Advanced MRI Techniques for Multiple Myeloma Detection and Management- Current Knowledge and Future Prospects

Abstract

Multiple myeloma is a neoplastic disorder of plasma cells, characterized by bone marrow infiltration, with a high morbidity and mortality. Imaging plays an important role in diagnosis, prognosis and evaluation of treatment response. Whole-body CT remains the mainstay for screening, but MRI has emerged as the most sensitive technique for lesion detection. In this article we will review the new emerging imaging modalities and future developments concerning multiple myeloma.

Keyword: MRI, Multiple myeloma, musculoskeletal, Dixon, whole-body MRI, diffusion-weighted imaging, artificial intelligence

Abbreviations

H-MRS: Proton Magnetic Resonance; 18F-FDG PET: 2-Deoxy-2-[Fluorine-18]-Fluoro-D-Glucose Positron Emission Tomography; ADC: Apparent Diffusion Coefficient; CT: Computed Tomography; DCE: Dynamic Contrast Enhanced; DWI: Diffusion-Weighted Imaging; EHA: European Hematology Association; ESMO: European Society of Medical Oncology; IMWG: International Myeloma Working Group; IP: In-Phase; MM: Multiple Myeloma; MRI: Magnetic Resonance Imaging; MYRADS: Myeloma Response Assessment and Diagnosis System; OP: Out-of-Phase; SMM: Smoldering Multiple Myeloma; T1WI: T1-Weighted Imaging; T2WI: T2-Weighted Imaging; WBCT: Whole-Body Computed Tomography; WBMRI: Whole-Body Magnetic Resonance Imaging

Introduction

Multiple myeloma (MM) is the most common primary malignant neoplasm of bone in adults and the second most common hematological malignancy, accounting for 1-1.8% of all cancer [1]. MM is part of a spectrum of monoclonal gammopathies where there is monoclonal proliferation of plasma cells in hematopoietic locations (e.g. bone marrow), and is diagnosed with clinical, biological and radiological criteria. Bone marrow infiltration can have several different patterns, such as focal lytic lesions or focal lytic involvement, homogeneous diffuse infiltration, combined diffuse and focal involvement and a rarer osteosclerotic form [2]. Thus, a complete spatial survey of the appendicular and axial skeleton is needed to avoid misdiagnosis and adequately evaluate disease burden.

Detection of lytic bone lesions was traditionally performed with...
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Bone marrow infiltration by MM cells creates a high diffusion signal due to replacement of yellow marrow adipocytes and increased cellular density. A focal lesion is defined as a lesion with low T1-weighted signal and high T2-weighted signal. Diffuse disease is described as diffuse bone marrow hypointense signal on T1WI and diffuse high signal on T2WI [27]. Care should be taken in the presence of chondroid, myxoid, hemorrhagic and sclerotic bone lesions, however, which behave differently. In this respect, diffusion-weighted whole-body MRI (DW-WBMR) has been used to screen bone marrow diseases, monitor and predict tumor response to therapy.

#### Dynamic Contrast-Enhanced MRI

Post-contrast administration imaging can provide functional information on bone marrow infiltration. Dynamic contrast-enhanced whole-body MRI (DCE-WBMR) captures the signal intensity throughout different time periods after intravenous contrast administration and computation of time-signal intensity curves provide signal maps with distinct patterns that may be correlated to higher or lower amounts of plasma cell infiltration. DCE-WBMR has been shown to have a positive correlation with MM activity and serum biomarkers [28] and predicts rapid progression from smoldering MM (SMM) to symptomatic disease [29]. Treatment response may also be evaluated with DCE MRI, in which persistence of elevated peaks of marrow enhancement and foci of early enhancement are correlated with poor treatment response [30]. Specific time-signal curves have also been associated with high cellularity in whole spine perfusion in MM patients, and better correlate with viable malignancy [31] (Figure 1).
Future Directions

Several novel imaging techniques are being employed for MM with promising results not only in early diagnosis but also in functional assessment and response to therapy. MRI is making steady progress and gaining ground due to its sensitivity for early diagnosis, the ability to make a non-invasive evaluation of disease activity and treatment response prone to cause a significant impact in clinical practice, without exposure to ionizing radiation. With the development of new techniques and sequences, with increased resolution and faster acquisition times that can be improved upon with artificial intelligence, it is only conceivable that MRI will get increasingly more attention and utility for MM patients over time in every stage of the disease.

Conflicts of Interest

The authors declare no conflicts of interest.

References

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