Whole-Body Magnetic Resonance Imaging: What is It and How Can it be Useful?

Ressonância de Corpo Inteiro: Em que Consiste e como Pode ser Útil?

Rita Lucas [1*]

***Corresponding Author/**Autor Correspondente
Rita Nobre Lucas [ritalucas1@gmail.com]
Hospital Lusíadas Lisboa, Rua Abílio Mendes, 1500-458 Lisboa, Portugal
ORCID ID: 0000-0002-7815-7812

https://doi.org/10.48687/lsj.156

Palavras-chave: Imagem Corporal Total; Imagem de Difusão por Ressonância Magnética; Neoplasias; Ressonância Magnética

Keywords: Diffusion Magnetic Resonance Imaging; Magnetic Resonance Imaging; Neoplasms; Whole Body Imaging

Introduction

Diffusion refers to the random Brownian microscopic movement of water molecules driven by thermal energy.

In a homogenous system diffusion is random and can occur with equal probability in all directions. However, in the human body water molecules are distributed within different heterogenous environments. For example, the water molecules in biological fluids like cerebrospinal liquid or urine experience relatively free diffusion, on the other hand water molecules located in the intracellular compartment of different organs have their movements relatively restricted by several barriers such as cell membranes or macromolecules. As so, healthy different tissues due to its proper architectures have distinguishing diffusion properties.[1]

It is possible to rely on these microscopic properties of biological tissues to create a method of signal contrast and imaging generation for magnetic resonance (MR) - the diffusion weighted imaging (DWI). DWI provides extremely valuable information on tissue structure, adding functional details to the anatomical data gathered by the conventional MR sequences.

DWI signal differences between tissues can be quantified and compared through the calculation of the apparent diffusion coefficient (ADC), a mathematical algorithm, displayed through a grey-scale in the so-called ADC-maps.

The high spatial and contrast resolution of MRI allied to the fact that DWI does not use ionizing radiation and does not require injection of any tracer greatly contributed to its fast acceptance.

Oncology imaging is one of the fields that most beneficiated from this technique.

Tumoral microenvironments are typically high cellular and therefore, as the proportion of intracellular water increases, the diffusion becomes relatively more restricted in this setting. Typically malignant lesion have high signal on diffusion sequences and low signal in the ADC map compared to surrounding normal tissue. [2]

Nevertheless, malignant tumors differ in their cellularity and biologic aggressiveness, which is reflected and quantified in terms of ADC values. Also, the ADC values variation might aid

1. Serviço de Imagiologia, Hospital Lusíadas Lisboa, Lusíadas Saúde, Lisboa, Portugal
Recebido/Received: 13/05/2023**– Aceite/Accepted:** 07/06/2023 **– Publicado online/Published online: – Publicado / Published:** 30/06/2023

in the evaluation of early tumoral response to chemoradiotherapy schemes, preceding tumoral size reduction.[2]

Whole-body magnetic resonance imaging (WB-MRI)

WB- MRI is an emerging technique that allows imaging of the entire body (usually head to midthighs) to be performed in a single imaging session.

WB-MRI implies multisequence reading: DWI (low, high ***b*** values and ADC maps) in conjunction with the anatomic T1- and T2-weighted images and relative fat fraction images, evaluated by using image linking and scrolling in workstation facilities. Considering the challenges of time acquisition limitation and artifact suppression, core WB-MRI protocols have been designed, mainly based in rapidly acquired sequences, to last around 40-60 minutes.

If suspicious lesions are found, complementary dedicated studies might be required to evaluate specific body regions.

The diffusion images are displayed as maximum intensity projections with an inverted gray scale, to make the images more familiar to clinicians, as they look like the positron emission tomography (PET-CT) reconstructed images. Signal from the majority of normal tissues are suppressed with some exceptions such as the prostate, spleen, ovaries, testes, spinal cord and endometrium, furthermore the highly cellular lesions are highlighted in black in a white background.

WB-MRI is increasingly being pointed as an alternative to positron emission tomography (PET-CT) as a whole body imaging technique. The relative strengths and weaknesses of both techniques have been compared in several works. In favor of WB-MRI is its remarkable contrast resolution, but also cost and availability.

However, to beneficiate from the potential of this technique, it is necessary that both radiologists and clinicians get familiar with the findings and displayed images. There is an individual learning curve, to precisely identify the normal range of non-pathological and pathological findings and to guarantee an adequate inter-observer agreement.

WB-MRI current applications in Oncology

1.WB-MRI evaluation of prostate cancer metastasis

Several works have proved that WB-MRI is more sensitive than conventional methods (bone scans and computed tomography) in detecting bone metastases in high-risk prostate cancer patients, allowing the detection of visceral and nodal metastases.[3]

Although PET-CT has been proved to offer improved sensitivity and specificity, it involves ionizing radiation exposure, has lower contrast resolution, and availability cost constraints that might restrict generalized use. In particular prostate-specific membrane antigen (PSMA) PET-CT has demonstrated considerable good results,[3] but its availability is limited and incurs in considerable costs.

Contemplating WB-MRI as a forceful alternative, an international multidisciplinary expert panel of radiologists, nuclear medicine physicians and medical physicists, has reviewed the advantages and limitations of this technique and formulated dedicated guidelines for the use of WB-MRI in the assessment of multi-organ involvement in advanced prostate cancer - the METastasis Reporting and Data System for Prostate Cancer (MET-RADS-P).

These recommendations are designed to promote standardization and diminish variations in the acquisition, interpretation, and reporting of WB-MRI exams.

2. WB-MRI for the assessment of involvement by myeloma

In patients with multiple myeloma, bone marrow infiltration in early disease preceding cortical bone destruction, also beneficiates from the excellent soft-tissue contrast of MRI, and higher sensitivity than x-ray or CT, allowing a prompt treatment with survival advantages for patients. [4]

For this reason, WB-MRI is increasingly being considered as a first line imaging in patients with a suspected diagnosis of multiple myeloma. In line with MET-RADS-P, experts formulated imaging recommendations designed to promote standardization and diminish variations in the acquisition, interpretation, and reporting of WB-MRI in myeloma - the Myeloma Response Assessment and Diagnosis System (MY-RADS).[5]

The MY-RADS system provides comprehensive characterization of the myeloma state, both at diagnosis and the start of treatment, as well as overtime as the disease evolves.[5]

3. WB-MRI for cancer screening in individuals with cancer predisposition syndromes

The role of WB-MRI in surveillance protocols in individuals with cancer predisposition syndromes has been growing particularly in high-risk specific populations (eg. Li-Fraumeni syndrome, hereditary paraganglioma and pheochromocytoma

syndromes, constitutional mismatch repair deficiency syndrome, hereditary retinoblastoma or neurofibromatosis).[6] This screening is included in surveillance protocols as an "advanced" screening test in addition, and never in substitution, of standard screening tests (e.g. mammography, colonoscopy).

Acknowledging this increasingly important role a multidisciplinary expert panel developed the Oncologically Relevant Findings Reporting and Data System (ONCO-RADS) recommendations to promote standardization in WB-DWI studies obtained for cancer screening in individuals, with cancer predisposition syndromes.

In what concerns to the use WB-MRI for cancer screening in asymptomatic individuals, considering the differences in cancer prevalence, it might be a possibility, however, currently it is unknow if it could be beneficial or potentially harmful due to an increase of additional, maybe unnecessary, workup and patient anxiety.

Limitations

The algorithms used in DWI acquisition make several assumptions, namely ***a*** perfect field homogeneity however this technique is still susceptible to artifacts, particularly at higher field strengths.

Another remarkable limitation of DWI technique itself is the questionable reproducibility of ADC values. ADC values are known to vary between systems, and even with the use of same MR system. Such variability has been attributed to the inherent MRI acquisition itself that can lead to distortions resulting in image degradation.[2]

The high negative predictive value of WB-MRI makes it a trustable test when negative, however it is not free from false positive and negative findings, that must be mitigated with increased experience and confidence.[6]

Future Challenges

DWI has opened a new functional paradigm to conventional anatomical based imaging, revealing the MRI potential to also provide information on the cellular organization of tissues.

Researchers must keep focusing on further optimization of DWI sequences to minimize challenges in acquisitions and find novel strategies to enhance the utility of DWI.

It is believed that WB-MRI has still not achieved to its full potential, and it is expected that in future DWI might have a more establish role, namely in staging.

For now, it is becoming established as a complementary imaging modality, but its use can be expected to increase in the near future, as the accumulated evidence may provide insight into early/subclinical disease behavior and even in the identification of new imaging biomarkers of risk.

Responsabilidades Éticas

Conflitos de Interesse: Os autores declaram a inexistência de conflitos de interesse na realização do presente trabalho.

Fontes de Financiamento: Não existiram fontes externas de financiamento para a realização deste artigo.

Proveniência e Revisão por Pares: Comissionado; sem revisão externa por pares.

Ethical Disclosures

Conflicts of Interest: The authors have no conflicts of interest to declare.

Financial Support: This work has not received any contribution grant or scholarship.

Provenance and Peer Review: Commissioned; without external peer review.

References

1. Bihan D Le, Iima M. Diffusion Magnetic Resonance Imaging : What Water Tells Us about Biological Tissues. PLoS Biol. 2015:1-13. doi:10.1371/journal.pbio.1002203
2. Baliyan V, Das CJ, Sharma R, Gupta AK. Diffusion weighted imaging: Technique and applications. World J Radiol. 2016. 2016;8:785-99. doi:10.4329/wjr.v8.i9.785
3. Mottet N, van den Bergh RC, Briers E, Van den Broeck T, Cumberbatch MG, De Santis M, et al. EAU-EANM-ESTRO-ESUR-SIOG Guidelines on Prostate Cancer-2020 Update. Part 1: Screening, Diagnosis, and Local Treatment with Curative Intent. Eur Urol. 2021;79:243-62. doi: 10.1016/j.eururo.2020.09.042.
4. Dimopoulos MA, Hillengass J, Usmani S, Zamagni E, Lentzsch S, Davies FE, et al. Role of magnetic resonance imaging in the management of patients with multiple myeloma: a consensus statement. J Clin Oncol. 2015;33:657--64. doi: 10.1200/JCO.2014.57.9961.
5. Schlemmer H, Landgren O, Asmussen JT, Kaiser MF. Guidelines for Acquisition , Interpretation , and Reporting of Whole-Body MRI in Myeloma : Myeloma Response Assessment and Diagnosis System. Radiology. 2019;291:5--13. doi: 10.1148/radiol.2019181949.
6. Petralia G, Karow D, Zugni F. Oncologically Relevant Findings Reporting and Data System (ONCO-RADS): Guidelines for the Acquisition , Interpretation , and Reporting of Whole-Body MRI for Cancer. Radiology. 2021;299:494-507. doi: 10.1148/radiol.2021201740.