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New advances on diagnostic imaging in spinal pathology☆

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ABSTRACT

In the past years, there has been a remarkable improvement on imaging technology. Magnetic resonance (MR) is the method of choice for detection, diagnosis and therapeutic management for many disorders of the spine. A variety of innovative new MR methods have been developed. These new techniques include molecular diffusion sequences, MR myelography, a complete study of the entire spine, kinematic MR imaging of the spine, whole body MR exam and the fusion of different imaging modalities. These new technological developments have the potential to profoundly impact and modify imaging interpretation to offer a more efficient diagnostic and work-up of patients suffering from spinal disease.

Nuevos avances en el diagnóstico por imagen de la enfermedad del raquis

Palabras clave:
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RESUMEN

En los últimos años se ha producido un avance espectacular en las técnicas de diagnóstico por imagen. La resonancia magnética (RM) es la técnica de elección para la detección, diagnóstico y manejo terapéutico en la enfermedad del raquis. Hay importantes innovaciones tecnológicas en el campo de la imagen en RM. Estas nuevas técnicas incluyen secuencias de difusión molecular, mielo RM, estudios de columna completa, técnica de la columna dinámica, técnica de RM de cuerpo entero y fusión de imágenes, entre distintas técnicas. Estos avances tecnológicos tienen el potencial de modificar la interpretación de la imagen y poder ofrecer una mejor eficacia diagnóstica y manejo terapéutico del paciente con enfermedad relacionada con el raquis.

Introduction

In the past 20 years imaging technology has revolutionized the health care system, leading to the fact that imaging diagnosis is currently one of the fundamental pillars of patient care. Magnetic resonance (MR) is a technique that has led to the most remarkable technological advances, constituting today a practical and useful tool in the management of spinal disease. MR allows for the identification of spinal affection because no other imaging technique offers an adequate contrast resolution that permits the identification of soft tissue, cord tissue or spinal canal pathology. This article will briefly review the most important technological advances regarding MR in spinal imaging, describing molecular diffusion techniques, myelo MR, cinematic studies, whole spine MR and whole body MR as well as image fusion from different techniques.

Diffusion in magnetic resonance

Diffusion sequencing has been commonly used from the beginning to detect cerebral ischemic disease. However, the past few years have seen the development of its use for different bone and muscle applications.[1] This technique allows the identification of normal random diffusion restriction of water molecules into different tissues. The alteration of water diffusion can be due to several causes (benign or malignant), making it possible to differentiate, in certain cases, between benign edema and malignant metastatic infiltration.[2] In addition, this technique allows the quantification of the degree of restriction of diffusion using the apparent coefficient of diffusion parameter. The possibilities for

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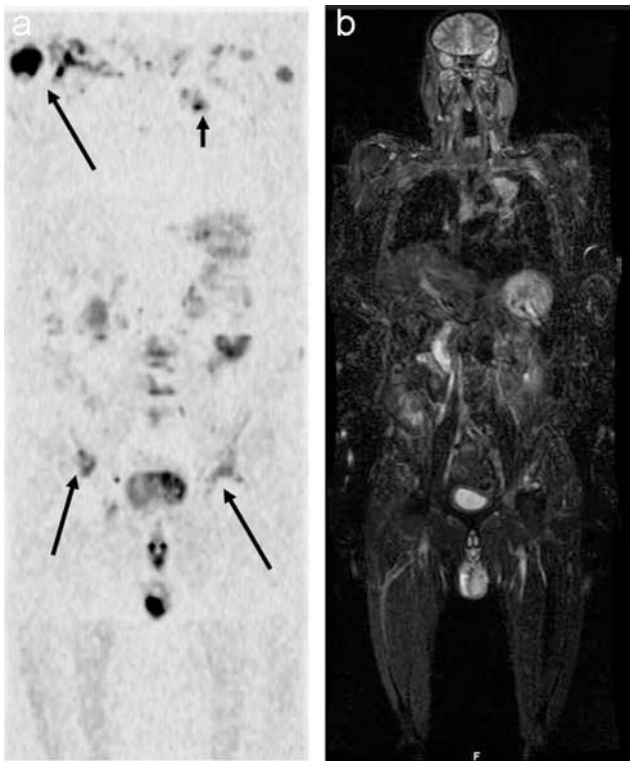

Figure 1. Magneti Resonance (MR) sudy of the whole body with a diffusion technique. a) MR image with diffusion and inversion of contrast, showing a left primary lung neoplasia (small arrow) with multiple diffuse bone metastasis (long arrows). b) Whole body MR with STIR (short tau inversion recovery) sequence complementing the diffusion sequence, showing a greater anatomical detail of the left lung neoplasia.

application of the molecular diffusion sequence in spinal disease are in its validation phase for different situations. Correlation has been seen between the severity of molecular diffusion of water with the degree of discal disease.[3] Other possible applications of the diffusion sequence are the therapeutic management of different malignant or benign diseases. Preliminary studies have recently been published on the potential use in therapeutic monitoring of patients with ankylosing spondylitis.[4] Its use for the differential diagnosis of infectious disease, osteoporosis or tumors has also been described.[2] One of the latest possible applications for the diffusion sequence is the application on whole body MR (Figure 1), as will be described below.

Magnetic myelo-resonance

MR myelography is a non-invasive technique, which provides anatomical information of the subarachnoid space. Its advantage in relation to other radiographic techniques is the absence of ionizing radiation, its non-invasive nature and the lack of a need to inject intrathecal contrast material. This technique provides a visualization of the whole thecal sac (Figure 2), even in the presence of stenosis, blockade or adherence that led to a block in the diffusion of contrast in radiographic myelography. The advantage of this technique is that it can be jointly applied with classical sequences of any MR study, without the need for supplemental tests and can be performed in a single MR. Possible indications for the use of this supplementary sequence are evaluation of nerve root anatomical variants, congenital abnormalities, posttraumatic pseudomeningocele, adhesive arachnoiditis, tumors, discal hernias, degenerative canal stenosis or arteriovenous malformations.[5]

Figure 2. Magnetic myelo-resonance (MR). Sagital Image in MR with myelographic technique showing the roots of the cauda echina in the thecal sac.

Dynamic study of the spine

Generally, clinical symptoms of spinal disease are produced under certain positions or movements that are not the ones under study at the moment of imaging. It is currently possible to reproduce the MR image of the spine through the acquisition of the spinal column in different positions (extension-neutral-flexion) in a cinematic manner, perform a load test or even a standing test through open resonance equipment that allow the observation of affections hidden during the conventional study such as hernias, dislocations or traumatic lesions.[6]

Complete study of the spine

MR allows the evaluation of the entire spine, although its acquisition must be performed independently between the cervical, dorsal or lumbar segments. With technological advances it is possible to reconstruct a post-processing image of the different segments in order to be evaluated as a single image of the whole spine. The possibility to evaluate the entire spine permits the identification of lesions in different zones that could modify the diagnosis or the management of the patient, especially when degenerative disease, trauma,[7] tumoral lesions

(Figure 3) or de inflammatory lesions are present. The whole spine technique is commonly performed in the whole body MR, described below.

Figure 3. Whole spine magnetic resonance (MR). Complete MR study in a potentiated sagital cut in T1 showing multiple metastasis of the dorsal, lumbar and sacral vertebral bodies with hypointense signal. The technique complements the whole body MR study.

Whole body magnetic resonance

Progressive technological evolution of MR with the improvement of acquisition sequences, higher speeds, more potent gradients and high resolution coils have led to the use of MR as a rapid and effective imaging method for whole body evaluation.[8] The technique depends on the equipment being used in order to employ adequate surface coils or the equipments body antenna. The study protocol is variable, and from this stems the difficulty for implementing the technique in a commonplace manner, precisely due to the lack of standardization between different MR equipments. It is important to perform T1 and STIR (*short tau inversion recovery*) potentiated sequences, mainly in the coronal plane of all of the body and in the spine's sagital plane for an adequate evaluation of the bone frame. For a study of abdominal organs and the brain it is necessary to perform the acquisition with an echopotentiated gradient technique in tridimensional (3D) T1 after the administration of intravenous contrast in a dynamic manner from the head to the pelvis. A whole body sequence can additionally be employed (Figure 1). Recently, a task force from this department has published its first results and shown a larger efficacy or whole body MR compared with radionuclide scans in the detection of bone metastasis using a diffusion sequence novel technique.[9] The approximate time a whole body scan without contrast takes is 25 to 35 min, and a 3D sequence after contrast administration takes approximately 45 min. The main indications for the use of whole body MR in order to evaluate a patient are in the field of oncology[10]: 1) detection of bone metastasis (Figures 1 and 3); 2) global tumoral extension of a primary neoplasia; 3) global evaluation of a patient with multiple myeloma; 4) evaluation of the patient with metastasis and unknown primary neoplasia, and 5) bone extension in the pregnant patient. There are other, non-oncological applications[11-13]: 1) benign multifocal osteo-muscular disease (infection, inflammatory, deposit, idiopathic); 2) abused children; 3) research: virtual autopsies, body fat, etc., and 4) preventive (cardiovascular angio MR). There is sufficient proof of the usefulness of the whole body MR technique, currently making it an alternative to other whole body techniques used less effectively. In any case, the scarce, commonplace use of this technique is probably due to its limited availability and accessibility, the scarce information available to clinicians, little integration with the radiologist in oncological or clinical circles in order to carry out diagnostic decisions, lack of standardization between different equipment, methods of iconographic presentation or radiologist's knowledge.

Image fusion

The progression of technological development makes it possible to have information from different techniques offering different, but complementary information. Technological possibilities make it possible to obtain not only morphological images, but also it is currently possible to obtain molecular, functional and metabolic data with nuclear medicine techniques such as positron-emission tomography, simple photon emission computerized tomography or MR itself.[14] Technological advances in informatics permits the integration of information in different diagnostic modalities in order to offer an improved global evaluation of disease an improve patient management.

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