Original Research Article

Musculoskeletal Ultrasound in Rheumatological Diseases

Abstract:

Rheumatology has seen a sonographic revolution in recent years. Ultrasonography (US) has been demonstrated to be capable of significantly altering the traditional approach to most clinical problems in daily rheumatologic practise due to its ability to provide rapid, safe, and inexpensive access to anatomical information on the early targets of the majority of rheumatic diseases. Ultrasonography completes the physical examination with speed and accuracy and enables the detection of a broad range of abnormal findings involving various musculoskeletal (MSK) anatomical components.

Ultrasonography is mostly used for interventional guidance (joint aspiration, synovial or soft tissue biopsy, joint or tendon sheath injection). When fluid collections are very tiny or when the inflammatory process is next to anatomical structures that might be severely harmed by the injection, sonographic guiding is very effective.

MSK US is a significant imaging modality for practising rheumatologists and provides an effective diagnostic tool for assessing patients with MSK problems. In the United States, the usage of MSK ultrasonography has evolved due to the availability of less priced, portable US equipment that give high-quality grayscale and power Doppler signals. The American College of Rheumatology (ACR) has given standardised training courses and a certification programme for practising

rheumatologists, and similar training is also offered through a number of fellowship programmes.

In certain clinical circumstances, rheumatoid arthritis (RA) might be difficult to diagnose since crystalline arthropathies can closely resemble RA. For instance, palindromic RA might appear with articular symptoms that, based on history and clinical characteristics, mimic a crystalline disease. This study sought to investigate the relevance of MSK ultrasonography in rheumatologic illness diagnosis.

Keywords: Musculoskeletal Ultrasound, Rheumatological Diseases, Ultrasonography, Rheumatoid Arthritis

Introduction

Rheumatology is an intriguing field of study. The diagnosis relies heavily on the medical history and physical examination. For the majority of rheumatologic disorders, viable therapeutic options are available once a diagnosis has been made. Can ultrasonography (US) enhance our clinical abilities while examining a patient with rheumatic illness suspicion? Indeed, it can! Combining a patient's medical history and physical examination with ultrasonography helps the rheumatologist to characterise rheumatic disease entities with precision. The rheumatologist can perform and interpret an US while questioning and evaluating the patient at the point of service. The additional benefit of US with clinical correlation expedites the diagnosis, management, and targeted therapy (e.g., US-guided injections) of rheumatologic disorders, with the potential for improved clinical outcomes and lower healthcare costs (1).

As rheumatology encompasses a broad spectrum of disorders, ultrasonography can be utilised for a growing variety of indications. The American College of Rheumatic has produced a study on the acceptable use of MSK US in rheumatology clinical practise that gives an overview of clinical situations with favourable evidence-based recommendations based on current literature (2).

US of the MSK system has become an established imaging method for the diagnosis and follow-up of patients with rheumatic disorders during the past decade.

1-5 This is a result of technology advancements that have led to faster processors and higher frequency transducers. US is most frequently used to evaluate soft tissue disorders or identify fluid collection, but it may also be used to examine other tissues, including cartilage and bone surfaces (3).

Due to the superior axial and lateral resolution of US, even the smallest bone surface anomalies may be seen. Consequently, damaging and/or reparative/hypertrophic alterations on the bone surface might be detected prior to their visibility on x-rays or even MRI. However, US frequencies cannot penetrate bone, therefore intra-articular disease imaging is typically not achievable. The "real time" capabilities of US allows for the dynamic evaluation of joint and tendon motions, which can frequently help in the discovery of structural problems. The non-invasive nature, mobility, relative affordability, absence of ionising radiation, and repeatability of US make it particularly valuable for monitoring therapy. US can also be utilised for aspiration, biopsy, and injection therapy guidance (4).

The majority of MSK work is accomplished using "grey scale," which produces black-and-white pictures; each white dot represents a reflected sound wave. Sound waves travel similarly to light waves, thus the denser a substance, such as bone cortex, the more reflecting it is and the whiter it will seem on the screen. Water is the least reflecting body substance, therefore sound waves go directly through it and look black (5).

Color and power Doppler imaging, which offer colour maps of tissue, are among the newest US methods now being researched. Here, the quantity of colour is proportional to the amount of blood flow, which may be useful for assessing vascular tissues, such as those affected by soft tissue inflammation. To boost the sensitivity of power Doppler even further, intravenous bubble contrast agents are currently being developed (6).

Characteristics of MSK US

Joint US is an accessible, simple, fast, and economical imaging method used to check MSK tissues, such as the tendons, ligaments, bursae, and articular surface. It does provide accurate images of structural abnormalities and a pathology caused by inflammation or degeneration conditions in a variety of rheumatologic diseases, including RA, osteoarthritis, SpA, and septic arthritis, and connective tissue diseases, including systemic lupus erythematosus (SLE), systemic sclerosis, inflammatory myositis, Sjogren's syndrome, and systemic vasculitis (7).

MSK US and MRI are among the new imaging modalities for rheumatic disorders with distinct properties. The benefits of MSK US over other imaging techniques include visibility of the joint cavity and soft tissue involvement, cost-effectiveness, availability, lack of radiation, multiplanar imaging capacity, and real-time dynamic evaluation of joints. MSK US is also a valuable instrument for directing invasive surgeries. It allows for accurate and exact needle placement and is a safe technique for patients requiring synovial fluid aspiration, injectable treatment, and/or biopsy (8). [12–14, 16]

MRI is a more sensitive imaging method for viewing inflammation and damage, and is especially beneficial for identifying bone inflammation; nevertheless, it is costly, not easily accessible, time-consuming, and restricted to a small anatomical area each examination (9).

Limitations of MSK US

The drawbacks of the US are its narrow field of view compared with MRI, and the fact that the US beam does not penetrate under the bone. Moreover, the US is highly operator dependent.

The sonographer should be aware of a variety of artifacts (Power Doppler artifacts and anisotropy), so as not to falsely recognize pathology where there is none. In addition, one must be aware not to over interpret slight US abnormalities that are observed by “sensitive” US machines and may not reflect disease (10).

Examination technique

Continuous technological advancements in the United States have resulted in the availability of exceptionally high-quality sonographic equipment, enabling the histological examination of superficial tissues (tendons, tiny joints, skin, peripheral nerves, and blood vessels) (11).

The term 'acoustic microscopy' is appropriate for characterising sonographic exams using probes with a very high frequency (0.16 MHz) and a resolution power of less than 0.1 mm. If having a high-quality US equipment is a must for MSK US, then the driver's expertise is even more crucial. US is a 'technical art' and is without a doubt the most 'user dependent' diagnostic imaging modality. In investigations of individuals with rheumatoid arthritis, a high level of interobserver concordance was

documented for the evaluation of synovitis and bone erosions in the minor joints of the hands and feet (12).

Even if the selection of the acoustic window is determined by the unique diagnostic necessity, a standardised method of examining the various anatomical locations is recommended. Each anatomical region should be investigated on many scan planes in order to collect all relevant data. An in-depth understanding of anatomy is necessary for MSK US (13).

Sonographic follow-up requires the acquisition of similar images of the same anatomical region at different time intervals. Even minute differences in the control parameters of the sonographic beam, such as location, applied pressure, and beam tilt, might impact the sonographic picture, hence influencing its interpretation (14).

Sonographic palpation may be of tremendous use in the investigation of regional pain syndromes if it can elicit tenderness in particular anatomical regions. Three-dimensional MSK US is an interesting new subject in US. The capture of the whole volumes of echoes generated by the probe permits a three-dimensional reconstruction of the studied area on an infinite number of scan planes, therefore enabling virtual MSK endoscopy. This approach is highly promising for evaluating entheses, tendons, and tiny joints (15).

Technical equipment

MSK work need high-quality, high-resolution instruments. The choice of transducer will rely on the exams that will likely be conducted. High frequency linear transducers (7.5–20 MHz) are optimal for displaying surface structures such as tendons, ligaments, and tiny joints, but low frequency linear transducers (3.5–5 MHz) are occasionally more appropriate for bigger or deeper-sited joints such as the shoulder or hip (16).

In the United States, there is a continual trade-off between picture resolution and sound wave penetration depth. Higher frequency transducers offer superior spatial resolution, but their depth of penetration is less than that of lower frequency transducers. The size of the footprint (the transducer's contact area with the skin) is also a significant examination procedure component (17).

For instance, transducers with a big footprint cannot be manoeuvred well enough to visualise fully tiny joints such as the metacarpophalangeal joints. However, these are merely basic factors; the most important factor is the total image resolution, which must be thoroughly analysed and compared prior to purchase. For practical reasons, it is recommended to test whether a specific piece of sonographic equipment is capable of displaying the fine definition of small structures, such as the insertion of a small extensor tendon of the finger or the minute amount of fluid normally detectable in the pre-Achilles bursa (18).

The practical utility of colour Doppler/power Doppler capabilities is currently being evaluated, particularly in light of the added expense. The purpose of color/power Doppler is to identify enhanced perfusion of soft tissue. Additionally, the prospective applications of three-dimensional US are also being evaluated. Finally, emphasis must be paid to picture documenting techniques. Every inspection should be meticulously documented. Images can be stored on paper, film, video cassettes, laser-printed x-ray acetates, optical discs, and digital storage systems. To increase the repeatability of these discoveries, all shown structures should be recorded in a standardised manner. In two perpendicular planes, pathological findings should be reported (4).

The development of rheumatological ultrasound

The 1978 demonstration of synovitis of the knee in rheumatoid arthritis (RA) likely marked the beginning of modern 'rheumatologic US' Advances in US technology have enabled high-resolution imaging of MSK structures, and MSK US is now a commonly utilised imaging technique for the MSK system. MSK US is a great tool for rheumatologists due to its improved awareness of rheumatic disorders, multiplanar imaging of articular structures in real time, cheap operating costs, lack of radiation, and high patient acceptance. Whether MSK US should be conducted by radiologists, rheumatologists, or other MSK specialists, or by all three, remains a source of debate (19).

The increasing inclusion of US as a common extension of clinical examination in other clinical specialties, such as obstetrics, gynaecology, and cardiology, suggested that MSK US would become a natural extension of MSK assessment conducted by rheumatologists. In Germany, rheumatologists pioneered the introduction of MSK US into clinical practise, and MSK US is now a routine component of the rheumatology training curriculum. Indeed, the use of MSK US by rheumatologists has made a significant contribution to the knowledge of the natural history of rheumatic disorders and to the improvement of clinical diagnostic and therapeutic abilities (20).

However, the use of MSK US by rheumatologists abroad varies significantly. MSK US is a standard element of rheumatology training in Italy and Germany, but it remains mostly the domain of radiologists in the United States and the United Kingdom, despite a worldwide interest among rheumatologists. The complicated reasons for this include money, equipment, standardisation, training, and the conventional views of rheumatologists toward MSK US (21).

Three- and four-dimensional ultrasonography

US lagged behind CT and MRI in terms of 3D imaging until recently. Now, breakthroughs in computation have enabled 3D US imaging (termed 4D as it has the advantage of being performed in real time). All of these cutting-edge technologies are now being studied and have the potential to remove MSK US from the shadow of MRI in the evaluation of MSK disorders. In a matter of seconds, 3D sonographic images of a target region may be obtained, enabling an off-line, exhilarating virtual anatomy tour in longitudinal, transverse, and coronal planes, as well as simultaneous 3D reconstruction. After the workstation has been appropriately configured, an expert sonographer and a beginner will capture identical images. In addition, 3D US has the potential to significantly shorten the length of MSK US examinations while simultaneously improving the quality and consistency of the approach (22).

Three-dimensional images give a magnificent and in-depth view of the tiny joints, are easier to comprehend, and vividly highlight a number of anatomical aspects that cannot be seen by conventional US. In rheumatology, the primary clinical indications for 3D MSK US may include the early diagnosis of bone erosions in tiny joints and a more thorough evaluation of enthesitis and partial tendon tears. Although the influence of 3D US on final diagnosis or therapeutic monitoring has not yet been determined, it appears fair to anticipate that as technology developments continue to enhance picture quality, the use of 3D sonography in the diagnosis of MSK problems will increase rapidly (23).

The proper selection of MSK US equipment is crucial for allowing the incorporation of MSK US into rheumatology practise and for facilitating MSK US training. When selecting sonographic equipment for MSK US,

cost, picture resolution and quality, transducer design, equipment size/portability, and color/power Doppler options are crucial factors (24).

The cost of US equipment is directly proportional to picture quality and resolution. A high-resolution system with enhanced imaging definition generates high-quality, interpretable pictures. A high-quality, high-resolution system might cost anywhere from £30,000 to £130,000. By configuring the system exclusively for MSK imaging, significant cost savings can be realised. Small, transportable systems are less costly (£15,000), provide pictures of adequate quality, and are simple to operate at the bedside. However, pictures on a smaller screen are more difficult to interpret for less-experienced ultrasonographers. The ideal combination, in the opinion of the authors, is to have access to a larger, high-resolution system for training and research purposes, as well as for "difficult cases," while a smaller, portable system is sufficient for the majority of routine clinical practise performed by the experienced sonographer (25).

Thirteen out of fifteen studies in our comprehensive assessment of the literature found that MSK US is useful for diagnosing RA when combined with clinical examination and laboratory evaluation. One research found greater sensitivity in identifying arthritis at the joint level, but no meaningful value was identified at the patient level (26).

Another research demonstrated no predictive value for RA when MSK US was included as a standard component of early arthritis evaluation. In terms of population size, these two studies are the greatest; the latter contained 379 participants. There are, however, limits to the MSK US performance in this investigation. The MSK US process lasted ten minutes, and only sixteen joints were checked. Additionally, wrists and MTP 3–5 were excluded. This might be a reason for the bad results, as RA frequently

causes wrist inflammation. MSK US is deemed beneficial in each of the remaining 13 trials included in this review, and wrist examinations are performed in each (27).

Conclusions

MUSU is quick, simple to apply, and readily available, no ionizing radiation, it is a low-cost procedure, well tolerated by patients, of better sensitivity than physical examination, allows evaluation of many structures over a relatively short period of time, enables dynamic examination during movement of joints and tendons which can be helpful to asses impingement syndrome of the shoulder for example and detects subclinical synovitis, enthesitis, early erosions.

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