Multi-parametric whole body MRI in paediatric lymphoma; A comparison with reference standard PET-CT

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Target Audience: Radiologists and Oncologists with interest in cancer imaging

Purpose:

Positron emission tomography fused with computed tomography (PET-CT) remains the gold standard imaging modality for staging of paediatric lymphoma despite the associated radiation risk [1]. Anatomical whole body MRI (WB-MRI) offers an alternative non-ionising technique [2] that can be supplemented by functional imaging, e.g. diffusion-weighted imaging (DWI) for the assessment of extent of the disease [3]. Some authors advocate a combination of anatomical and functional MR imaging whilst other highlighted that DWI adds no benefit to anatomical imaging alone [4]. In this study we investigate the usefulness of a multi-parametric WBMRI (mpWBMRI) for initial staging of paediatric lymphoma compared to reference standard imaging.

Material and Methods:

Thirty-seven (16 male, 21 female, 12.8 -18 years, mean 16.1 years) biopsy proven Hodgkin's lymphoma patients with baseline mpWBMRI and PET-CT were chosen for retrospective analysis. All patients underwent axial WB-T2 weighted (STIR-HASTE, TE/TR=60/800ms, TI=130ms, slice thickness=7mm, acquisition matrix=256*256, iPAT=2) augmented by WB-DWI (STIR-EPI, TE/TR=77/6000ms, TI=180ms, slice thickness=4mm, acquisition matrix=128*100, iPAT=2, b-value= 0, 300, 500 s/mm^2) using 1.5T scanner. Additionally an axial T2 (breath-held Periodically Rotated Overlapping ParallEL Lines with Enhanced Reconstruction (PROPELLER) imaging) through the chest (TE/TR=133/3000, slice thickness=4mm, acquisition matrix=256*256, iPAT=1) and an axial dynamic contrast enhanced MRI (DCE) of liver and spleen (3D FLASH, TE/TR=0.93/2.87, slice thickness=2.5mm, acquisition matrix=256*176, iPAT=2) were acquired for all patients.
The body was divided into 11 nodal and 11 extra-nodal stations based on conventional anatomical definitions [2]. Images were reviewed in locked sequential read by two radiologists independently and then in consensus and results recorded on study specific proforma. The DWI sequence was read first, followed by whole body STIR-HASTE supplemented with breath held T2 BLADE, and finally DCE imaging of the liver and spleen. On all sequences, the criteria for disease involvement were: nodal short axis greater than 1cm, focal signal abnormality within solid abdominal viscera or bone marrow, greater-than-background visceral signal or adjacent skeletal muscle, bone cortical disruption, and extra nodal infiltration seen as contiguous nodal tissue signal extending into adjacent structures. Pulmonary involvement was considered positive where a single visible nodule >1cm, or >=3 nodules <1cm were present, as per current EuroNet interim guidelines [5]. Each patient was assigned an overall stage for each part of the locked sequential read, according to the Ann Arbor classification [6].
As a reference standard, PET-CT images were reviewed in consensus by two nuclear medicine physicians and disease recorded for the same anatomical sites. To eliminate nodal site anatomical matching errors between studies, imaging of non-concordant PET-CT - mpWBMRI positive nodal stations was re-reviewed by an independent expert panel (comprising a radiologist, nuclear medicine physician and oncologist). The panel identified discordant sites, determined whether PET-CT and mpWBMRI were positive at adjacent locations, and where positive confirmed (by review of both sets of images) that the same node was positive on both imaging techniques. The remaining discrepancies between mpWBMRI and the PET-CT reference were then classified by the panel as either due to: (i) perceptual error i.e. due to mpWBMRI reader error; or (ii) technical error i.e. due to limitations of the MRI protocol. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were derived for nodal and extra-nodal assessment, for each reader, for each component of locked sequential read against the PET-CT reference. Agreement between final consensus mpWBRI and PET-CT reference standard staging was evaluated by Cohen's kappa test.

Results:

Sensitivity, specificity, PPV and NPV for DWI only imaging for reader 1 was 88.1%, 96.7%, 90.8% and 95.7% for nodal and 65.5%, 98.7%, 90.4% and 93.9% for extra-nodal assessment, respectively. Addition of STIR imaging resulted in sensitivity, specificity, PPV and NPV of 92.9%, 95.3%, 86.9% and 97.2% for nodal and 78.5%, 98.1%, 88% and 96,3% for extra-nodal assessment. Finally, the addition of DCE resulted in sensitivity, specificity, PPV and NPV of 85.7%, 97.4%, 85.7% and 97.4% for extra-nodal assessment. For reader 2, DWI alone the sensitivity, specificity, PPV and NPV was 87.5%, 97.6%, 93% and 95.5% for nodal and 68.9%, 95.5%, 74% and 94.3% for extra-nodal assessment, respectively. Additional STIR imaging increased the sensitivity, specificity, PPV and NPV to 88.1%, 98%, 94.2% and 95.7% for nodal and 82.1%, 95.6%, 76.6% and 96.8% for extra-nodal assessment. The addition of DCE resulted in sensitivity, specificity, PPV and NPV of 96.4%, 94.9%, 77.1% and 99.3% for extra-nodal staging. Post-consensus sensitivity, specificity, PPV and NPV was 90.4%, 98.4%, 95.5% and 96.6% for nodal assessment and 90%, 100%, 100% and 98.1% for extra-nodal assessment. For nodal assessment there were 5 perceptual errors (false negative [FN]=3, false positive [FP]=2) and 15 technical errors (FN=11, FP=4) whilst there were 2 false positive perceptual and 1 false positive technical errors for extra-nodal assessment. Cohen's kappa agreement for final Ann-Arbor staging between mpWBMRI and reference standard PET-CT was 0.9 (95%CI=0.8-1.0).

Discussion and Conclusion:

We demonstrate that despite being accurate for nodal assessment, the diagnostic performance of WB diffusion imaging is lower for assessment of extra-nodal involvement. The addition of STIR and DCE imaging improves extra-nodal disease assessment (figure 1). mpWBMRI offers a non-ionising alternative for staging of lymphoma with a performance similar to the gold standard of PET-CT. Our results support the prospective evaluation of mpWBMRI for staging of paediatric lymphoma.

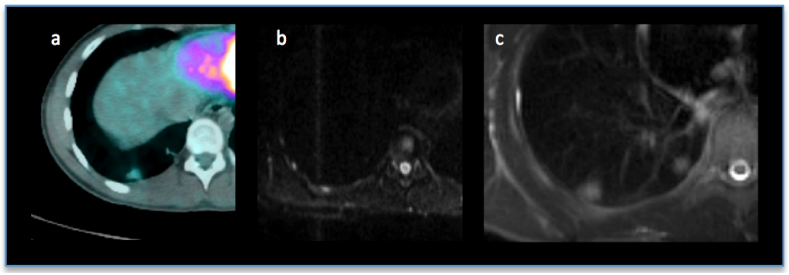

Figure 1: Right pulmonary involvement depicted on PET CT (a) that is not visible on DWI (b) but apparent on T2 STIR-HASTE (c).

References:

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