

Whole-body magnetic resonance imaging, including diffusion-weighted imaging, for diagnosing bone marrow involvement in malignant lymphoma

T. Kwee¹, R. Fijnheer², I. Ludwig³, H. Quarles van Ufford¹, C. Uiterwaal⁴, M. Bierings⁵, T. Takahara¹, and R.-J. Nijvelstein¹

¹Department of Radiology, University Medical Center Utrecht, Utrecht, Netherlands, ²Department of Hematology, Meander Medical Center, Amersfoort, Netherlands, ³Department of Hematology, University Medical Center Utrecht, Utrecht, Netherlands, ⁴Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, Netherlands, ⁵Department of Pediatric Hematology, University Medical Center Utrecht, Utrecht, Netherlands

Introduction

The malignant lymphomas, Hodgkin lymphoma (HL) and non-Hodgkin lymphoma (NHL), comprise approximately 5.0% of all cancers and account for approximately 3.7% of all cancer deaths in the United States [1]. Accurate assessment of the bone marrow is of major importance in malignant lymphoma because of its prognostic and therapeutic implications [2, 3]. Bone marrow biopsy (BMB) is considered as the gold standard for diagnosing bone marrow involvement, but is an invasive and painful procedure with risk of (hemorrhagic) complications [4]. Recently, whole-body magnetic resonance imaging (MRI) and diffusion-weighted imaging (DWI) have emerged as potential alternatives to CT for staging of malignant lymphoma [5]. Whole-body MRI also allows visualizing the bone marrow of the entire body. Furthermore, DWI is expected to be of additional value because its high lesion-to-background contrast may increase detectability of bone marrow lesions. If whole-body MRI is accurate in excluding bone marrow involvement, it may spare patients unnecessary BMBs. The purpose of this study was therefore to determine the value of whole-body MRI, including DWI, for diagnosing bone marrow involvement in malignant lymphoma using BMB as the standard of reference.

Subjects and Methods

Forty-eight consecutive patients with newly diagnosed malignant lymphoma (HL: n=10; NHL: n=38; low-grade NHL: n=13; intermediate-grade NHL: n=4, high-grade NHL: n=21) prospectively underwent whole-body MRI (T1-weighted and short inversion time inversion recovery [STIR] [n=48] and DWI [n=44]) and BMB of the posterior iliac crest (unilateral: n=40; bilateral: n=8). Whole-body magnetic resonance images were interpreted by a radiologist who was blinded to BMB findings. Patient-based sensitivities and NPVs of whole-body MRI (without and with DWI) for diagnosing bone marrow involvement were calculated, using BMB as the standard of reference. Whole-body MRI was considered to be sufficiently sensitive compared to BMB in case its sensitivity was equal to or higher than 95%. Sensitivity of whole-body MRI without DWI was compared to that of whole-body MRI with DWI using a McNemar test. *P* values less than 0.05 were considered significant.

Results

Whole-body MRI without DWI and whole-body MRI with DWI were positive in only 5 of 12 and 5 of 11 patients with a positive BMB, yielding sensitivities of 41.7% (95% CI: 19.3-68.1%) and 45.5% (95% CI: 21.3-72.0%), respectively. Note that the 95% CIs for sensitivities did not include 95%. Sensitivity of whole-body MRI without DWI was not significantly different (*P*=1.000) from that of whole-body MRI with DWI. Figures 1 and 2 show two representative whole-body MRI examples.

Figure 1. True positive whole-body MRI in a 64-year-old male with follicular lymphoma. Unilateral BMB revealed bone marrow involvement. Coronal TIW (a, b), STIR (c, d), and (gray-scale inverted) diffusion-weighted whole-body MRI (e) not only show widespread supra- and infradiaphragmatic nodal disease and splenic involvement, but also extensive bone marrow involvement in the thoracic and lumbar vertebrae, sacrum, and pelvic bone (arrows).

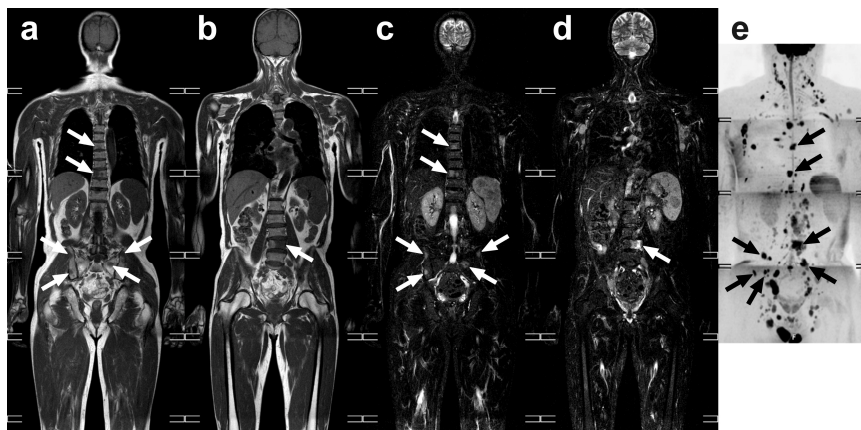
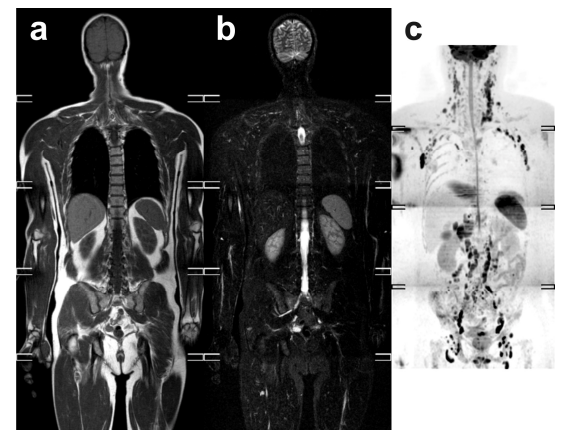


Figure 2. False-negative whole-body MRI in a 56-year-old male with small lymphocytic lymphoma. Unilateral BMB revealed bone marrow involvement. Coronal TIW (a), STIR (b), and (gray-scale inverted) diffusion-weighted whole-body MRI (c) show widespread nodal disease, but no signs of bone marrow involvement.



Conclusions

The results of this study show that whole-body MRI (without and with DWI) is negative for bone marrow involvement in a considerable proportion of patients with a positive BMB. Therefore, whole-body MRI is not sufficiently reliable yet to replace BMB for bone marrow assessment in malignant lymphoma. Against our expectation, diagnostic performance of whole-body MRI with DWI was not significantly higher than that of whole-body MRI without DWI. BMB remains necessary in the staging work-up of patients with malignant lymphoma until more advanced whole-body MRI protocols (e.g. at higher field strengths, or using a higher spatial resolution) or whole-body MRI/DWI protocols with bone marrow-specific negative contrast agents like ferumoxtran-10 have proved to achieve a higher diagnostic performance.

References

1. Jemal A, et al. CA Cancer J Clin 2009;59:225-249
2. Armitage JO. CA Cancer J Clin. 2005;55:368-376
3. Connors JM. J Clin Oncol 2005;23:6400-6408
4. Bain BJ. Haematologica 2006;91:1293-1294
5. Kwee TC, et al. Invest Radiol. 2009;44:683-690