

Body Diffusion Experience with Over 600 Patients

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Introduction

Diffusion MR imaging has been up to now used mostly in the head. By detecting water motion over small distances, it is now routinely performed and enables the diagnoses of an acute stroke*.

In our institution, we have been very interested in the potential of the technique applied to imaging of the body, pelvis and organs other than the brain. Indeed, there have been several reports in the literature that diffusion MRI in the body can indicate the malignancy of lesions.

Methods

There are today many discussions about technical aspects regarding the optimal way to perform body diffusion. Our institution works with a MAGNETOM Avanto and we have been performing body diffusion using a single-shot EPI sequence with a PAT factor of 2.

Initially, we performed free-breathing and respiratory triggered scans to compare them. Now, however, respiratory triggering is mainly used. The parameters of the free-breathing scan are as follows: TR of 3500 ms, TE of 65 ms, slice thickness of 5 mm, 128 x 64 matrix with zero-fill interpolation, 40 slices, and scan time of 3:30 minutes. The parameters of the triggered scan are as follows: respiration cuff placed on the abdominal wall, TR of 1500 ms, TE of 65 ms, slice thickness of 5 mm, 128 x 64 matrix with zero-fill interpolation, 12 slices, and scan time of 3-4 minutes depending on the patient's breathing.

Low (50) and high (1000) diffusion b-values are typically investigated.

The total time for an examination of a specific anatomical segment is 15-20 minutes. A whole abdominal examination consists of T1-weighted, T2-weighted and diffusion-weighted images and can be done in the same period of time. Slice thickness of DWI is usually 6 mm.

* The information about this application is preliminary. The application is under development and is not commercially available in the U.S., and its future availability cannot be ensured.

The information presented in these case studies is for illustration only and is not intended to be relied upon by the reader for instruction as to the practice of medicine. Any health care practitioner reading this information is reminded that they must use their own learning, training and expertise in dealing with their individual patients. This material does not substitute for that duty and is not intended by Siemens Medical Solutions to be used for any purpose in that regard.

Clinical Cases

Case 1: 58-year-old male with lung cancer (squamous cell carcinoma)

The T2-weighted image showed a mass lesion in the left lower lobe (LLL) adjacent to the pleura with a small amount of pleural effusion (Fig. 1). The mass was shown as a mixed high signal area on the STIR image (Fig. 2). With diffusion imaging, the corresponding area showed a ring-like high signal intensity on DWI with $b = 1000$ (Fig. 3) and very low signal intensity on ADC map (Fig. 4). These DWI findings helpfully suggested that the lesion was a lung cancer.

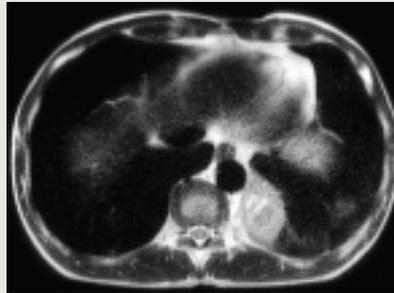


Figure 1 T2-weighted image

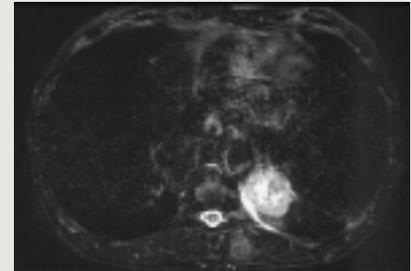


Figure 2 Short TI Inversion Recovery – STIR image

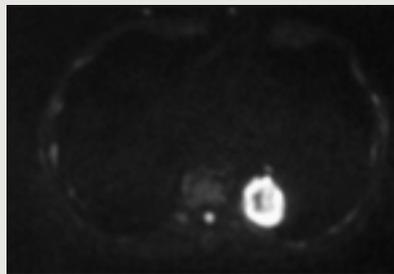


Figure 3 Diffusion-weighted image – DWI ($b = 1000$)

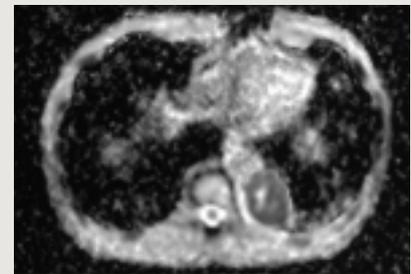


Figure 4 ADC map

Case 2: 70-year-old male with chronic empyema with chest pain

There was a left chronic empyema with a pleural mass lesion (Figs. 1-3). The empyema showed high signal on both T1-weighted image and T2-weighted. The pleural mass showed low signal on T1-weighted, high signal on T2-weighted and very well enhanced on the post-enhanced image; these features were compatible with malignant lymphoma. In diffusion imaging (Figs. 4, 5), while both the empyema and the mass showed high signal on DWI with $b = 50$, only the mass showed high signal on DWI with $b = 1000$. Additional metastatic nodules can be seen on DWI. With these findings from diffusion images, we came to the conclusion that the mass was of malignant origin. Further tests confirmed the diagnosis of Non-Hodgkin lymphoma.

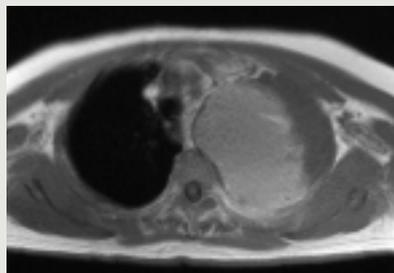


Figure 1 T1-weighted image

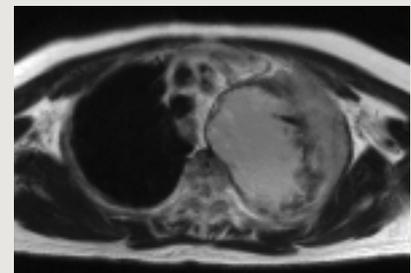


Figure 2 T2-weighted image

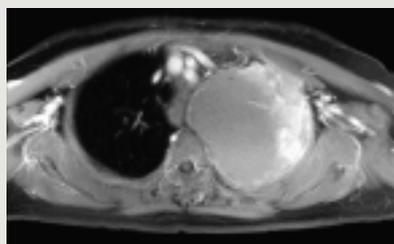


Figure 3 Post-enhanced image

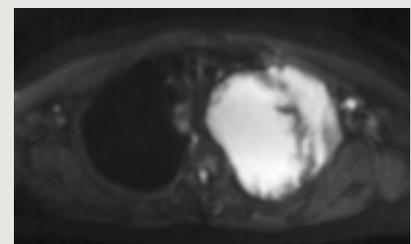


Figure 4 Diffusion-weighted image – DWI ($b = 50$)

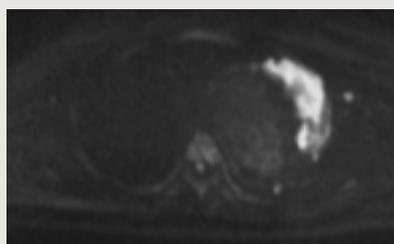


Figure 5 Diffusion-weighted image – DWI ($b = 1000$)

**Case 3:
58-year-old male with
hepatocellular carcinoma
(HCC) after lipiodol TAE
(Trans Arterial Embolization)**

Figures 1-4 show a round hepatic mass with a capsule in the right lobe. The mass showed high signal on the fat suppressed (FS) T1-weighted; this finding was compatible with HCC after lipiodol TAE. A bizarre recurrent tumor was seen adjacent to the mass. In dynamic study (Figs. 5-8), the recurrent mass showed gradual enhancement pattern, proving to be poorly differentiated adenocarcinoma. An intrahepatic metastatic tumor in the left lateral segment also showed gradual enhancement. DWIs with $b = 1000$ (Figs. 9, 10) clearly show the recurrent tumor and intrahepatic metastatic tumor as bright lesions, as well as residual viable component in the primary lesion.

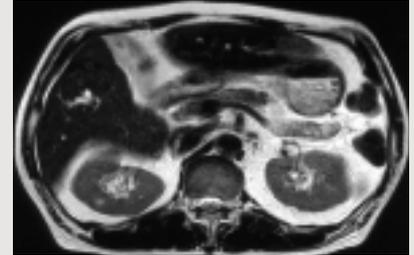
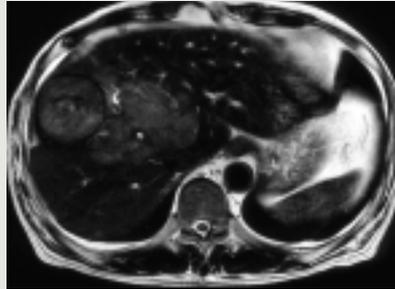


Figure 1, 2 T2-weighted images

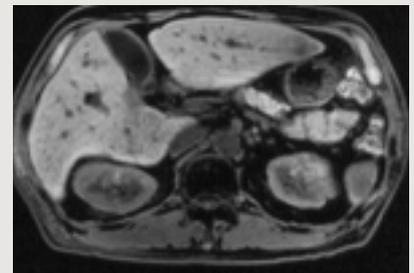
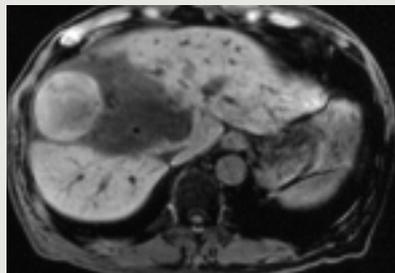


Figure 3, 4 Pre-contrast 3D VIBE (Volume Interpolated Breathhold Examination) with fat saturation.

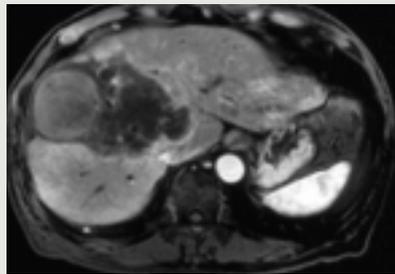


Figure 5, 6 Early phase of dynamic study (3D VIBE with fat saturation).

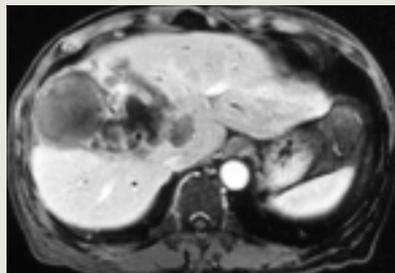


Figure 7, 8 Delayed phase of dynamic study.

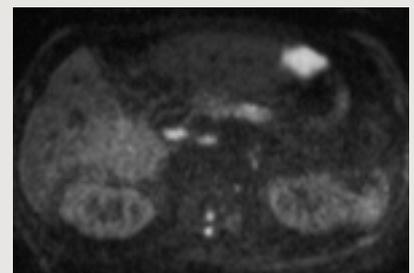
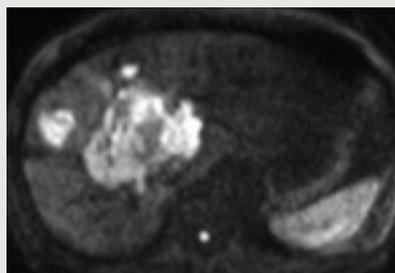


Figure 9, 10 Diffusion-weighted image – DWI ($b = 1000$)

**Case 4:
35-year-old male with renal cell carcinoma**

Figures 1-3 show a round mass with a capsule in the lower pole of the left kidney, which showed mild enhancement after administration of contrast medium. The lesion showed very high signal on DWI (b = 1000), proved to be renal cell carcinoma (Fig. 4). There was no evidence of metastasis. Our experience has shown that DWI eliminates the need for contrast medium in evaluation of primary and metastatic tumors in such patients.



Figure 1 T1-weighted image



Figure 2 T2-weighted image

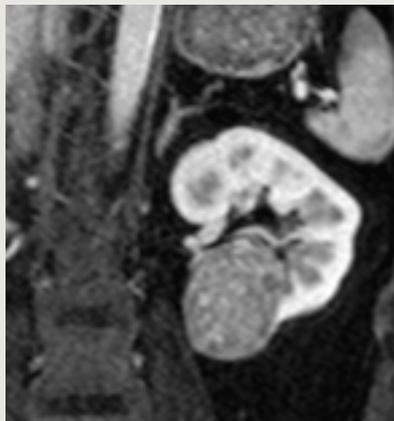


Figure 3 Post-enhanced 3D VIBE (Volume Interpolated Breathhold Examination) with fat saturation.

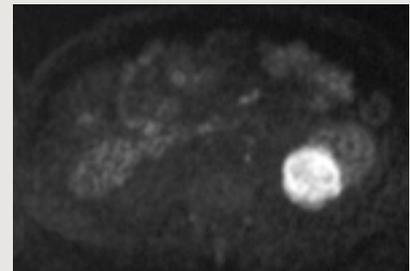


Figure 4 Diffusion-weighted image – DWI (b = 1000)

**Case 5:
39-year-old female with left
ovarian tumor**

Figures 1-4 show a round mass lesion in the left adnexa with various components including fat; proving to be ovarian dermoid. The high-signal component within the mass was consistent with the epidermoid component shown on DWI ($b = 1000$), and the finding of a high-signal component in the right ovary was consistent with hemorrhagic cyst (Figs. 5-7). A benign lesion such as epidermoid and hemorrhagic cyst shows bright signal on DWI due to its viscosity and/or density, so this is a diagnostic pitfall. Abnormal protrusion of the endometrium that can be seen in the right uterine wall as a bright structure, proves to be endometrial carcinoma. From the findings that the metastatic nodules in the right adnexa showed high signal on DWI but low signal on T2-weighted, and the endometrial carcinoma showed high signal on DWI (Fig. 8, $b = 3000$), it is suggested that advanced endometrial carcinomas could easily be missed without DWI.

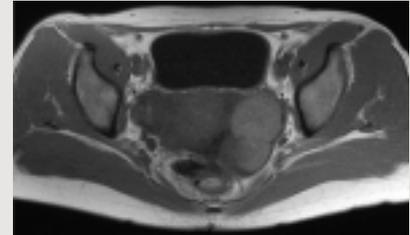
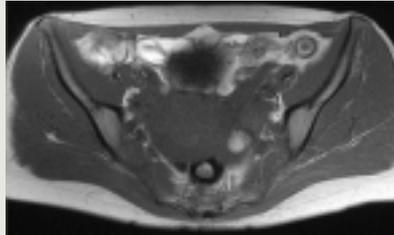


Figure 1, 2 T1-weighted images

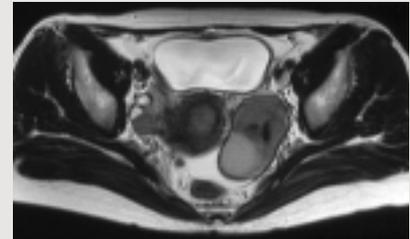
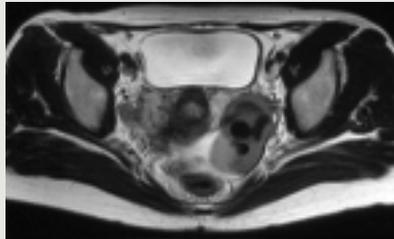


Figure 3, 4 T2-weighted images

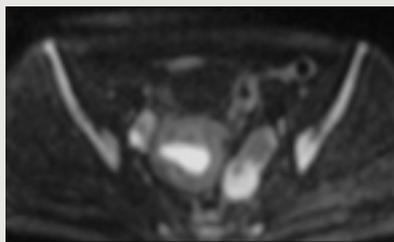
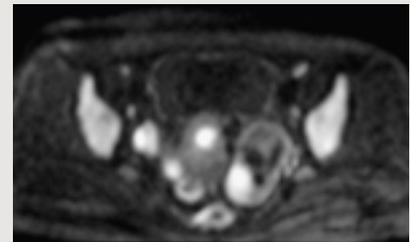
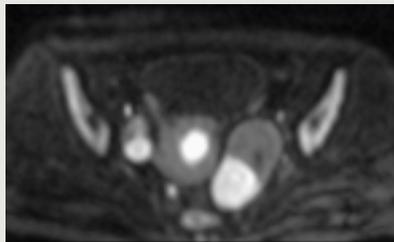


Figure 5-7 Diffusion-weighted images – DWI ($b = 1000$)

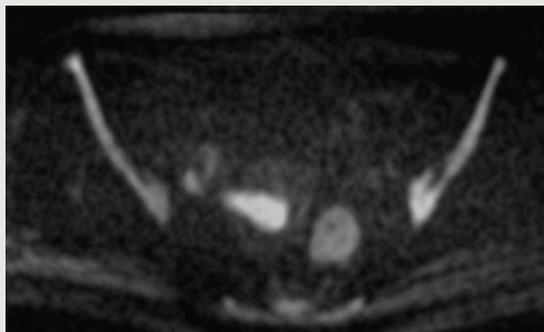


Figure 8 Diffusion-weighted image – DWI ($b = 3000$)

Case 6:
36-year-old female whose PAP smear result was Class V

There were no remarkable malignant tumors in the uterus, but a huge intramural myoma was seen on sagittal images (Figs. 1-4). Careful observation of the DWI ($b = 1000$) showing a bright region in the uterine cervix (Fig. 5) revealed that a cervical cancer in the portio vaginalis has been missed on the sagittal FS TrueFISP image.

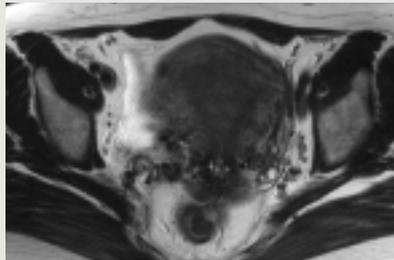


Figure 1 *T1-weighted image*

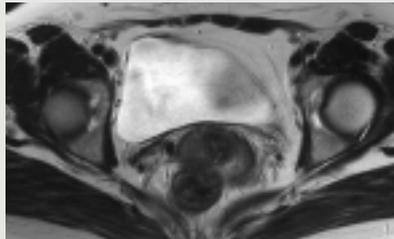


Figure 2, 3 *T2-weighted images*



Figure 4 *TrueFISP (Fast Imaging with Steady Precession) with fat saturation.*

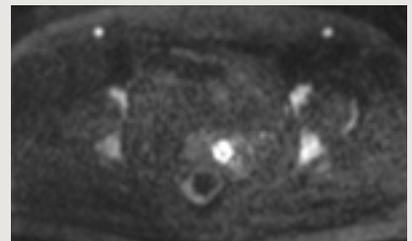


Figure 5 *Diffusion-weighted image – DWI ($b = 1000$)*

Case 7:
50-year-old female, post-operative state of ovarian cancer, with an elevated tumor marker level

There was no remarkable evidence of recurrent tumors on T2-weighted and FS CE T1-weighted (Figs. 1, 2), but multiple recurrent iliac lymphadenopathies were seen on DWI with $b = 1000$ (Fig. 3). Fusion images of T2-weighted and DWI (Figs. 4, 5) were useful in grasping the anatomical distribution of the lesions.

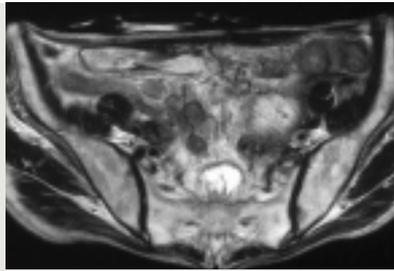


Figure 1 T2-weighted image

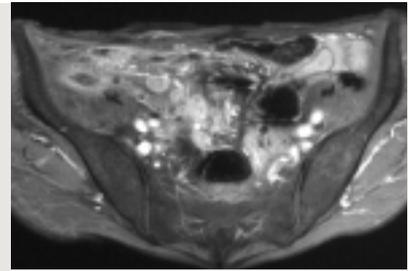


Figure 2 Contrast-enhanced T1-weighted image with fat saturation.

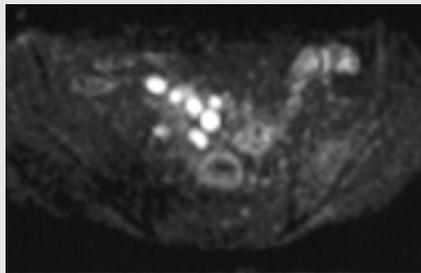


Figure 3 Diffusion-weighted image – DWI ($b = 1000$)

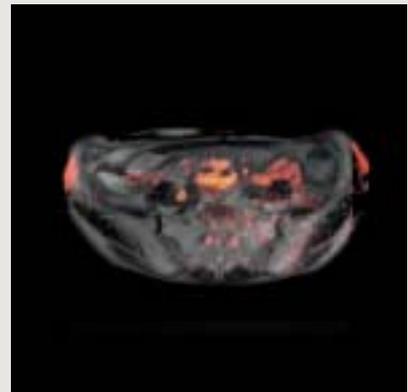
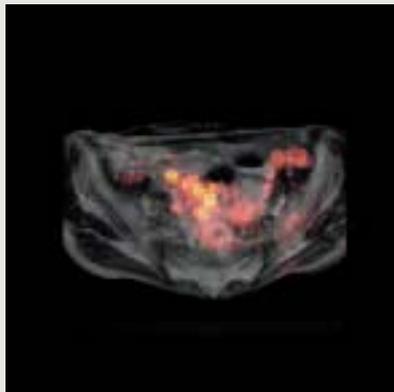


Figure 4, 5 Fusion images.

Case 8:
76-year-old male with bladder cancer

Thickening of the right wall of the urinary bladder can be seen on EPI-T2-weighted (Fig. 1, $b = 0$). There are high and low signal components in the lesion on DWI (Fig. 2, $b = 1000$); the former corresponds to malignant tumor and the latter to reactive inflammatory process. The bright spots on bilateral iliac walls are normal lymph nodes, proved by their symmetrical spherical shapes and typical location.

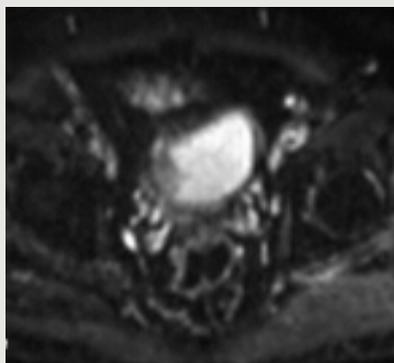


Figure 1 T2-weighted Echo Planar Image (EPI) ($b = 0$)

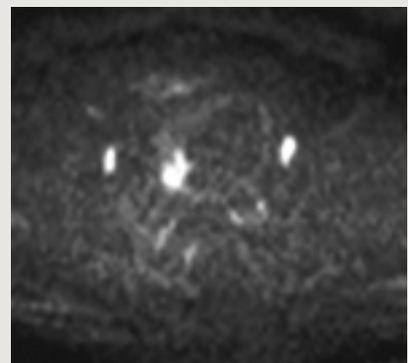


Figure 2 Diffusion-weighted image – DWI ($b = 1000$)

**Case 9:
56-year-old male with
prostate cancer**

A low-signal mass in the inner gland of the prostate was seen on T2-weighted (Fig. 1). With DWI (b = 1000), the mass showed bright signal but the normal peripheral zone of the prostate was also bright (Fig. 2). On DWI with higher b value (b = 3000) shown in Figure 3, only the mass that showed bright signal, proving to be prostate cancer.

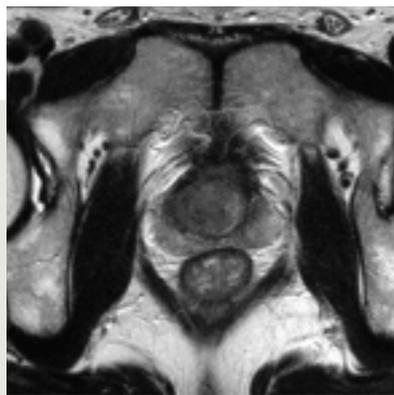


Figure 1 T2-weighted image

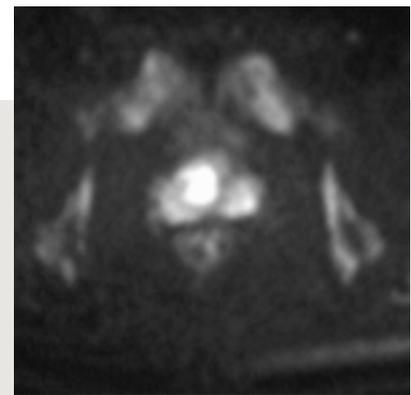


Figure 2 Diffusion-weighted image – DWI (b = 1000)

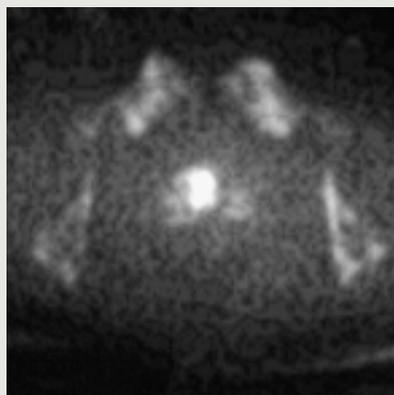


Figure 3 Diffusion-weighted image – DWI (b = 3000)

**Case 10:
67-year-old male with
recurrence of rectal cancer**

Extensive post-operative change in the presacral region was seen on T2-weighted (Figs. 1-3). It was difficult to determine the presence of a recurrent tumor on these images, but DWIs (b = 1000) clearly revealed the recurrent tumor (Figs. 4, 5).



Figure 1-3 T2-weighted images

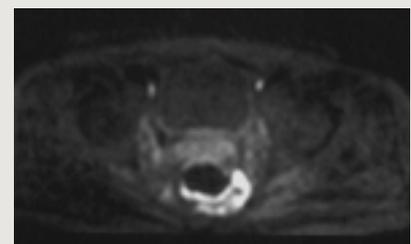
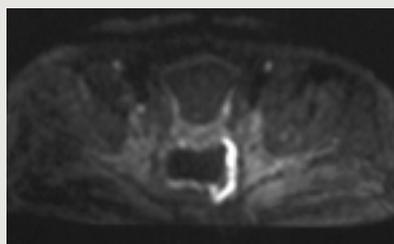
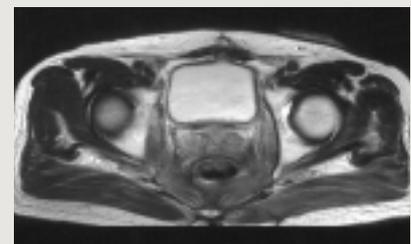
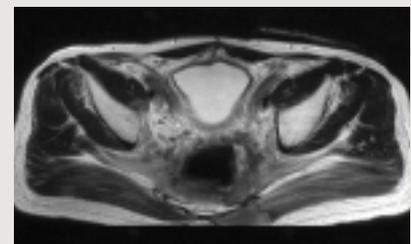


Figure 4, 5 Diffusion-weighted images – DWI (b = 1000)

Case 11:
39-year-old female with rectal cancer accompanied by liver metastasis

Rectal wall thickening and multiple liver nodules were seen on SPIO-T2-weighted (Figs. 1-4), but it was unclear whether the lesions were malignant. SPIO-DWIs (b = 1000) showed high signal in the corresponding lesions, revealing that they were malignant tumors (Figs. 5-8). Regional lymphadenopathy around the rectum can also be seen on DWI.

SPIO, short for small particle iron oxide or superparamagnetic iron oxide. Used as darkening contrast agent for liver imaging.

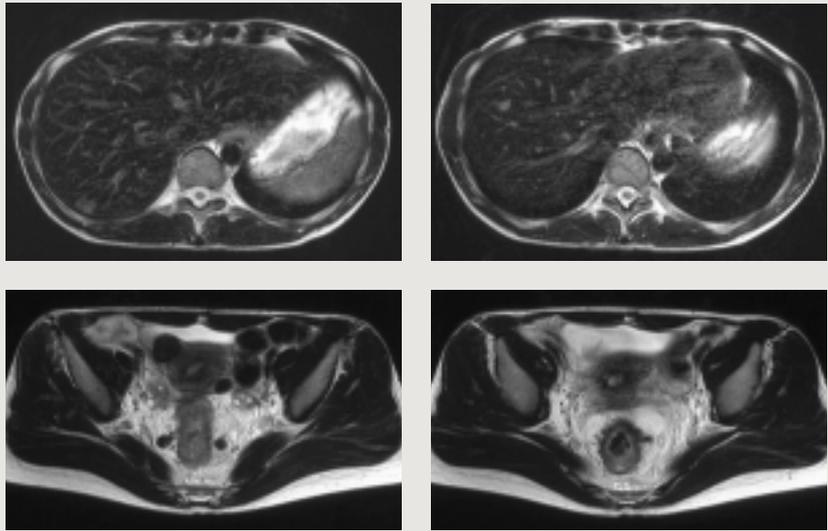


Figure 1-4 SPIO T2-weighted image

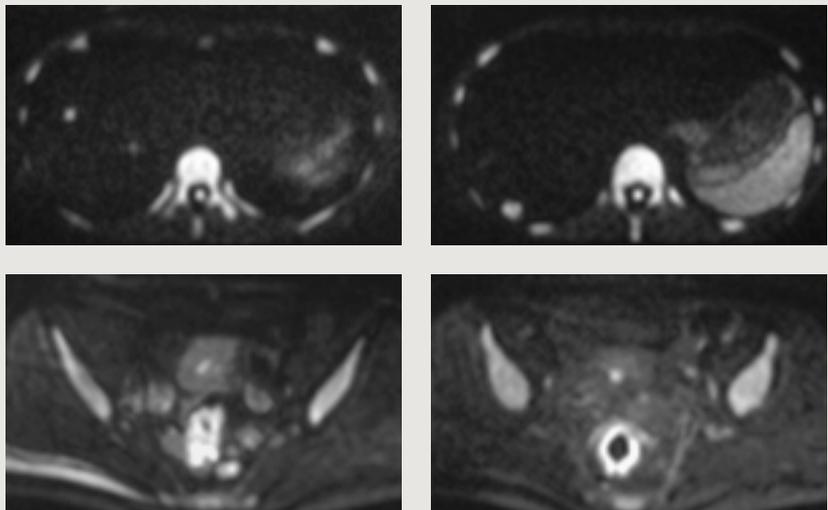


Figure 5-8 SPIO diffusion-weighted images – DWI (b = 1000)

**Case 12:
70-year-old male with recur-
rence of rectal cancer**

PET image showed mild uptake behind the urinary bladder (Fig. 1). There was an enhancing mass adjacent to the rectum (Figs. 2, 3), which showed high signal on DWI (b = 1000), turning out to be local recurrence (Fig. 4). Fusion image of contrast enhanced 3D VIBE and DWI (b = 1000) (Fig. 5) was useful in identifying the lesion.

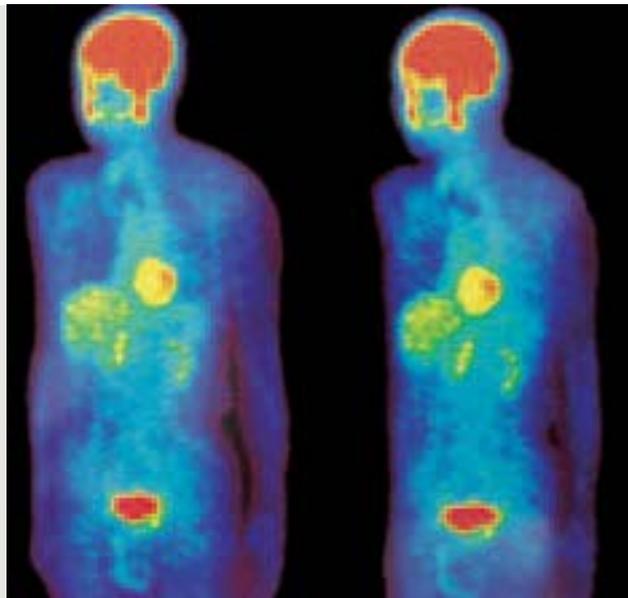


Figure 1 PET image (Positron Emission Tomography)

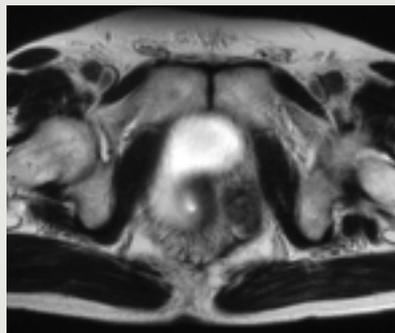


Figure 2 T2-weighted image

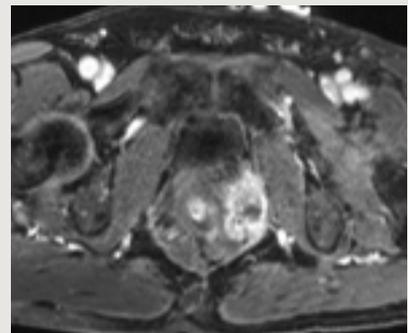


Figure 3 Post-enhanced 3D VIBE (Volume Interpolated Breathhold Examination) with fat saturation.

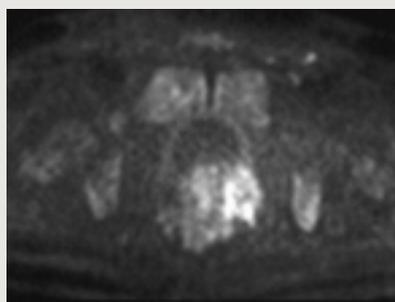


Figure 4 Diffusion-weighted image – DWI (b = 1000)

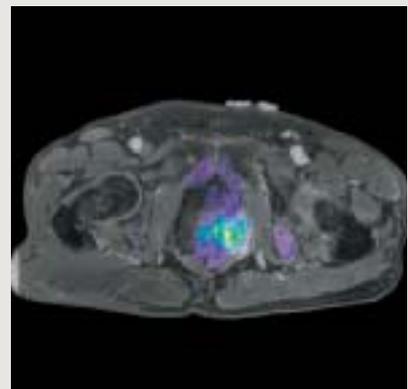


Figure 5 Fusion image.

Conclusion

The single-shot EPI with iPAT and CHES fat suppression on MAGNETOM Avanto has produced very satisfactory body diffusion results.

Therefore, in Jikei University, we currently perform a body diffusion scan for all body patients. This adds only 3:30 min to the entire examination and has proven very useful for the detection of primary as well as metastatic malignant tumors, differentiation between benign and malignant tumors, and differentiation between post-operative inflammatory changes and recurrences. DWI significantly reduces the need for intravenous administration of contrast medium in evaluation of malignancies. Weighing up these features of DWI, we think that DWI should be performed to obtain additional useful information in detailed body examinations.