Imaging innovation and rheumatology

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Imaging studies are an integral part of the diagnostic and therapeutic workup of patients in rheumatology and this scenario is unlikely to change in the coming decades. Imaging is used in clinical practice to support diagnosis, to assess disease activity including its changes over time and to define structural and chronic changes .Imaging is also used in investigational studies, for example, in randomized controlled trials to study the effect of a specific drug, in observational studies to investigate disease outcomes and clinical associations and in basic studies to define pathophysiological aspects of disease.

Until the last two decades of the XX century radiology's contribution to the study and evaluation of rheumatic diseases was mostly confined to radiographs of the skeleton[1]. Patterns were studied to formulate a diagnosis and damage was detected in an advanced state of the disease. Radiographs depict bone and joint anatomy but are not very accurate for early soft tissue inflammation and tracking subtle changes over time. Radiographs are usually normal in the early stages of the inflammatory process showing normal bone and joint alignment with early changes comprising non-specific soft tissue thickening. When damage is seen this is usually irreversible (erosions, joint space narrowing, productive changes).

When new disease modifying antirheumatic drugs (DMARDs), specifically biological agents, became available, early and effective control of disease activity became possible, improving clinical outcomes and preventing damage. Companies sponsoring costly clinical trials also demanded outcome measures that could be measured more quickly, and alongside more sensitive laboratory tests, came the need for more sensitive imaging studies that could demonstrate changes in a timeline of months and not years.

Imaging of the musculoskeletal system was always a challenge for radiology because of the need to provide adequate images of two very different anatomical systems. We need adequate imaging of bone detail and structure but also of the soft tissues that support and surround the skeletal system; muscle, tendon, subcutaneous compartment, fascia. For most of the XX century only the first area mentioned above (bone imaging) was adequately addressed. Fortunately, alongside therapeutic advances, imaging also underwent significant changes in the last twenty years of the XX century. Ultrasound machines with greater probe resolution and Doppler sensitivity (for the study of inflammation), Magnetic Resonance Imaging (MRI) at increased field strengths and with better dedicated joint antennae allowed exams to be faster, with better image quality and with information that is not only anatomical but also functional. MRI protocols [2,3] and new hardware now allow us to have very high-resolution images of small joints and ligaments but also to have a Whole-Body MRI (WBMRI) study. New protocols and software allow for comprehensive evaluation of the degree of inflammation, oedema, cartilage and bone damage. Advances in Computed Tomography (CT) have also been very useful for the evaluation of the musculoskeletal system. Traditionally CT produced x-rays of a single magnitude of energy but the new machines are capable of generating x-rays with different energy levels. The new multienergy CT[4] machines provide information about different materials and lesion tissue composition without the use of intravenous contrast agents and with substantial dose reduction. Applications include detection and characterization of different types of calcifications, detection of bone marrow edema[5], metal artefact reduction, detection of bone tumours and studies of bone mineral density.

However in these first almost twenty years of the XXI century one of the biggest changes in Radiology has been that the images that we see are no longer simple pictures but collections of digital data that can be studied , manipulated with software tools , and shared almost instantaneously between virtually every place of the planet. This, coupled with the new Artificial Inte-

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lligence algorithms (AI), allows the collection and analysis of huge volumes of data. Musculoskeletal imaging (and Rheumatological imaging as a consequence) is already benefiting from the main directions of research with the new AI methods, namely Lesion Detection, Imaging Quantification, Imaging Segmentation, Diagnostic Classification and Functional/ /Molecular Imaging.

Despite significant progresses in this field it is important to dispel the myth that an imaging study is the sole result of a technological advance or innovation. Several confounders can influence the outcome of imaging acquisition, far more than just the technology that is being used. Having technologically advanced equipments is therefore not synonymous of high-quality imagens. Given the example of the magnetic resonance technique, we have to be sure that the machine has an adequate field strength and that the proper coils to image the body part that we want to study are applied. Furthermore, if the protocol of sequences is correct for the objective of the study and if our equipment supports this protocol? If we do this protocol in January do we have the quality control and the standards to ensure that when we repeat the protocol months later the imaging data is comparable and standardized? And even if the imaging data is of equal quality do we consistently interpret and score the changes in the same way? What is our intra and inter-reader variability? Do we report and communicate the results in a standardized manner? How do we integrate results that affect the musculoskeletal system with systemic changes seen for example in the ever more present Whole-Body Imaging protocols? These concepts are also true for the "simpler" radiographic studies. To adequately interpret a study or several studies of the same patient over time, we have to ensure that positioning, proper radiographic settings, exposure and image windowing are the same. Small changes in these parameters affect the final result.

Radiology was always since its foundation a highly collaborative medical specialty. The exponential growth of imaging techniques and protocols, the advent of Interventional Radiology as a subspecialty with advances in minimal invasive therapies demand an ever close collaboration between radiologists and other medical specialties in multidisciplinary and interdisciplinary settings. This is needed, among other things, to define proper clinical imaging protocols, build strategies to select the best imaging studies for specific diseases in a cost-effective manner, and to define research directions. Setting aside I am confident that it is in the best interest of patients and of our two medical specialties that the collaboration between rheumatologists and radiologists deepens in the years to come.

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