by MSUS through imaging of tenosynovitis, tendon effusion, amyloid deposition, hypertrophied accessory muscle, increased fatty tissue, ganglion cyst or variant median artery.

Skin Abnormality

The development of higher-frequency probe (13-20 MHz) allows skin thickness and edema to be visualized. Ultrasound (US) assessment of skin thickness in scleroderma showed that skin thickness was increased over the proximal phalanx of the right second finger and forearm compared with controls. Therefore, US criteria of scleroderma have been successfully used to differentiate scleroderma from other skin plaques with a diagnostic sensitivity of 92% and a specificity of 100%.

Figure 6. t=Achilles tendon; k=Koer's fat pad; cal=calcaneus. Left: Transverse scan of Achilles tendon demonstrates Achilles tendonitis with presence of power Doppler signal.

Figure 7. Volar transverse scan (left) and volar longitudinal scan (right) at the carpel tunnel. n= median nerve; flexor tendon bound by white arrow.
Soft Tissue Pathology
Other pathologies such as panniculitis, subcutaneous edema, cellulitis, necrotizing fasciitis, subcutaneous abscess or cystic, and solid dermal masses can be depicted by MSUS (Figures 8 & 9).\textsuperscript{20,21}

Uses of Ultrasound on Other Connective Tissue Diseases
The role of ultrasound is becoming more and more relevant in the assessment of rheumatic disease apart from the arthritis. There are still more exploring field including use of ultrasound in scleroderma,\textsuperscript{22} polymyalgia rheumatica,\textsuperscript{23} temporal arteritis (Figure 10), Takayasu’s arteritis,\textsuperscript{24} and Sjogren’s syndrome.\textsuperscript{25}

Ultrasound Guided Intervention
Ultrasound can be used for guidance of aspiration, biopsy, and injection treatment.\textsuperscript{26} In patients with inflamed metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints, MSUS improved accurate needle placement from 59\% by palpation guidance to 96\% by MSUS guidance.\textsuperscript{27} A pilot study showed that using US to localize effusions and guide aspiration produced a 3-fold increase in the rate of successful aspiration when compared with conventional aspiration of the peripheral joint.\textsuperscript{28} Figure 11 shows the technique of MSUS guided depomedrol injection for carpel tunnel syndrome.

Advantages of Musculoskeletal Ultrasound
Ultrasound has a number of distinct advantages, including better patient tolerability, non invasive imaging with no radiation, ready accessibility, portability and its ability to scan multiple joints in a brief period of time. Rheumatologist, with clinical understanding of the patient's problem, can scan in the clinic (rather than sending the patient for another appointment), thereby allowing rapid interpretation of the images and immediate decision-making, such as starting or changing dosage of a disease-modifying anti-rheumatic agent.

Figure 8. Increase power Doppler signal over the subcutaneous tissue in panniculitis.

Figure 9. Presence of hypoechoic fluid within subcutaneous tissue suggests subcutaneous edema.
Pitfalls of Musculoskeletal Ultrasound

However, ultrasound is often perceived as an imperfect and operator-dependent tool. There is also lack of data regarding its validity, reproducibility, and responsiveness to change, making interpretation and comparison of studies difficult. In particular, there are limited data describing standardized scanning methodology and standardized definitions of US pathologies. In addition, experience and proper training is required to perform consistent and high-quality scanning.

Training of Musculoskeletal Ultrasound

Over the last 10 years, the EULAR Working Group for Musculoskeletal Ultrasound in rheumatology and the British Society of Rheumatology had been organizing basic, intermediate, and advanced US courses which had been successful. Rheumatologists are always encouraged to attend these courses. Using the EULAR website (http://www.eular.org) as a training reference for obtaining a MUSU standard images is a good self-directed learning method too. Of course, the best way to train is directly under the supervision of an expert and constant practice is the key to success. Although, MSUS is still the infancy in most of the Asian Countries, we hope, in the near future, Hong Kong will organize a musculoskeletal ultrasound course for the Asian Rheumatologists.

Conclusion

Musculoskeletal ultrasound used in rheumatology had been getting more and more popular in recent twenty years. Several applications especially in the management of arthritis have been successful and made a great contribution to patient care. With the great quality improvement of sonographic equipments and the more training opportunities provided to the rheumatologists, hopefully, in one day, MSUS could be integrated into our clinical practice in helping us to make an early diagnosis, monitor the disease progression, and treatment response.

Figure 10. (a) Longitudinal color Doppler image of the temporal arteries in acute temporal arteritis. (b) Transverse color Doppler image of the temporal arteries in acute temporal arteritis. The arrows point to the edematous wall swelling "halo"

Figure 11. (a) Preparation before MSUS guided injection. (b) Insertion of needle towards median nerve using ultrasound guidance. (c) MSUS confirm the needle tip touching the median nerve sheath. (d) Injection of the depomedrol.
References