

Case Reports:

Tumor Detection by Diffusion-Weighted MRI and ADC-Mapping with Correlation to PET/CT Results

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The early and correct estimation of metastatic spread is essential for a patient-specific and efficient therapy regime. Therefore knowledge of total tumor load, extent of lymph nodes and distant metastases as well as potential threats e.g. infiltration of vertebral body with high risk of fracture, is required. During recent years significant efforts have been undertaken to improve the detection of metastases – either by spiral multi-slice computed tomography (CT) or magnetic resonance imaging (MRI). By providing best soft tissue contrast compared to CT, high-resolution whole-body (wb) MRI proved itself as a powerful tool in oncology [1, 2, 3]. However, detection of metastases and therapy monitoring with wbMRI is mainly based on morphological changes. Integration of metabolic data (acquired e.g. by MR spectroscopic imaging) and functional information (e.g. dynamic contrast enhanced scans) is potentially possible with MRI, but due to time constraints these methods could prove its clinical impact only in dedicated applications e.g. detection of prostate cancer within the prostatic gland and cannot easily be implemented in wbMRI so far. The amount and complexity of wbMRI data also hampers the widespread use of this technique in clinical routine. Positron emission tomography (PET) with an integrated CT scanner (PET-CT) provides combined morphological and

metabolic information. Compared to wbMRI, however, PET-CT is associated to x-ray exposure and the tracer production, transport and its application are more labor- and cost intensive. Sensitivity and specificity of PET-CT and examinations depends also on tumor type, applied tracer and tissue of interest. Therefore, the selection of the appropriate staging modality is highly dependent on histology and the pattern of metastatic spread [4]. However, cancer is not only characterized by pathologic metabolism e.g. high glucose uptake; also higher cellularity and therefore restriction of water diffusion have also been found to be common features of tumors. Diffusion-weighted imaging (DWI) with high b-values has therefore been applied for imaging metastasis. However, comparisons of DWI with other imaging modalities and with special focus on wbPET/CT are not widely available. In the following two case reports, results of MRI and wbDWI are compared to 18F-FDG PET/CT findings.

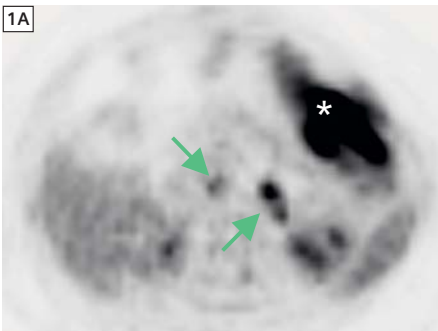
Imaging techniques

CT was conducted with application of intravenous contrast agent (Ultravist 370, Schering AG, Germany) and oral administration of negative contrast dispersion as multi-phase protocols [7]. All PET-CT scans were performed on a single dual modality scanner (Biograph

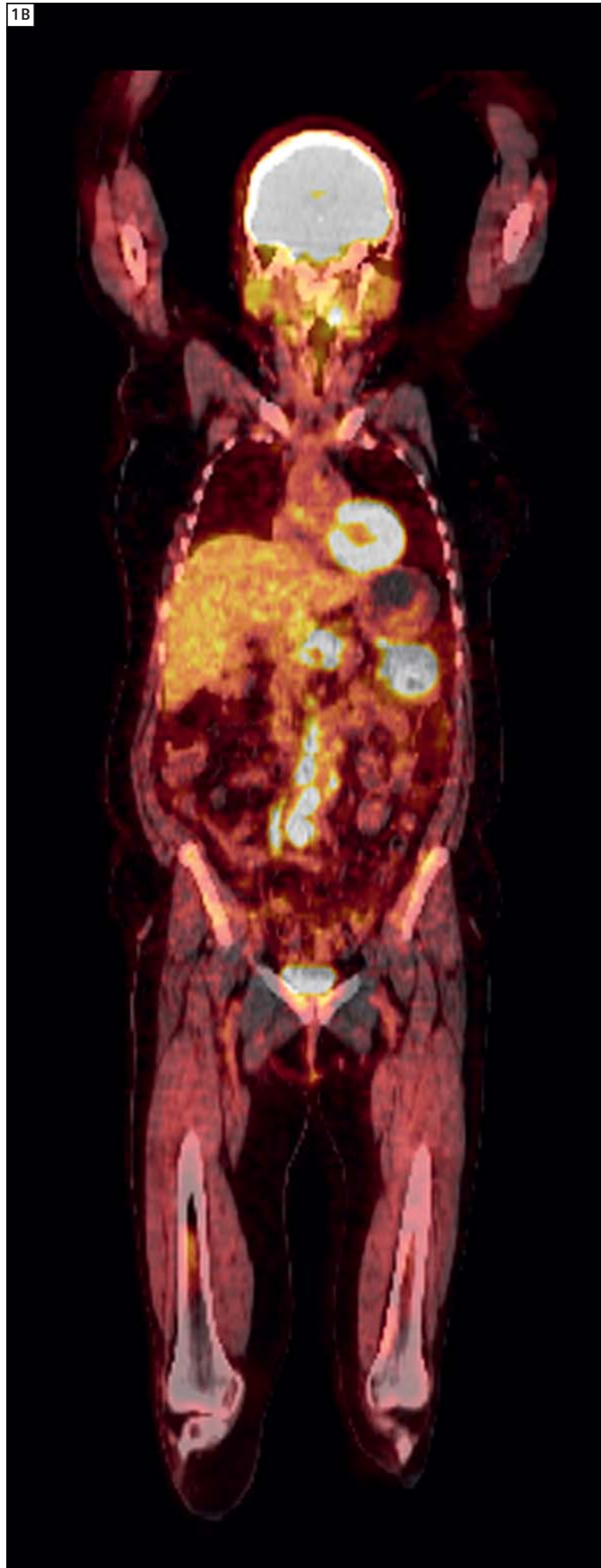
16, Siemens Medical, Knoxville, USA) consisting of a 16-row multi-slice CT system (minimal rotation time of 0.5 sec) and a full ring lutetium oxortho-silicate (LSO) PET. WbMRI and DWI were performed on a 1.5 Tesla MR tomography with 32 receiver channels (MAGNETOM Avanto, Siemens Medical, Germany). For (wb) DWI application, a single-shot echo-planar-imaging (EPI) sequence with diffusion-module and fat-suppression-pulse was used (*syngo* REVEAL). This sequence has the ability for navigator-based respiratory triggering (PACE). For respiratory-triggered DWI sequence, data was acquired in expiration. In case of non-triggering, the patient was breathing freely. Water diffusion was measured with a 3-scan-trace technique and b-values of 0, 400 and 1000 s/mm²; apparent diffusion coefficient maps were generated automatically (*syngo* Inline Diffusion). Sequence parameters of the single-shot echo-planar-imaging (EPI) sequence with diffusion-module and fat-suppression-pulse used in these two cases were: TR / TE 3900 (1500 for non-triggered DWI) / 76 ms, slice thickness 4 mm, FOV 380 x 380, 192 Matrix, EPI factor of 192, 4 averages, PAT factor of 2 (*syngo* GRAPPA), resulting voxel size 2 x 2 x 4 mm³, TA 1:52 (non-triggered, 30 slices; for triggered DWI depending on respiration cycle TA approximate 5 min).

Case 1: Malignant Melanoma

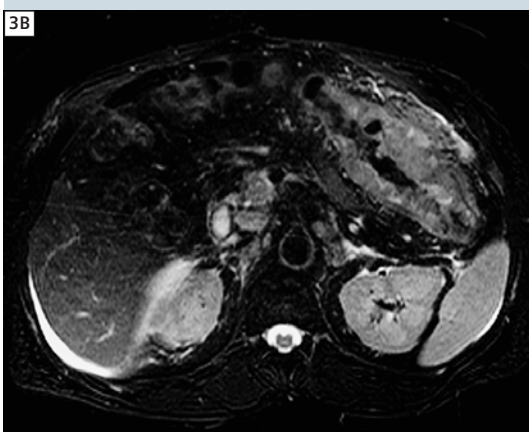
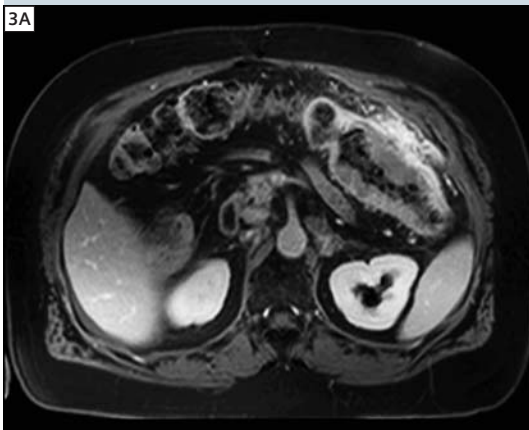
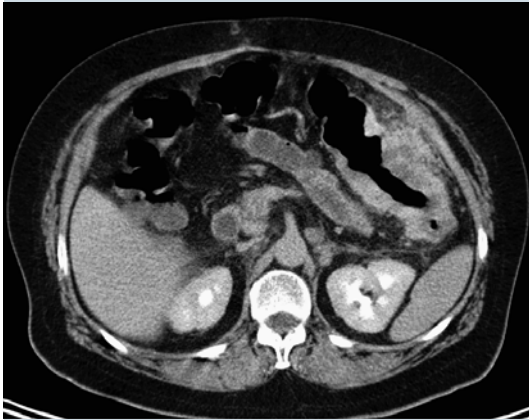
This case shows the results of wbPET/CT and wbMRI including DWI of a female patient with an advanced malignant melanoma (stage IV). The DWI sequences were able to visualize even the extensive tumor spread within the bowel wall as well as lymph node metastasis in detail. All suspicious lymph nodes as well as the diffuse tumor infiltration of the bowel wall are characterized by a high restriction of water diffusion (compare with ADC map). However, the extension of this advanced melanoma and therefore the irresectability is already proven with the standard contrast-enhanced single-phase CT scan. However, comparing the thick-slice MIP of the inverted original $b=1000 \text{ s/mm}^2$ DWI images, providing a "PET-like" image, with the corresponding PET image it is clearly shown that the resolution of the DWI here is clearly superior to the PET image and lymph node metastases and bowel infiltration are well delineated. However, fat-suppressed, contrast enhanced T1w and fat-suppressed T2w MRI are also able to display all metastases. While the ADC-map is essential to differentiate real restriction of diffusibility from T2-shine-through artifacts, this image cannot be used for a fast assessment of tumor spread. However, original b-value images especially at $b=1000 \text{ s/mm}^2$ are characterized by suppression of all healthy tissue with exception of the spleen and clearly elevated signal intensity of the metastases.



1 A: Corresponding original attenuation-corrected PET image (*bowel infiltration, arrows lymph node metastases).

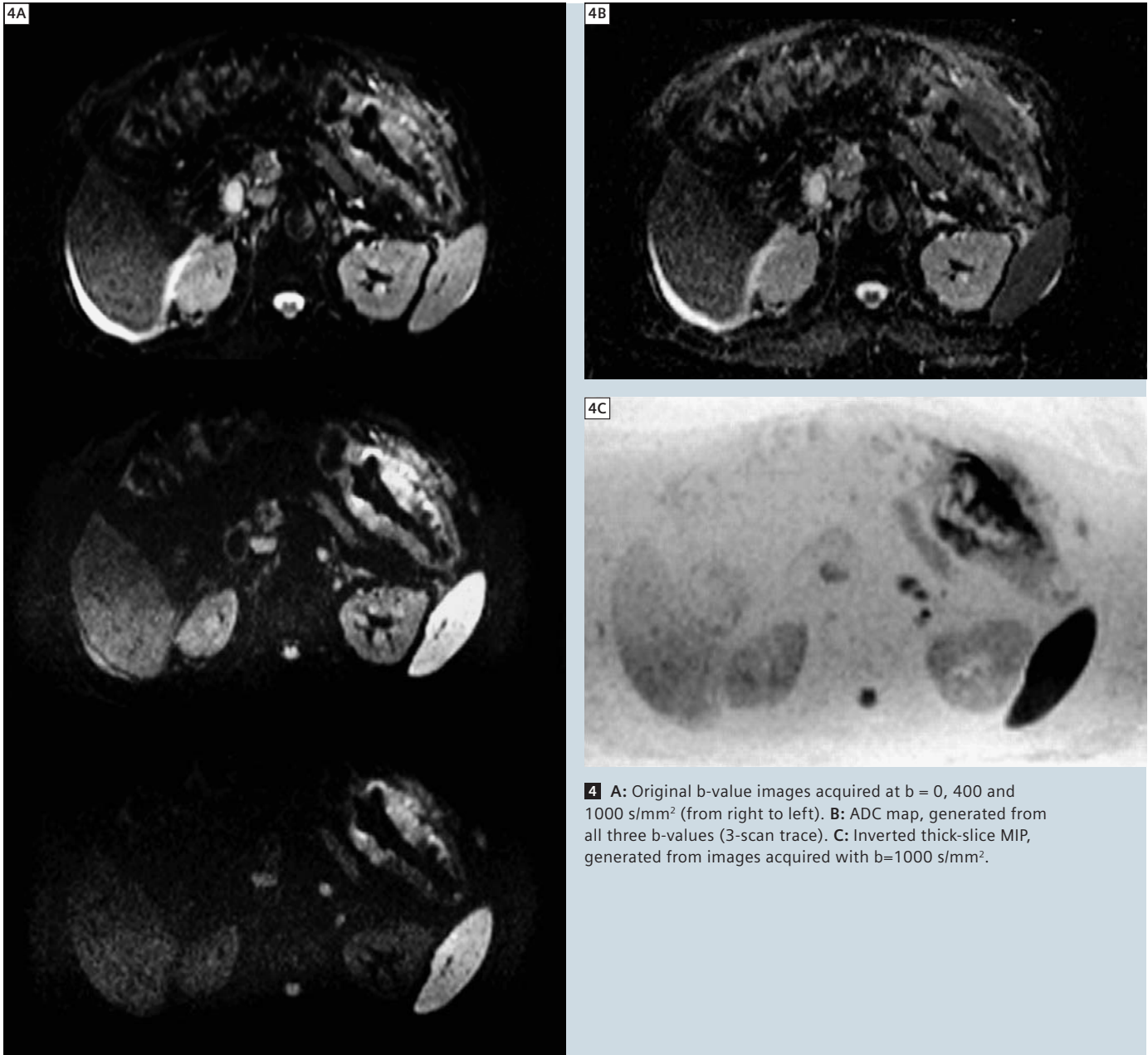


1 B: Fused ^{18}F -FDG PET/CT demonstrating multiple paraortic metastases and diffuse bowel infiltration of a malignant melanoma (stage IV).



2 Corresponding single-phase CT scan (acquired during PET/CT scan).

3 **A:** Contrast-enhanced T1w 2D Flash MRI (breathhold). **B:** T2w TSE with spectral fat-suppression (free breathing, triggered with PACE). **C:** Composed whole-body T2 TIRM.

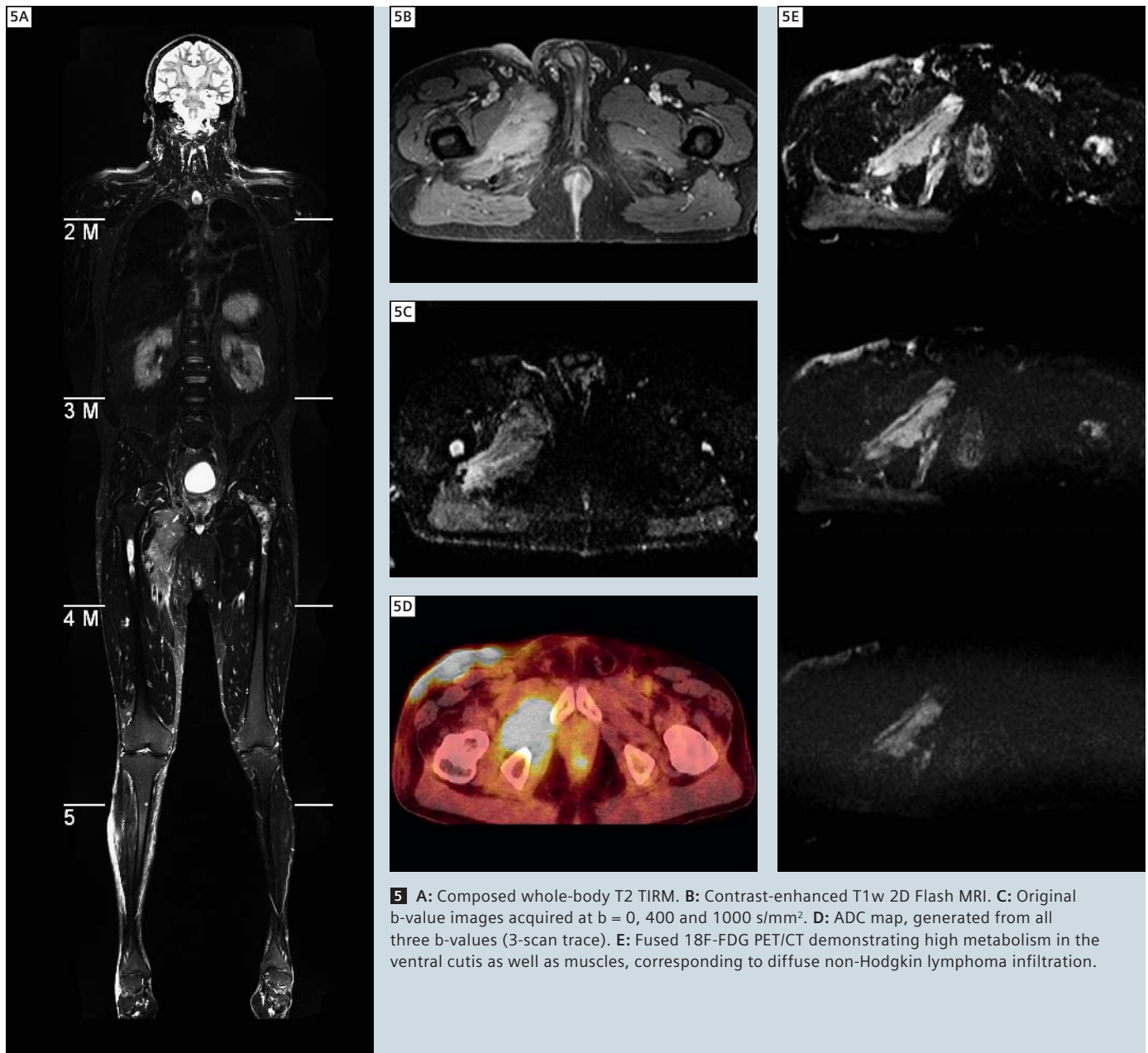


Case 2: Non-Hodgkin Lymphoma

In this case, the results of PET-CT and DWI examination of a male patient with a non-Hodgkin lymphoma are shown. PET-CT with ^{18}F FDG revealed a diffuse tumor infiltration of the muscles and also of the right ventral skin of the right thigh. High b-value imaging was able to visualize diffuse tumor infiltration in detail even of the cutis. However, if one had to rely only on a single b-value

image, in this case a clear differentiation of restriction of diffusibility from potential insufficient spectral fat suppression would be problematic and therefore hamper the correct diagnoses. Muscle atrophy of the right gluteal muscle results in restriction of water mobility, too, and also a pathologic signal of the femoral bone marrow is obvious at $b = 0$ and 400 s/mm^2 values. ^{18}F FDG uptake was not

suspicious, either in the bone marrow or in the atrophic muscles, but based on MRI tumor could not be ruled out. The ADC-map also shows unexpectedly high ADC-values in the muscles with high tracer uptake compared to the atrophic gluteal one. Atrophy of the right gluteal muscles is also obvious on fat-suppressed T2w and contrast-enhanced, fat-suppressed T1w MRI.



5 **A:** Composed whole-body T2 TIRM. **B:** Contrast-enhanced T1w 2D Flash MRI. **C:** Original b-value images acquired at $b = 0, 400$ and 1000 s/mm^2 . **D:** ADC map, generated from all three b-values (3-scan trace). **E:** Fused ^{18}F -FDG PET/CT demonstrating high metabolism in the ventral cutis as well as muscles, corresponding to diffuse non-Hodgkin lymphoma infiltration.

References

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