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Review Article

Ultrasound in musculoskeletal disorder – A new horizon in rheumatology

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ABSTRACT

Early detection of rheumatological diseases is an important step in prevention of permanent damage and deformities. Conventional radiography has traditionally been used as a diagnostic tool in rheumatology but is incapable to detect early changes in the periarticular tissues and bones. MRI has gained undoubted superiority for detection of soft tissue pathologies and early bony inflammatory changes but its widespread use is restricted by multiple factors. Ultrasonography (USG) is a promising tool for bridging this gap. Though the use of USG in the field of Rheumatology is almost three decades old, recent advancement in technology has made it an attractive imaging tool for early detection various musculoskeletal disorders. The utility of USG is not only limited to the detection of synovitis but has expanded to detect various extra skeletal manifestations of rheumatological diseases. Absence of radiation hazards, reasonable cost, and widespread availability are the added advantages of USG. In this article the promising role of USG in musculoskeletal diseases has been reviewed.

1. Introduction

Radiography has traditionally being used as the diagnostic modality in patients with Rheumatological diseases. It has the ability to show findings like swelling of soft tissue, osteopenia, erosion, diminution or loss of joint space, and joint deformities. Currently, early disease detection is an important aspect of managing rheumatologic conditions. X-ray is insufficient to see early changes in the soft tissue like synovial proliferation in rheumatoid arthritis or changes in cartilage architecture in early osteoarthritis. MRI is the gold standard for diagnosing soft tissue abnormalities. Ultrasonography (USG) has also been used in Rheumatology for more than three decades. With the advancement of ultrasound technology, its use has increased dramatically in the field of rheumatology. USG is cheap, free from radiation hazards, non-invasive and widely available. Addition of colour Doppler and power Doppler techniques have immense value in detection of pathologies not only of major vessels but also of microvasculature.

Sound is an audible mechanical wave that propagates through various compressible media like air, water and solids as longitudinal waves and also as a transverse waves in solids. As like other waves sound also has frequency and wavelength. Frequency is the number of wavelengths per unit time. It is measured as cycles per second or hertz (Hz). Audible range of

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sound frequency for human ear is 20 Hz–20 kHz. In USG, frequency used is more than 20 kHz; usually ranging from 2 to 15 million Hz.[1] When an USG beam passes through the tissue various types of interaction can happen including attenuation, reflection, scattering, refraction and diffraction. Reflection of the incident USG forms the basis of B mode USG imaging. USG waves are reflected at the sites of tissue boundaries and interfaces. Reflection of USG wave depends upon the difference in density and propagation velocities of USG between the tissues. USG waves are generated from piezoelectric crystals of ultrasound transducer. Piezoelectric effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress or vice versa. Piezoelectric crystals used in transducers change electrical signals to mechanical vibrations and change mechanical vibrations to electrical signals. The reflected sound from the area under scanning is picked up by the transducer which creates an image in the screen.

The history of USG is more than a century old. In 1794, Lazzaro Spallanzani, an Italian Biologist first speculated that the capacity of bats to 'see' in dark was dependent on their ears. Curie brothers of France in 1880 discovered the piezoelectric effect; however the use of USG for human imaging started after almost four decades. Karl Dussik, a neurologist is regarded as the first physician to use USG in 1942 for diagnosing brain tumour through skull. Few years later in 1948, George Ludwig used USG to diagnose gall stone. The first published report of Musculoskeletal (MSK) USG was in 1972 by American radiologists Daniel McDonald and George Leopold, for differentiating Baker's cyst from thrombophlebitis.[2] Within next few years Cooperberg used USG to detect synovitis and treatment response in patients with Rheumatoid arthritis.[3] Since then the MSK use has rapidly expanded in rheumatology. Addition of Doppler USG imaging further helped in detection of inflammatory MSK pathologies of tendon and synovium. Advancement of transducer technologies made it possible to image MSK structures with excellent resolution. Use of high frequency linear transducers, hockey stick linear array transducers, high frequency pencil array vascular transducers opened a new horizon in MSK and vascular imaging especially for small and difficult to reach body parts.

2. Use of USG in rheumatology

The role of USG in Rheumatology is multifaceted. It is now used for both diagnostic and therapeutic purposes and also to assess treatment response. USG has an important role in a number of rheumatological diseases including rheumatoid arthritis, crystal-induced arthritis, spondyloarthropathies, osteoarthritis, connective tissue disorders including Sjogrens syndrome, vasculitis, and the list is still increasing.[4] It is also useful for detection of periarticular soft tissue pathologies.

3. Rheumatoid arthritis (RA)

Early diagnosis and treatment initiation has an important role in halting disease progression in RA and thereby preventing deformities. USG is useful in differential diagnosis, early disease detection, guiding treatment decisions, disease activity monitoring and follow-up of remission in RA patients.[5]

Clinical detection of synovitis may not be possible in the very early stage of the diseases and typical X-ray changes like erosions, joint space alterations takes a long time to appear. Initial studies showed the utility of USG and Doppler in detecting synovial inflammation in RA patients.[6,7] PDUS had good reliability in comparison to dynamic contrast MRI for detection of hand joint synovitis in RA. Kane, et al showed that USG is more sensitive than clinical examination for detection of suprapatellar bursitis, knee effusion, and Baker's cyst in RA.[8] Apart from diagnosis utility of power Doppler was also observed in monitoring treatment response.[9] In 2005 the OMERACT defined synovitis as abnormally thickened, hypo echoic, intra-articular tissue that is poorly compressible and can demonstrate increased Doppler signals.[10] In grey scale synovial hypertrophy is graded in a semi quantitative scale (0: no intra-articular changes, 1: mild, 2: moderate, and 3: large synovial hypertrophy). Similarly Power Doppler USG scoring for synovial inflammation consists of four grades (0: absence of any flow within synovium; 1: single vessel signals, 2: confluent vessel signals in less than half of the area of the synovium, 3: vessel signals in more than half of the area of the synovium). Using semi-quantitative scoring system high interobserver agreement rate was noted for USG detection of synovitis and erosions.[11] USG is also more sensitive than radiography for the detection of early erosions in RA. Erosion in USG is defined as the discontinuity of the smooth echogenic bone surface or cortex greater than 2 mm in diameter, visualized in two planes and having an irregular floor.[12] Recently a new scoring system (the modified US7 score) has been assessed in patients with early rheumatoid arthritis with good result.[13] With the help of defined synovitis and erosions and using the established grading system, PDUS is now is an essential investigation in patients with clinical suspicion of RA. A recent study from China showed the presence of subclinical synovitis in RA patients achieving clinical remission.[14] In an another interesting study PDUS score has been found to be a predictor of future joint destruction.[15]

The utility of USG in RA is not only limited to detection of articular pathologies but include soft tissue abnormalities like tenosynovitis, rheumatoid nodule etc. Recently an USG based tenosynovitis score in RA patients has also been published with good interobserver agreement.[16] Some of the USG features of RA have been illustrated in Fig. 1.

4. Crystal induced arthritis

Detection of monosodium urate (MSU) and calcium pyrophosphate dehydrate (CPPD) in aspirated synovial fluid has been considered as the gold standard for diagnosing crystal induced arthritis for more than fifty years. USG has been in use for crystal arthritis for more than a decade. Grassi, et al showed the utility of USG in both diagnosing and differentiating crystal induced arthritis caused by MSU and CPPD deposition.[17] The MSU crystals predominantly deposit on the surface of articular cartilage where as CPPD crystal deposition is seen within the cartilage substance. Tophus formation, micro deposits within the tendons and hetero echo intensities