Whole body diffusion weighted MRI vs FDG-PET/CT in patients with suspected lung cancer

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Purpose

Lung cancer is the leading cause of cancer related death [1]. Accurate staging is mandatory to determine prognosis and select the most appropriate therapy. ¹⁸F-Fluorodeoxyglucose Positron Emission Tomography / Computed Tomography (PET/CT) is considered as standard of reference for preoperative assessment of non small-cell lung cancer (NSCLC) [2,3]. However, PET/CT is associated with a considerable radiation burden to patients and medical personnel. Magnetic Resonance Imaging (MRI) enables non-invasive whole-body assessment without ionizing radiation and creates high soft tissue contrast. A novel powerful source of contrast generation for MRI is diffusion weighted imaging with background signal suppression (DWIBS) [4]. The image contrast of DWIBS is based on the diffusion properties of water molecules and reflects cellular density and tissue architecture [5]. The objective of this study is to assess the diagnostic value of whole-body MRI with DWIBS in comparison to PET/CT for comprehensive preoperative assessment of NSCLC in a clinical setting. Data evaluation included primary tumor detection, T-staging, detection of individual lymph node metastases, N-staging, and UICC-staging with histopathology as reference standard.

Methods and Materials

Thirty-three patients with suspected NSCLC underwent PET/CT and whole body MRI before surgery. No therapy was performed between imaging and surgery. All procedures were in accordance with the ethical standards of the World Medical Association.

PET/CT exams were performed on an integrated PET/CT system with 16 slice CT. ¹⁸F-FDG was administered in a standard dose of 5 MBq per kg body weight (max. 500 MBq) 60 min before scan after a fasting period of minimum 6 hours. All patients received unenhanced low dose CT for attenuation correction. In patients without prior dedicated chest CT exam, additional contrast enhanced CT of the chest was performed. MRI exams were performed on a 1.5 T whole-body MRI scanner using a dedicated 18-channel coil array system. The used sequences were T1-weighted Turbo Spin Echo (TSE), T2-weighted Short Tau Inversion Recovery (STIR), and DWIBS (ss-EPI with STIR fat suppression, b=0 and 800 s/mm²) in transverse orientation. Total examination time was 30 min. All data were acquired during free breathing. No contrast agent was applied.

Staging was done by two board certified radiologists and nuclear medicine physicians according to the 7th edition TNM and UICC classifications [6]. Lymph node stations were divided into three groups for individual assessment: N1-nodes (ipsilateral intrapulmonary,
peribronchial and hilar nodes), N2-nodes (subcarinal nodes, ipsilateral mediastinal and paraaortic nodes), and N3-nodes (contralateral mediastinal and paraaortic nodes, and supraclavicular nodes). A group of lymph node stations was rated positive, if at least one lymph node was considered to be metastatic.

Overall accuracy was calculated for primary tumor detection, T-staging, N-staging, group-wise assessment of lymph nodes, and UICC-staging. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for primary tumor detection and assessment of lymph node groups. Observer agreement rates were calculated as percentages of actually observed agreement. Statistical significance of differences between PET/CT and MRI was tested using the McNemar test. A p value of less than 0.05 was considered statistically significant.

**Results**

Whole-body MRI with DWIBS as well as PET/CT provided diagnostic image quality in all cases. The typical appearance of a primary pulmonary tumor in PET/CT and MRI images is shown in figure 1. A sample case of N2 nodal disease as detected by PET/CT and MRI is displayed in Figure 2.

Sensitivity, specificity, accuracy, PPV and NPV for primary tumor detection were 93%, 50%, 89%, 95% and 42% for MRI and 98%, 33%, 92%, 93% and 75% for PET/CT. Three patients were diagnosed negative for lung cancer by histology. Two patients were diagnosed with malignant pathology of non-pulmonary origin (1 lymphoma, 1 colon cancer metastasis) and were thus excluded from further statistical evaluation. Sensitivity, specificity, accuracy, PPV and NPV for metastatic involvement of individual lymph node groups were 44%, 93%, 85%, 61% and 89% for MRI and 47%, 96%, 88%, 71% and 90% for PET/CT. Staging accuracies for T-stage, N-stage and UICC-stage were 63%, 66% and 66% for MRI and 56%, 71% and 74% for PET/CT. A schematic overview on tumor detection and staging accuracies for both modalities is given in Figure 3. Observer agreement rates were 52% for T-Staging, 68% for N-Staging, and 74% for UICC-staging with MRI compared to 65%, 68% and 90% with PET/CT. Comparison of methods by McNemar test revealed no statistically significant differences between MRI and PET/CT for any of the calculated measures.

**Images for this section:**
Fig. 1: Sample case of a 45-year-old man with basaloid large cell carcinoma stage pT3 pN2 (UICC IIIA). Original PET image (a) and inverted grey-scale high b-value diffusion weighted MRI image (e) display the primary tumor in the left upper lobe with high contrast against the background and the central cavity. CT images in soft tissue (b) and lung window (d) as well as fat-suppressed T2-weighted MRI images (f) serve to delineate the anatomic margins of the tumor and assess invasion of chest wall or mediastinum (not present in this case). Standardized uptake values derived from (a) and ADC values (h) serve as quantitative measures for tissue characterization by means of glucose metabolism or cellular density, respectively. Fusion datasets (c, g) from black and white CT or MR images and color coded PET or DWI data facilitate final visualization of findings.
Fig. 2: Sample case of a 76-year-old woman with UICC stage IIIA (pT1b pN2) adenocarcinoma. Hilar and subcarinal lymph node metastases (arrows) are clearly identified by high signal in PET (a) and high b-value diffusion weighted MRI (d). CT images in soft tissue window (b) and fat-suppressed T2-weighted MRI images (e) show the morphological extent of lymphadenopathy. Combined morphological and functional information is rendered by PET/CT (c) and T1w/DWI (f) fusion images. The structure indicated by the arrowheads is a peripheral cross section of the primary tumor in the right lower lobe.
**Fig. 3:** Figure 3: Schematic overview on tumor detection and staging accuracies for MRI and PET/CT. The error bars represent 95% confidence intervals.
Conclusion

This study has shown in agreement with previous studies that whole-body MRI with DWIBS is a powerful method for staging of NSCLC and provides results comparable to the reference standard PET/CT. Thus, whole-body MRI with DWIBS may qualify as first line modality for staging of NSCLC when PET/CT is not available. As opposed to other authors [7,8], we are not yet convinced that there is a clear evidence of a superiority of DWI with respect to lymph node assessment. We agree that the method of diffusion weighted MRI has two intrinsic technical advantages over FDG-PET which are spatial resolution and soft tissue contrast. However, this potential has not been exploited to its full extent by today's routinely available applications. There is need for further technical improvement of both diffusion weighted and conventional MRI sequences for optimized morphological and functional assessment of pulmonary and mediastinal structures. By this MRI with diffusion weighting may finally succeed to overcome the two most relevant challenges in staging of NSCLC which are correct assessment of higher T-stages and sensitivity for small lymph node metastases.

References


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