New MRI approaches in myeloma

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Plan

- Whole-Body MR imaging
- Biological aspects
- DCE MR imaging
- Whole Body DCE WB MR imaging
- Whole Body DWI imaging

MRI in Myeloma

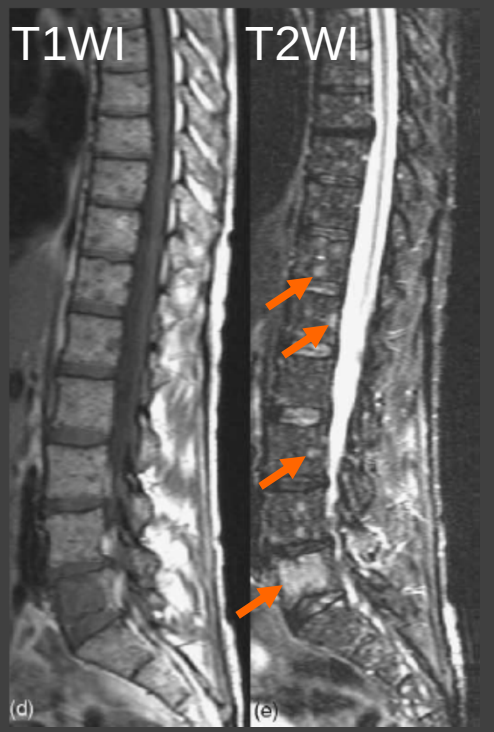
- Standard MRI – direct, high contrast visualization of bone marrow: best imaging technique for detection

61y female patient

?

Durie/Salmon 1975

Durie/Salmon *PLUS* 2006



Rahmouni et al. AJR 1993,
Baur-Melnyk A et al. *EJR* 2005

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Myeloma, biological aspects

1. Myeloma cells produce angiogenic cytokines (VEGF…) inducing bone marrow neovascularization

   Vacca A et al. *Blood* 1999; 3064-3073

2. Parameters of angiogenesis on bone marrow biopsy : Microvessel density (MVD) and total vascular area
   - Higher in MM patients than controls ($p < 0.001$)
   - Higher in nonresponders than complete responders ($p < 0.001$)

   Bhatti SS et al. *Am J Hematol* 2006;81:649-656

3. MVD density: independent prognostic factor

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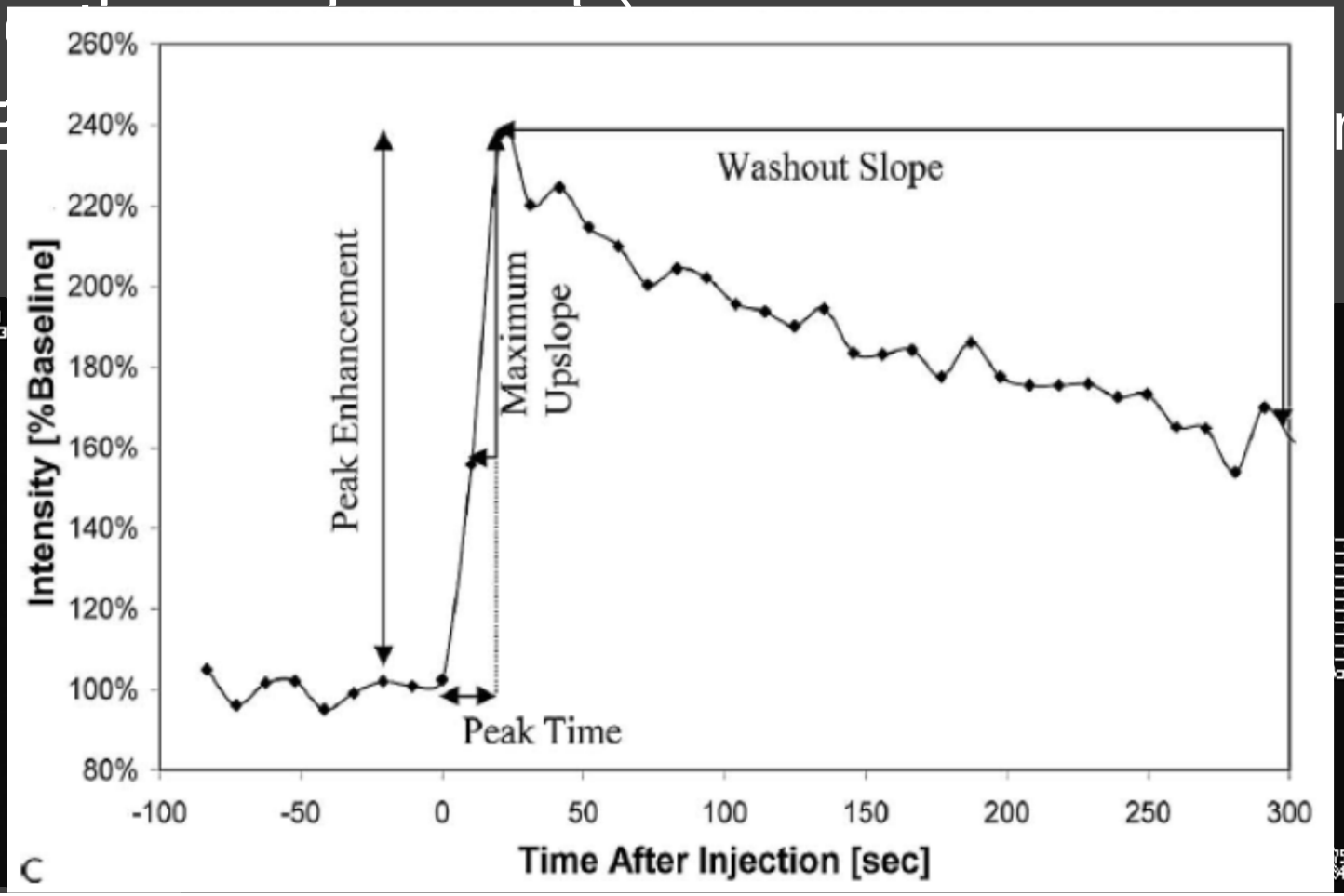
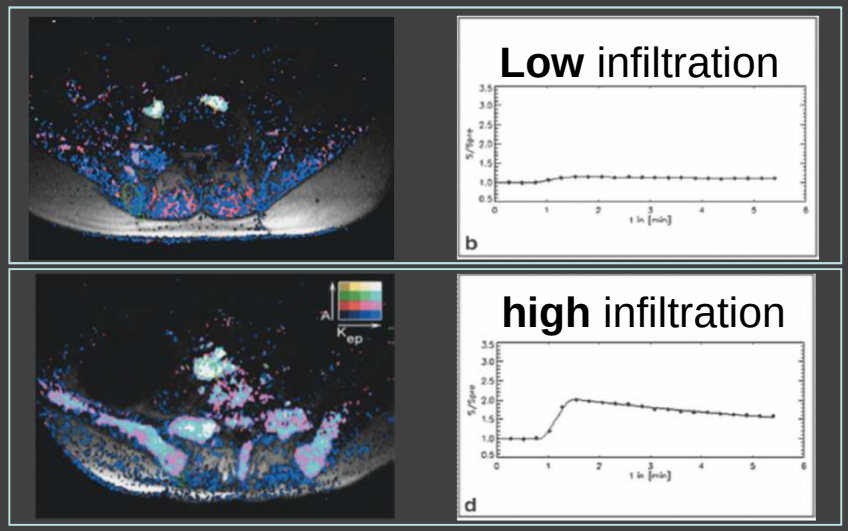
Dynamic Contrast Enhanced DCE-MR Imaging

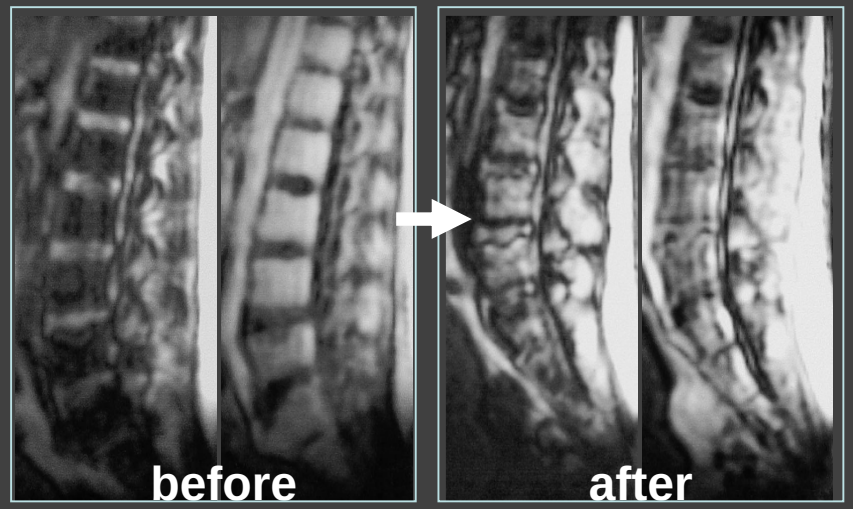
- ✓ Repeated imaging to track the entrance of diffusible "paramagnetic" contrast agents into tissue over time (refl
- ✓ DCE me and



DCE-MR Imaging

- Infiltration grade /MVD/disease activity (serum markers)
- Treatment response





** ***But only a single segment!***

2D turboFLASH sequence

single or 11 slices

Norsas-Garcia S et al. *J Magn Reson Imaging* 2005.

Rahmouni A et al. *Radiology* 2003.

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- WB DWI imaging

DCE WB MR Imaging

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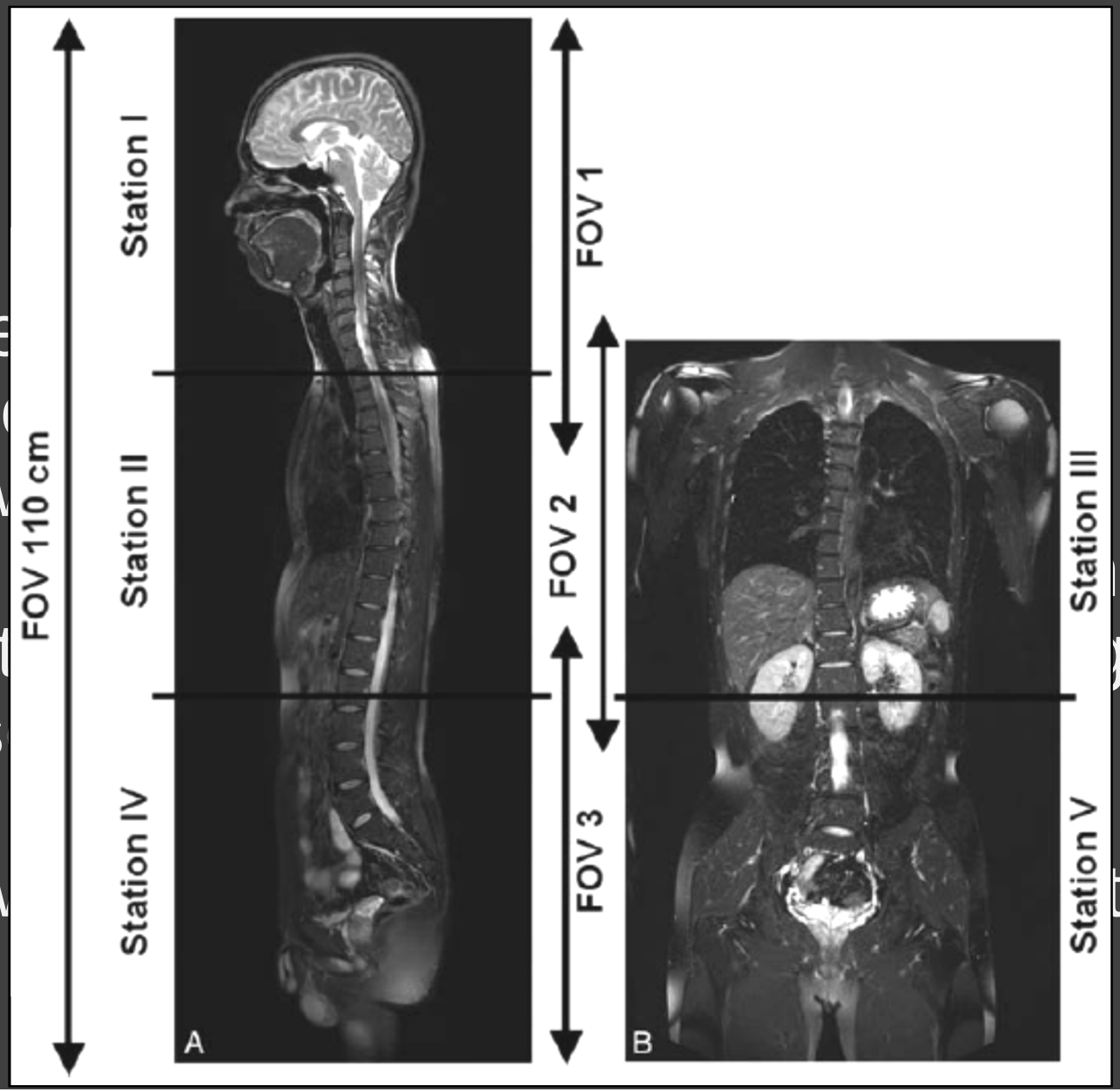
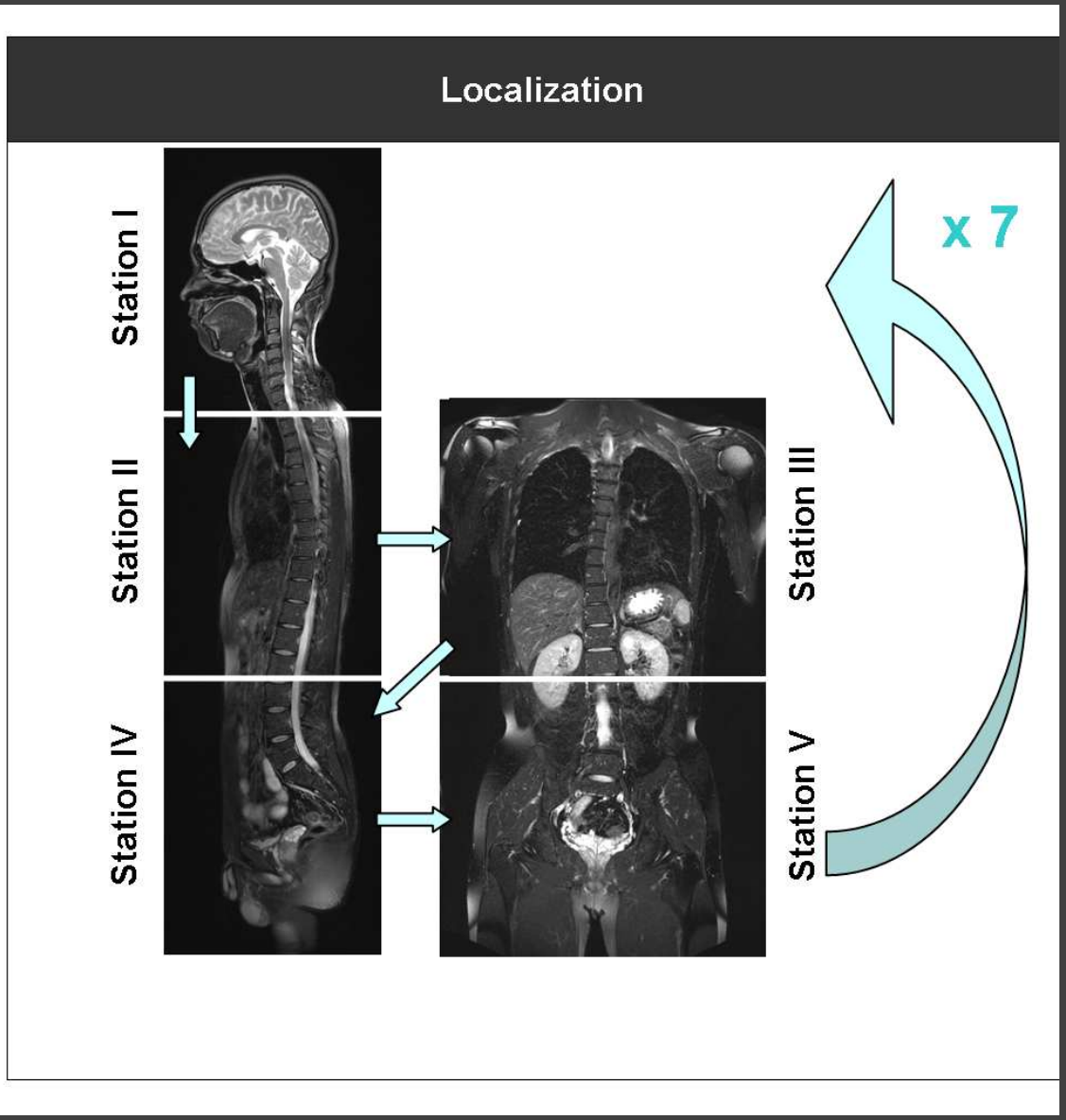
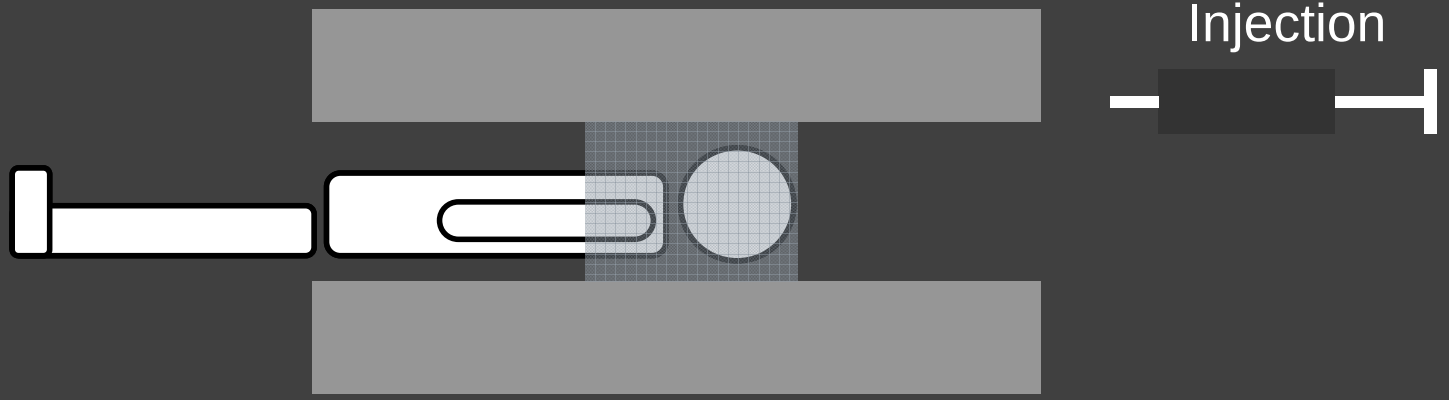


DCE WB MR Imaging

WB 5-stations DCE-MRI



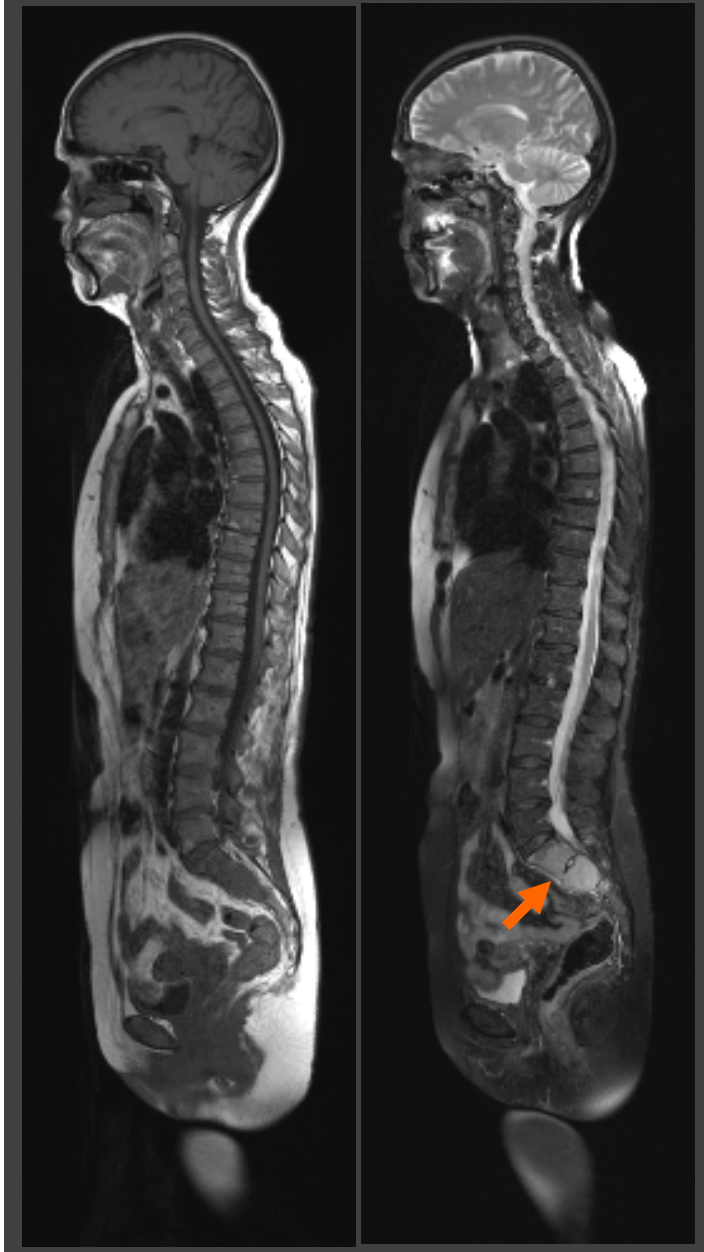
DCE WB MR Imaging



Each sagittal station: 24 slices in 5 seconds (3mm/slice)
Each coronal station: 40 slices in 7 seconds (5mm/slice)
152 slices/30 seconds

T1 SE

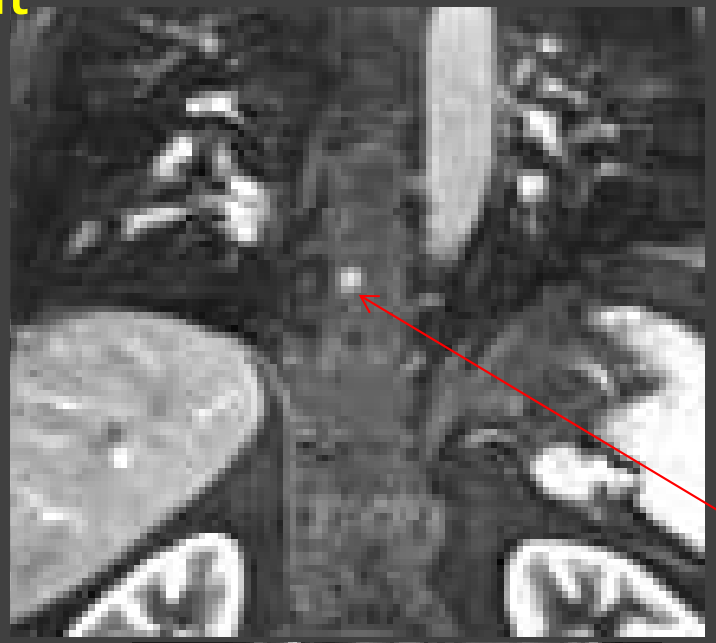
T2 TSE FS



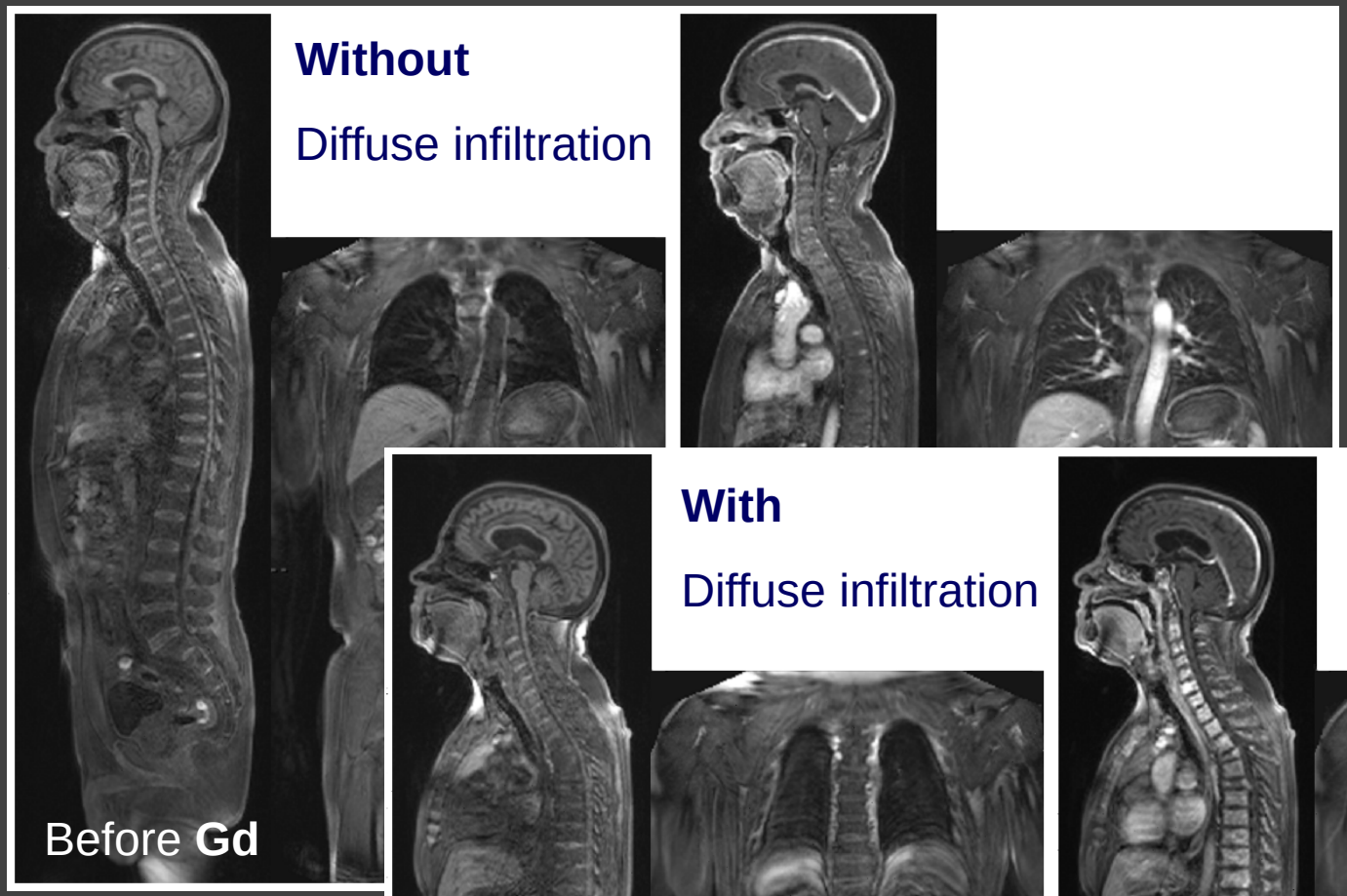
Example: 64 ans / baseline

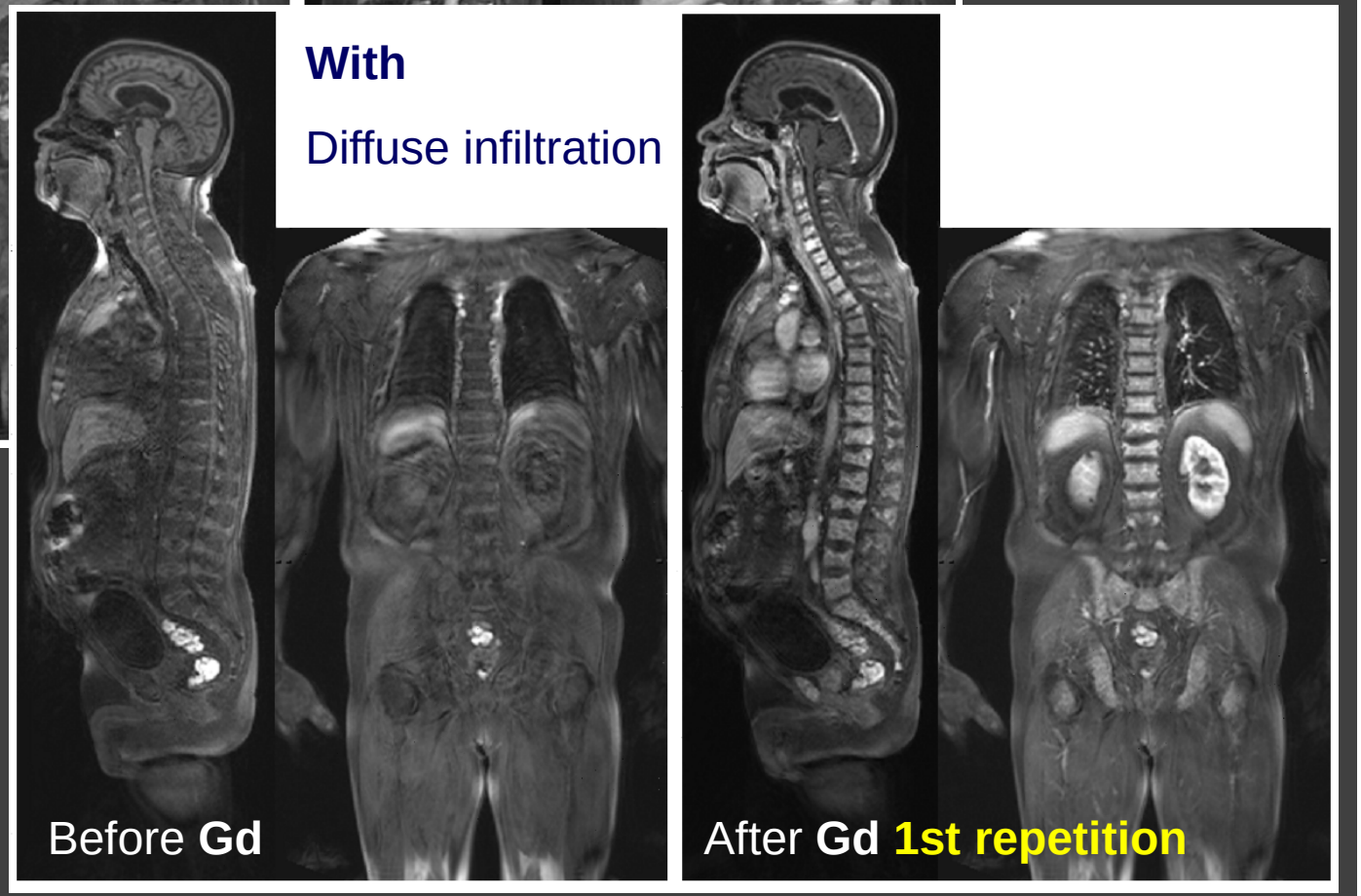
7ème répétition

Recent Improvement

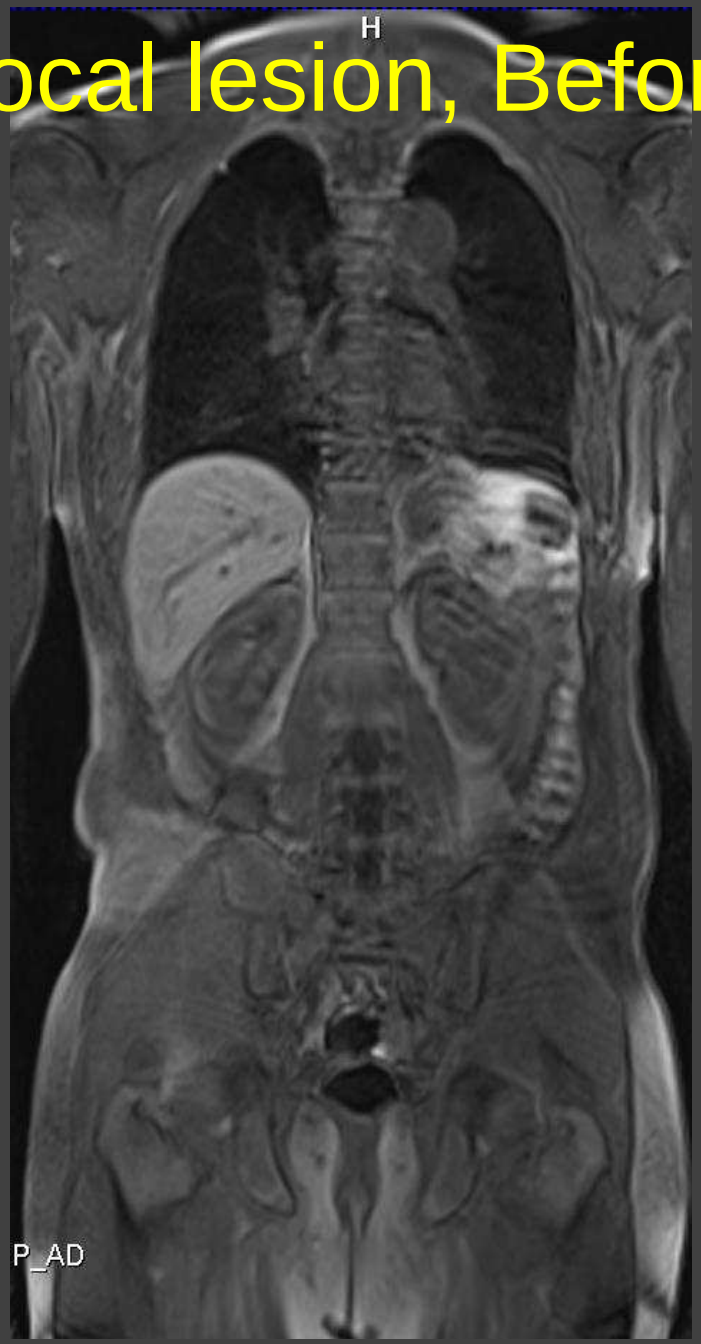


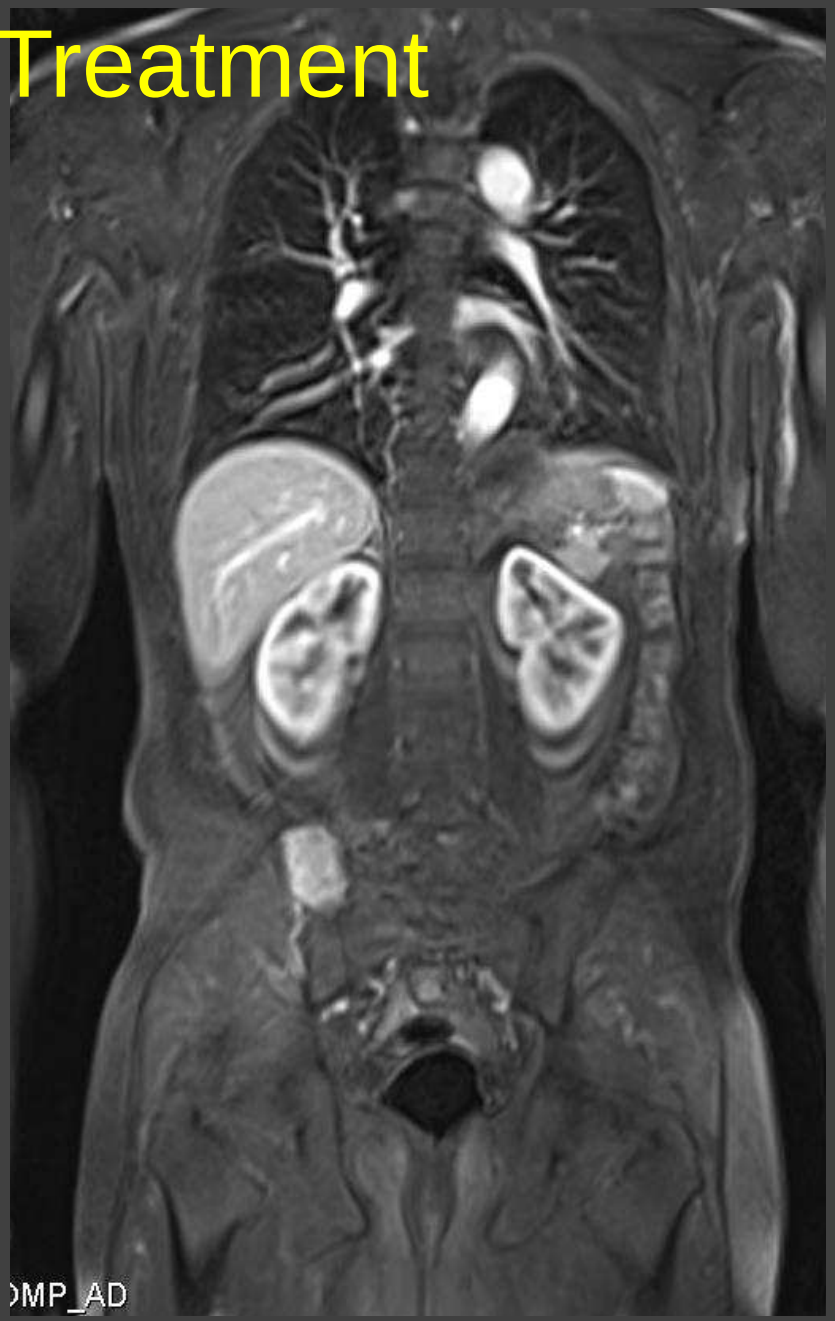
3D Isotropic 2mm Coronal acquisition
360 images in 39 sec


Without
Diffuse infiltration
Before **Gd**


With
Diffuse infiltration
Before **Gd**
After **Gd** **1st repetition**

Focal lesion, Before Treatment

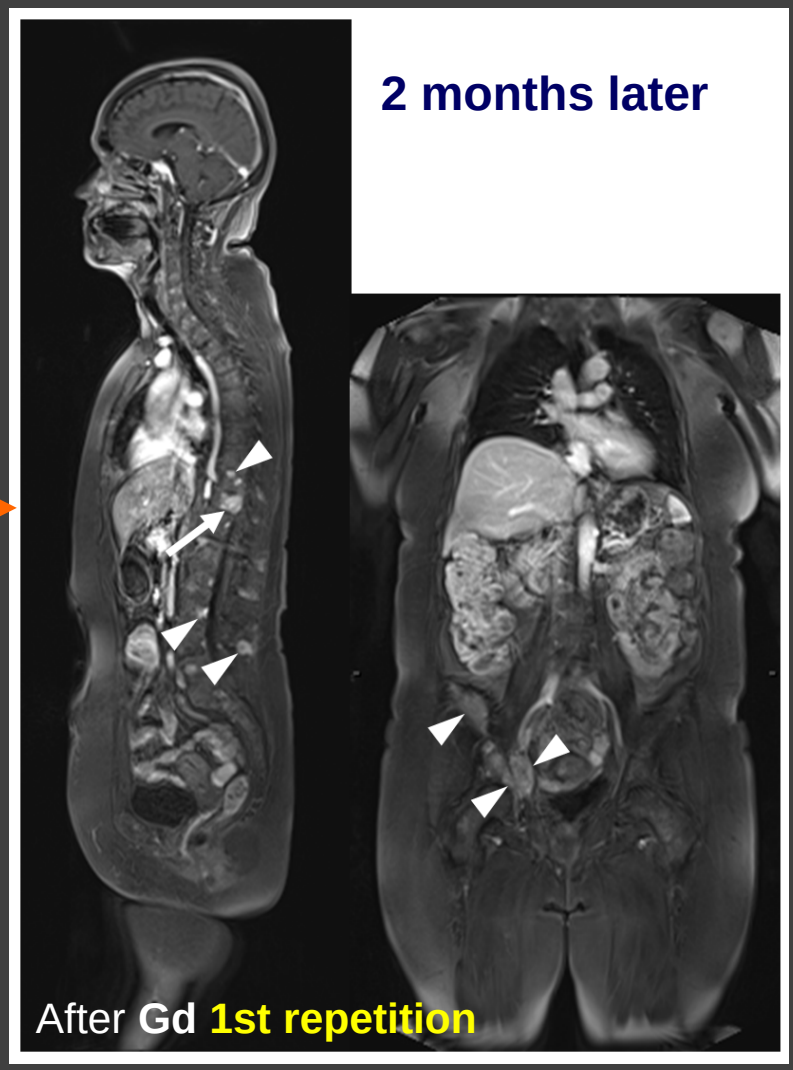




Focal lesion After Treatment, GR

Female patient, 63y, good responder after ASCT on clinical and biological criteria but not WB DCE MRI

M-protein IgA: from 37 g/L to 0g/L → CR (uniform criteria)



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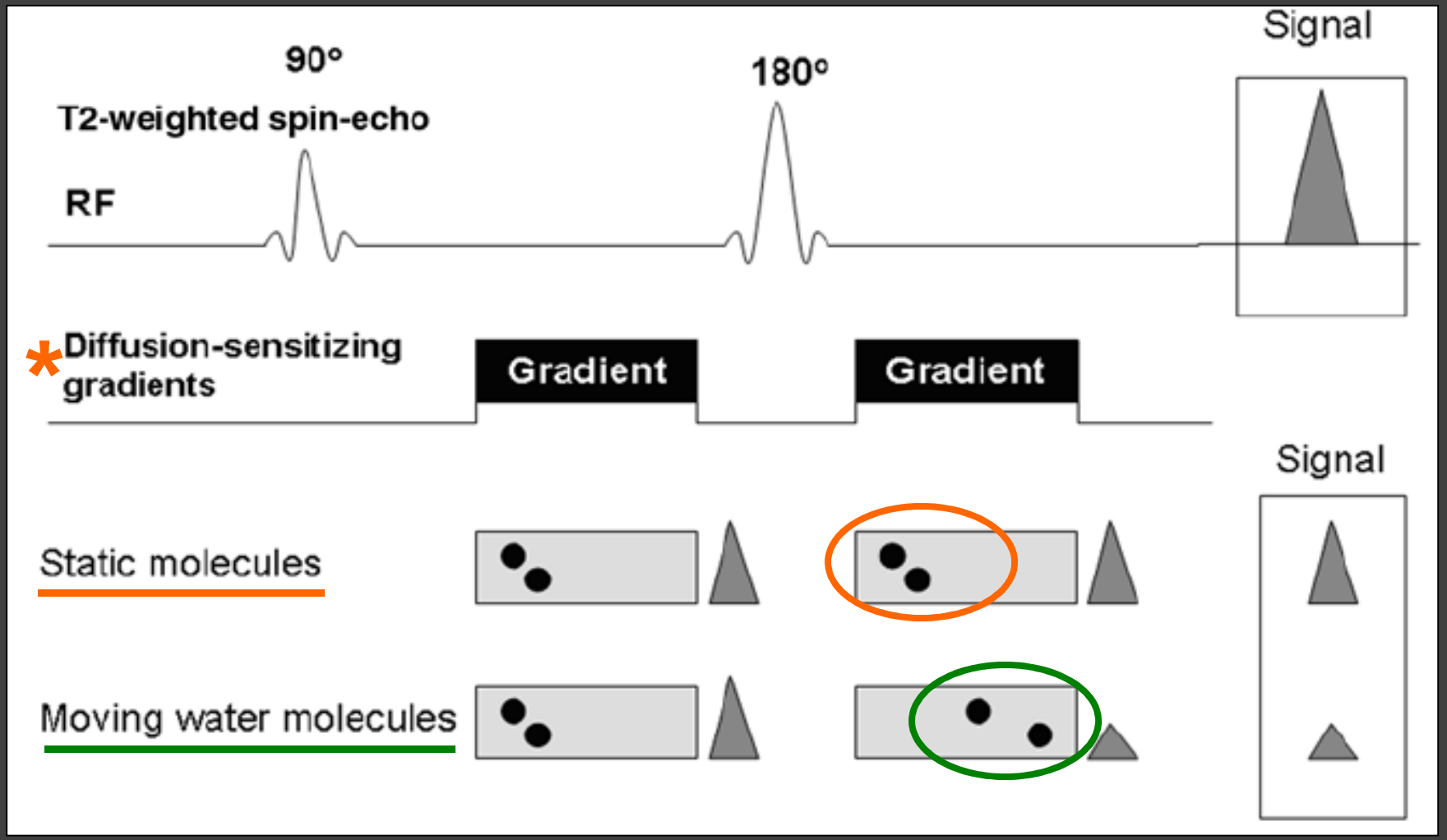
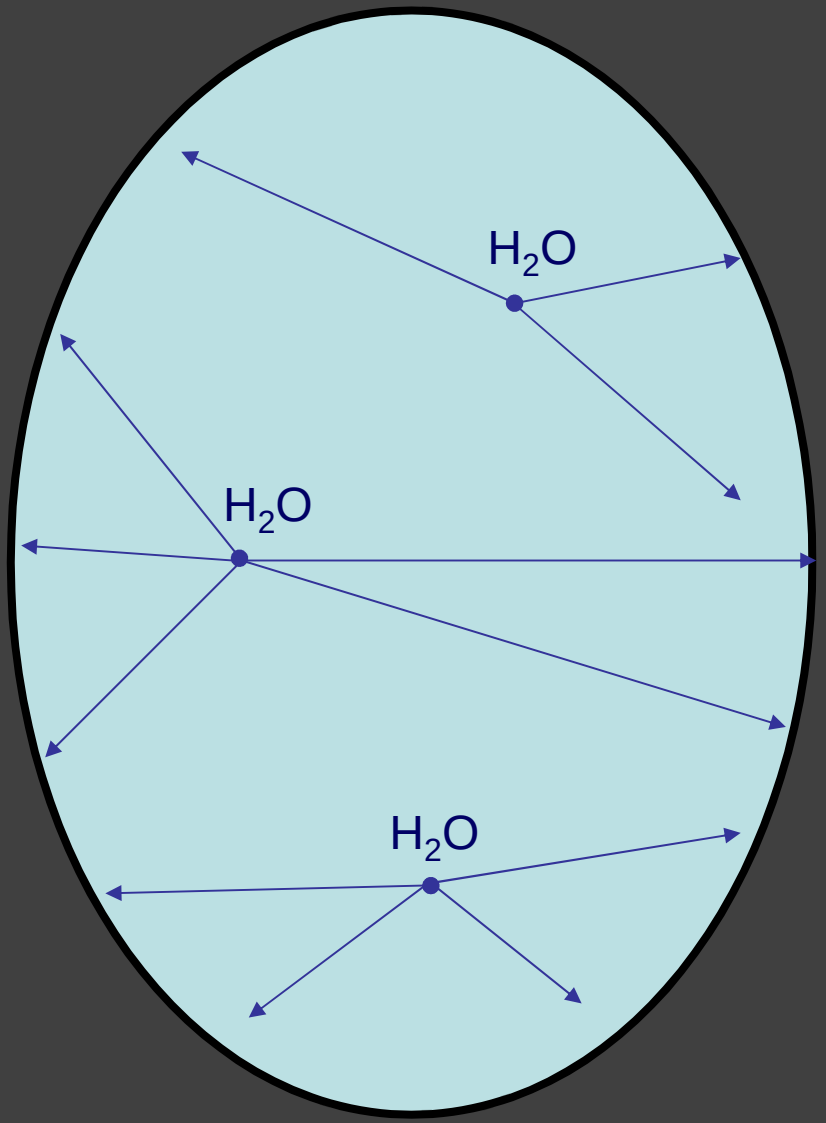
Diffusion

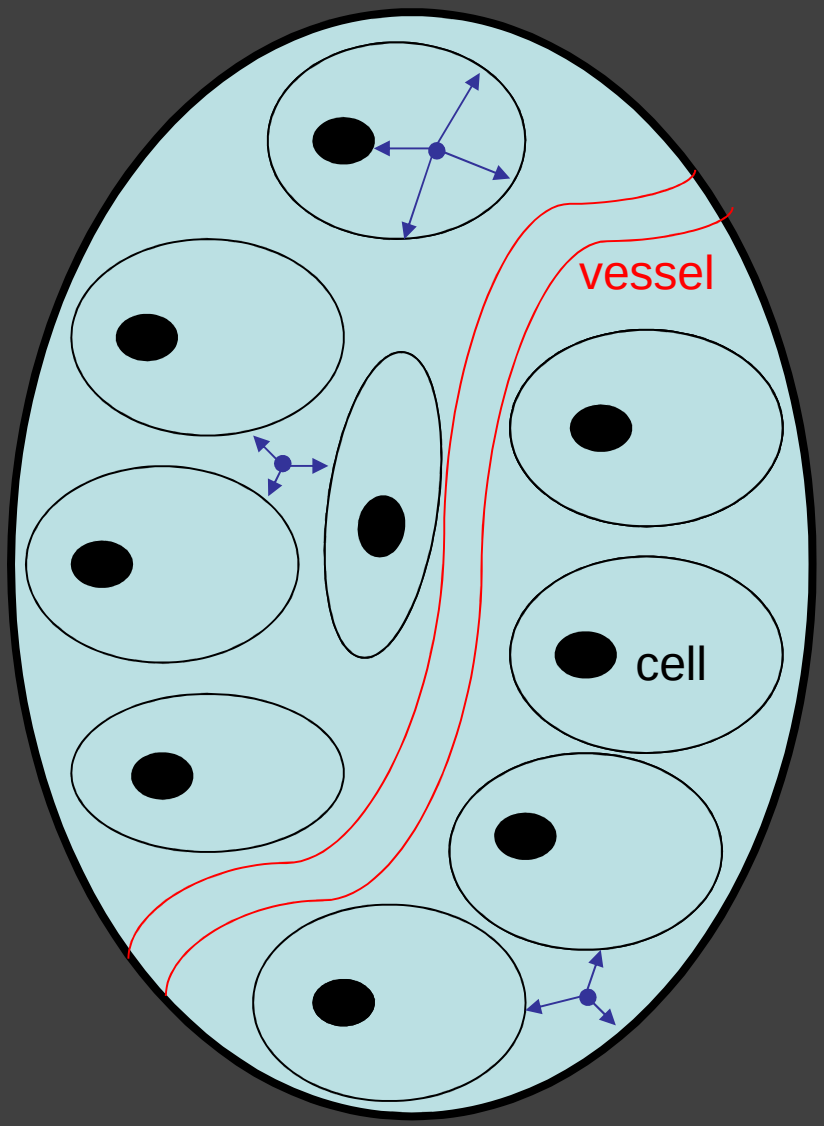


Stejskal and Tanner (1965)

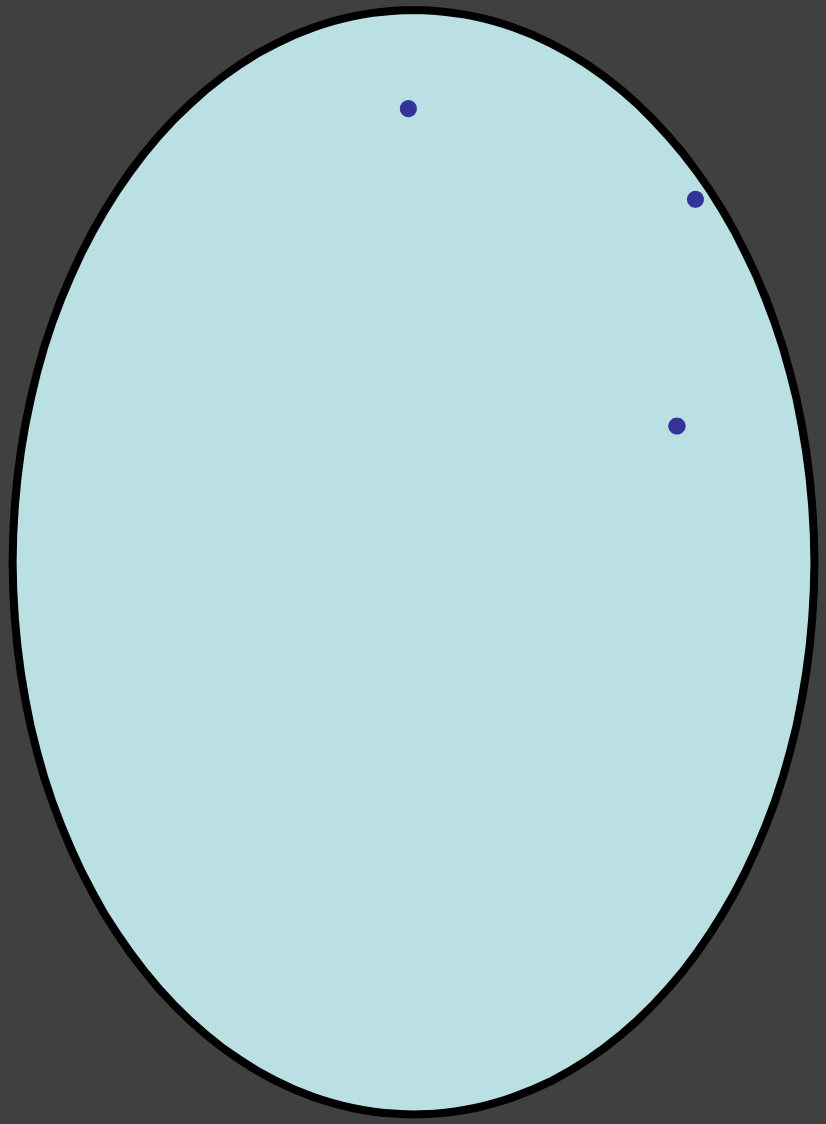
Koh DM et al. ***AJR*** 2007



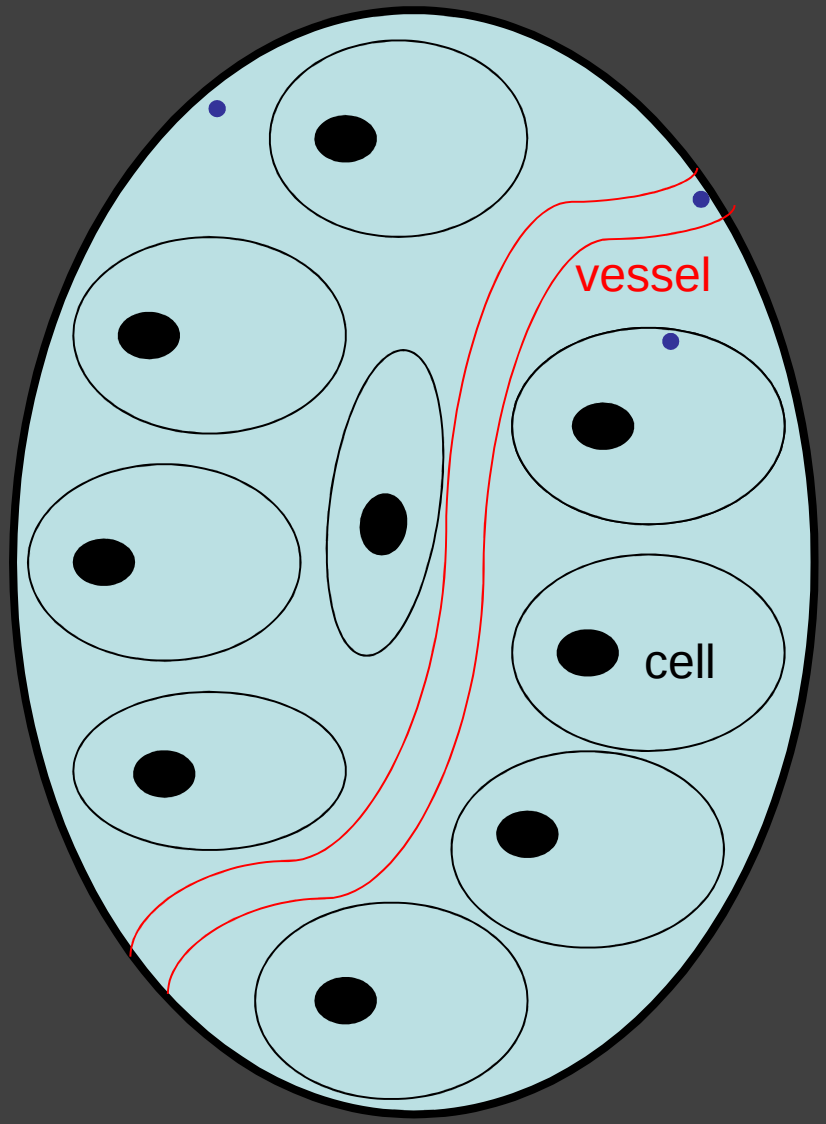
No restriction
High ADC



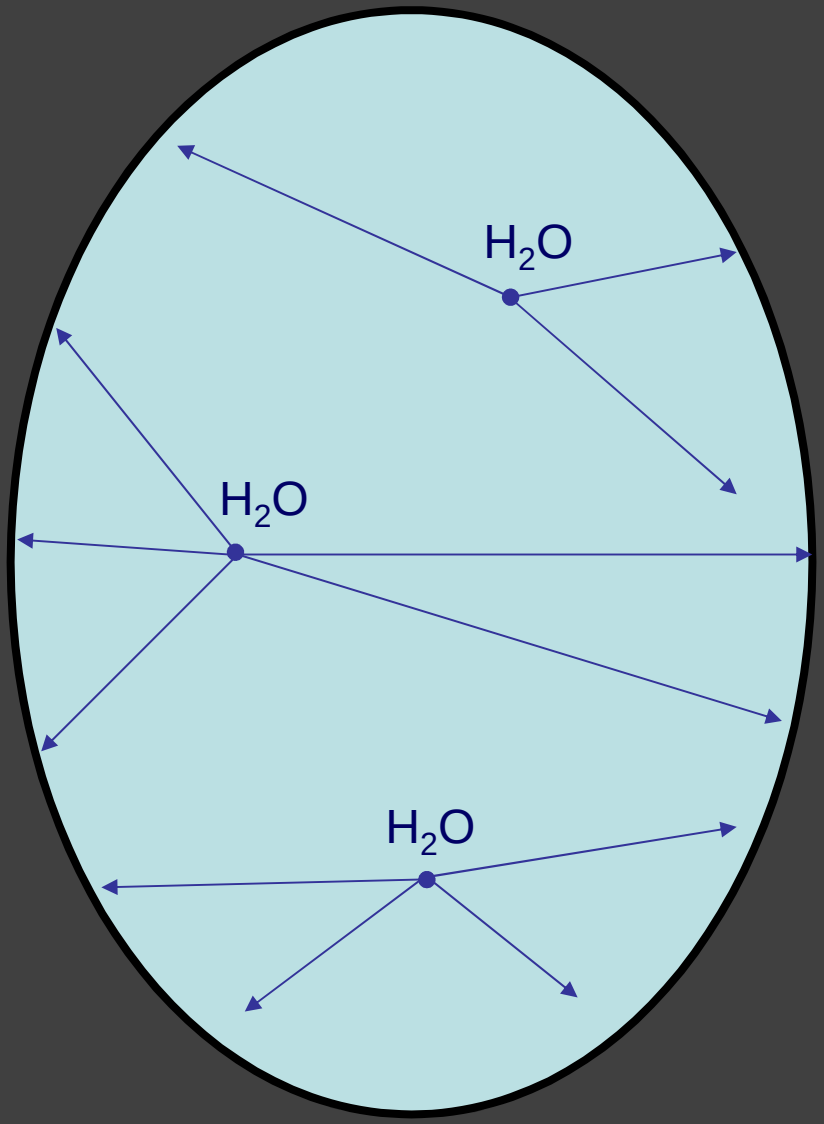
Restriction (tumor)
Low ADC



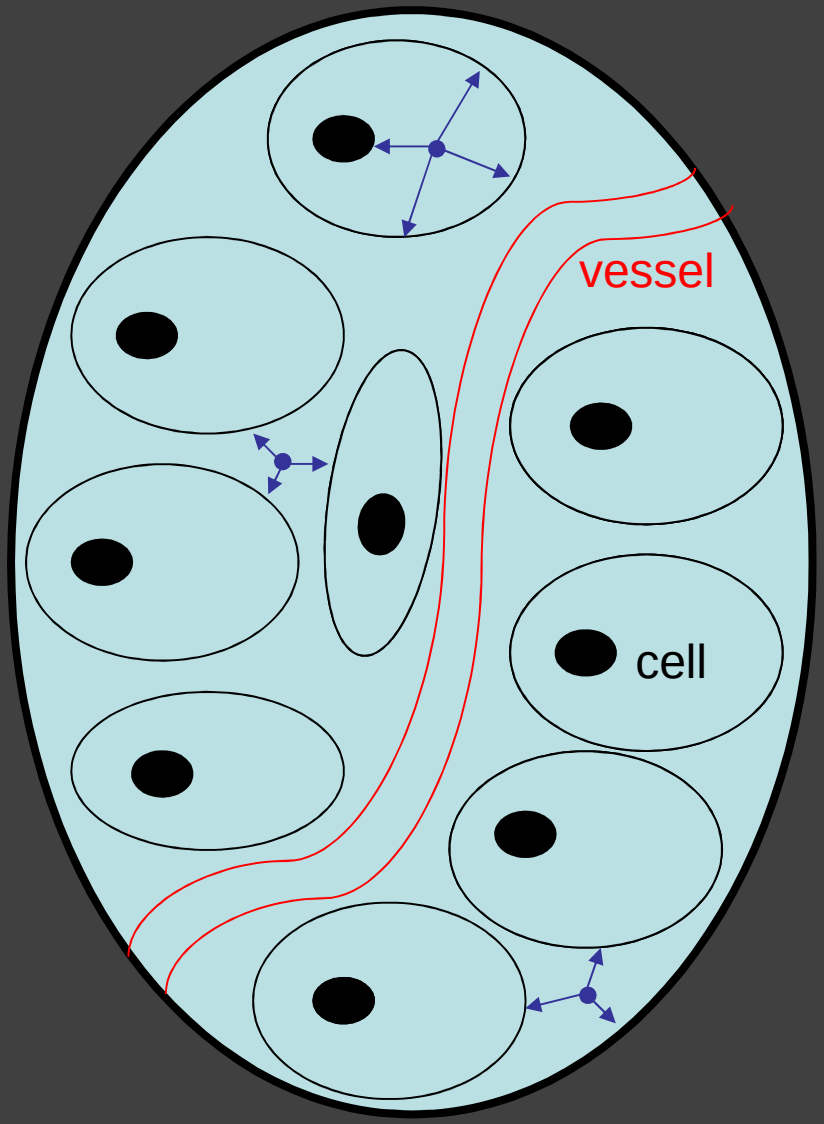
No restriction: ADC is high



Restriction: ADC is low

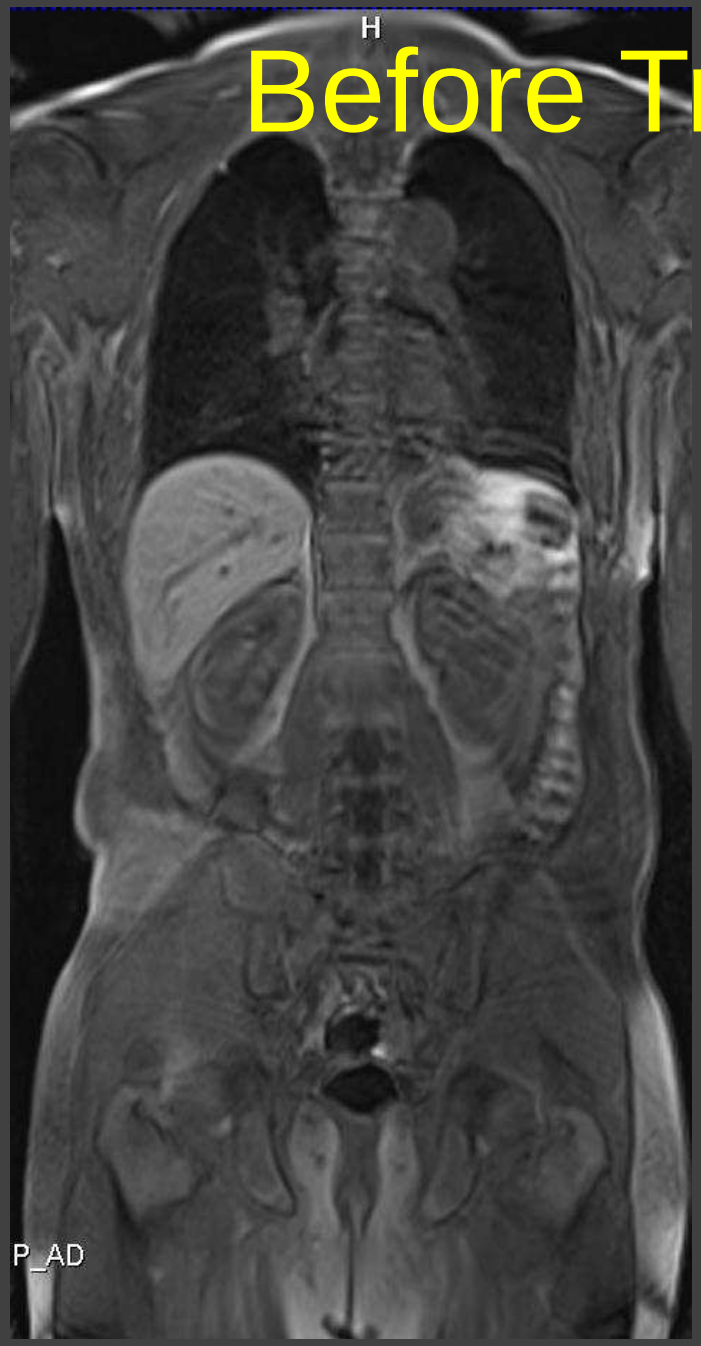


No restriction

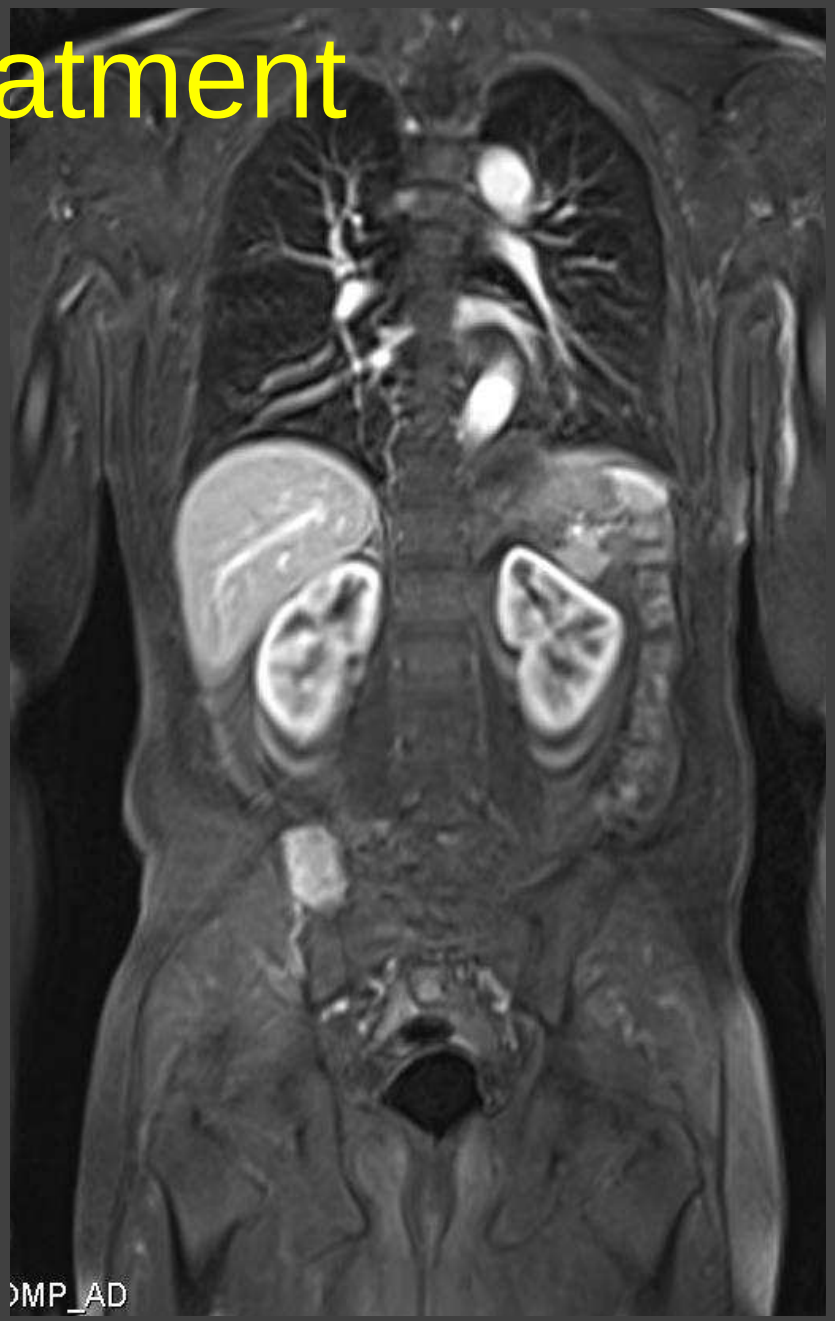


Restriction (tumor)

Before Treatment



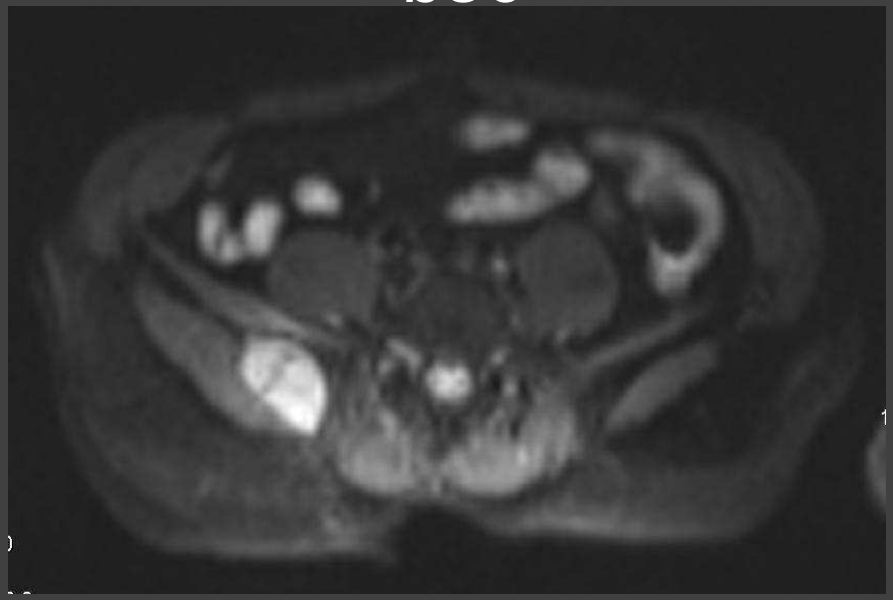
Before IV GADO



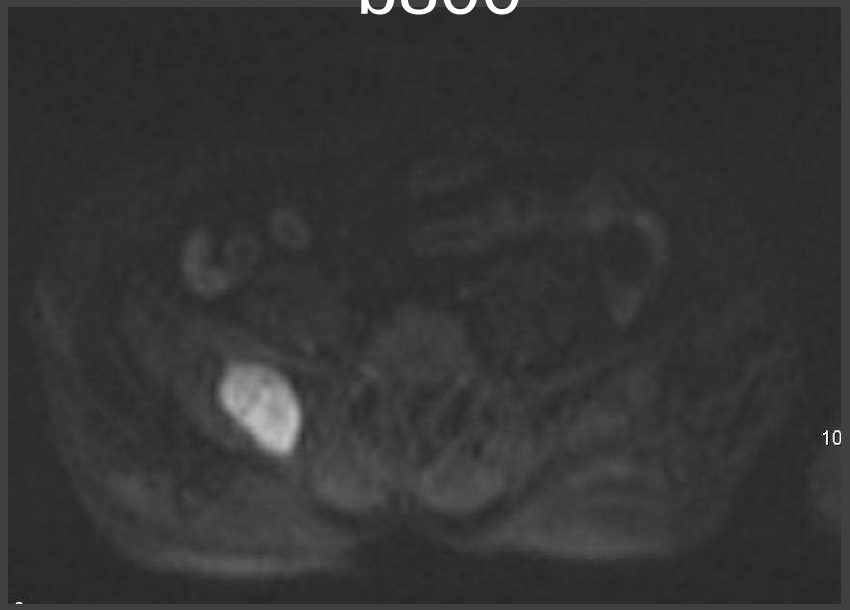
After IV GADO

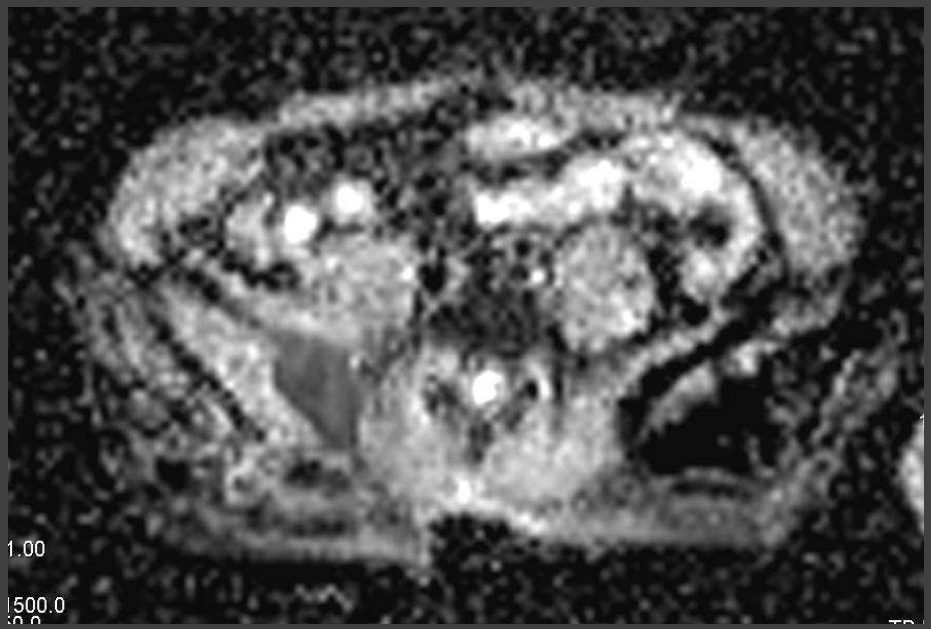
After Treatment, GR

b50



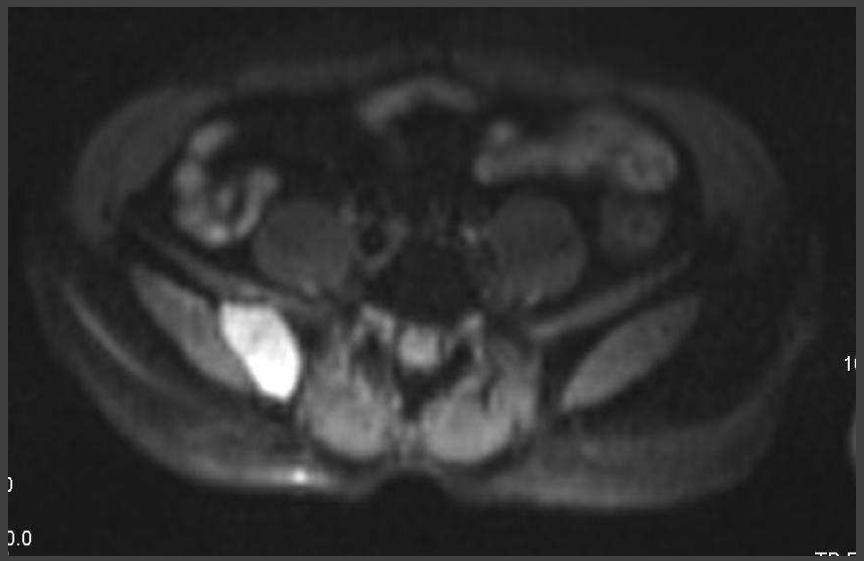
b800



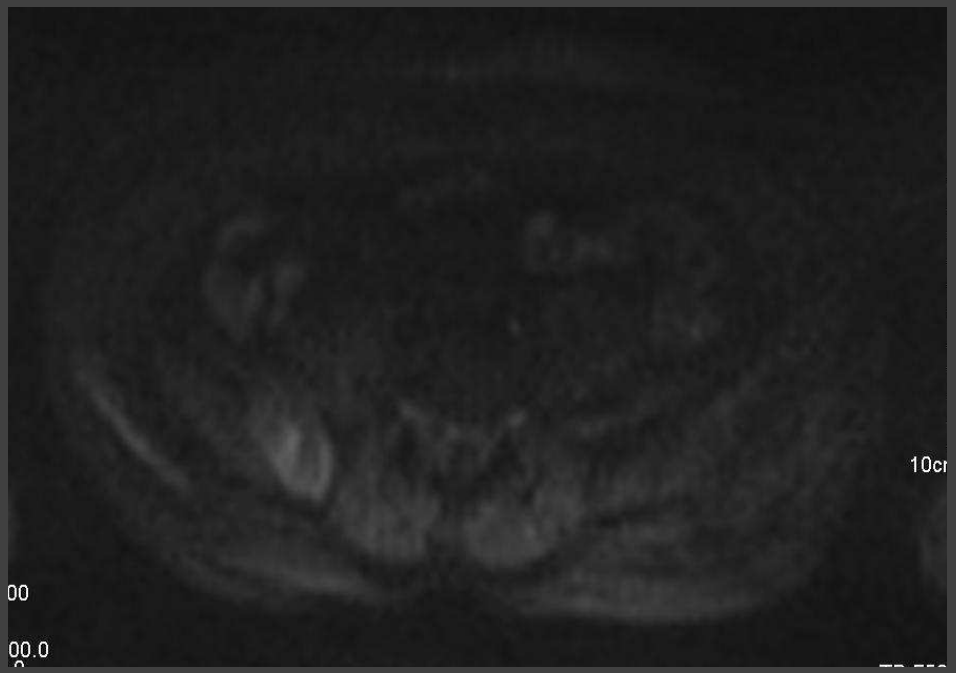


Before Treatment

b50



b800



After Treatment, GR

Apparent Diffusion Coefficient: ADC

Radiology

Separation of diffusion and perfusion in intravoxel incoherent motion MR imaging.

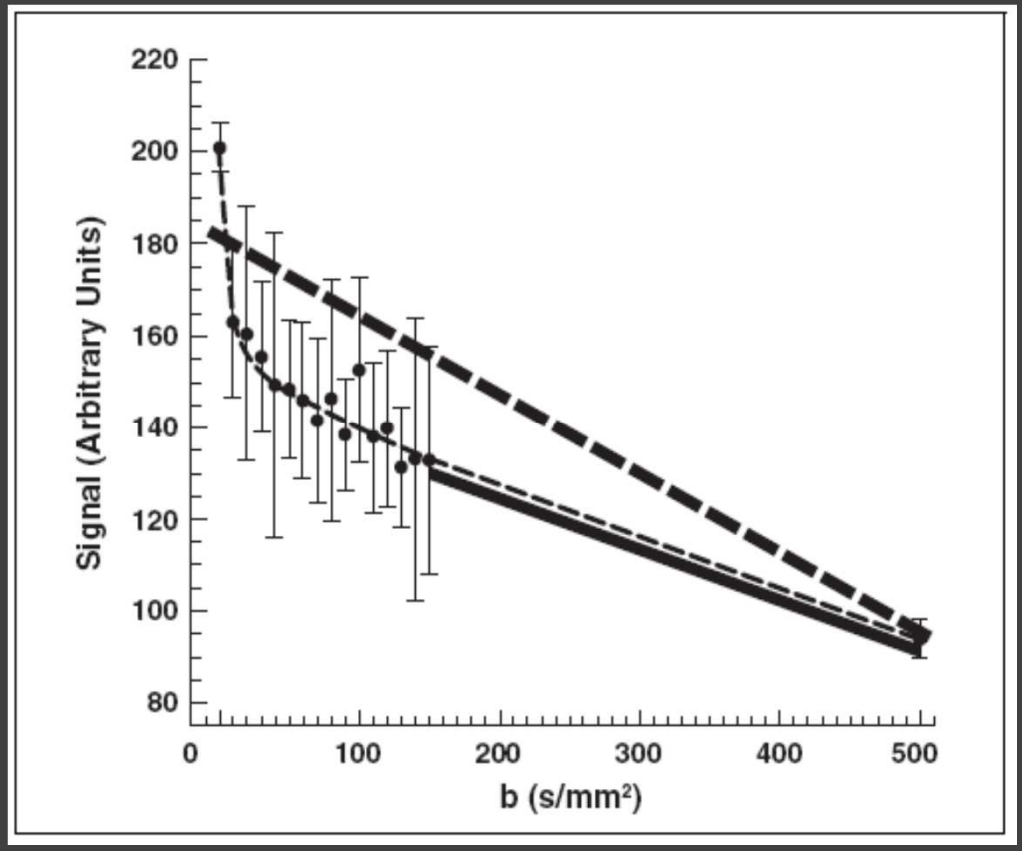
D Le Bihan, E Breton, D Lallemand, M L Aubin, J Vignaud and M Laval-Jeantet

Groupe de Biophysique, Ecole Polytechnique, Palaiseau, France.

Abstract

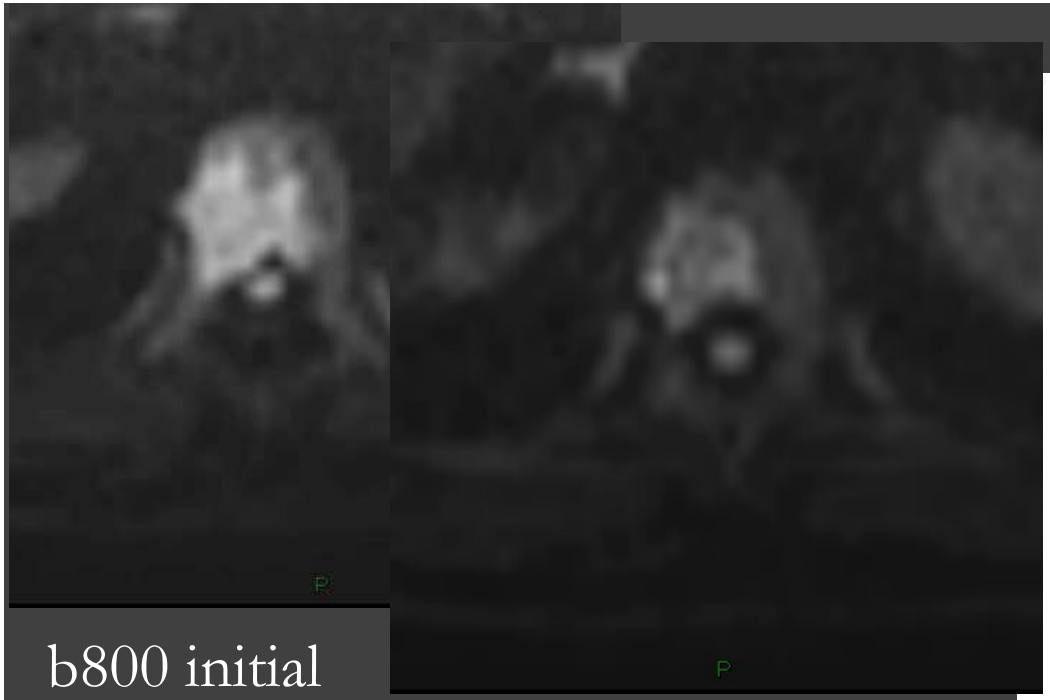
Intravoxel incoherent motion (IVIM) imaging is a method the authors developed to visualize microscopic motions of water. In biologic tissues, these motions include molecular diffusion and microcirculation of blood in the capillary network. IVIM images are quantified by an apparent diffusion coefficient (ADC), which integrates the effects of both diffusion and perfusion. The aim of this work was to demonstrate how much perfusion contributes to the ADC and to present a method for obtaining separate images of diffusion and perfusion. Images were obtained at 0.5 T with high-resolution multisection sequences and without the use of contrast material. Results in a phantom made of resin microspheres demonstrated the ability of the method to separately evaluate diffusion and perfusion. The method was then applied in patients with brain and bone tumors and brain ischemia. Clinical results showed significant promise of the method for tissue characterization by perfusion patterns and for functional studies in the evaluation of the microcirculation in physiologic and pathologic conditions, as, for instance, in brain ischemia.

Radiology 1988;168:497-505



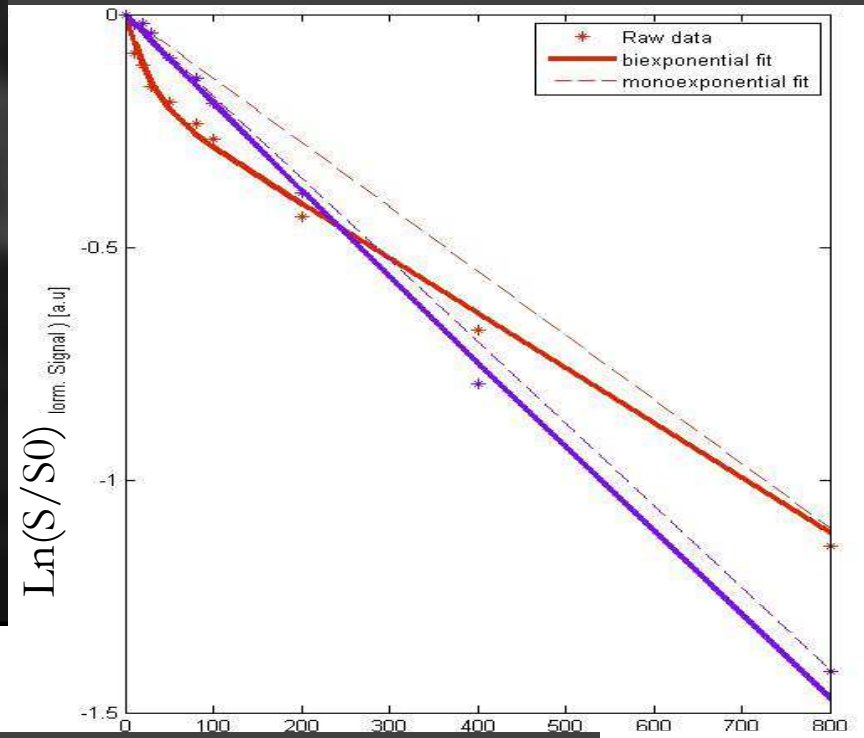
- ***b*** (s/mm^2) determines diffusion-weighting
- ADC can be calculated with ≥ 2 data points with different ***b*** values = $(1/b_1\text{-}b_0)$ ln $(S[b_1]/S[b_0])$ mm^2/s

Koh DM et al. *AJR* 2007



b800 initial

b800 post-CT



Initial

FLEmax = 376 %
D=1 mm2/sec
D*= 37,7 mm2/sec
F= 15,9%
ADC= 1,3 mm2/sec

Post-CT

FLEmax = 110 %
D=1,7 mm2/sec
D*= 1,4 mm2/sec
F= 1,6%
ADC= 1,7 mm2/sec

Intravoxel Incoherent Motion Diffusion-weighted Imaging of Multiple Myeloma Lesions:

Correlation with Whole-Body Dynamic Contrast Agent–enhanced MR Imaging[1]

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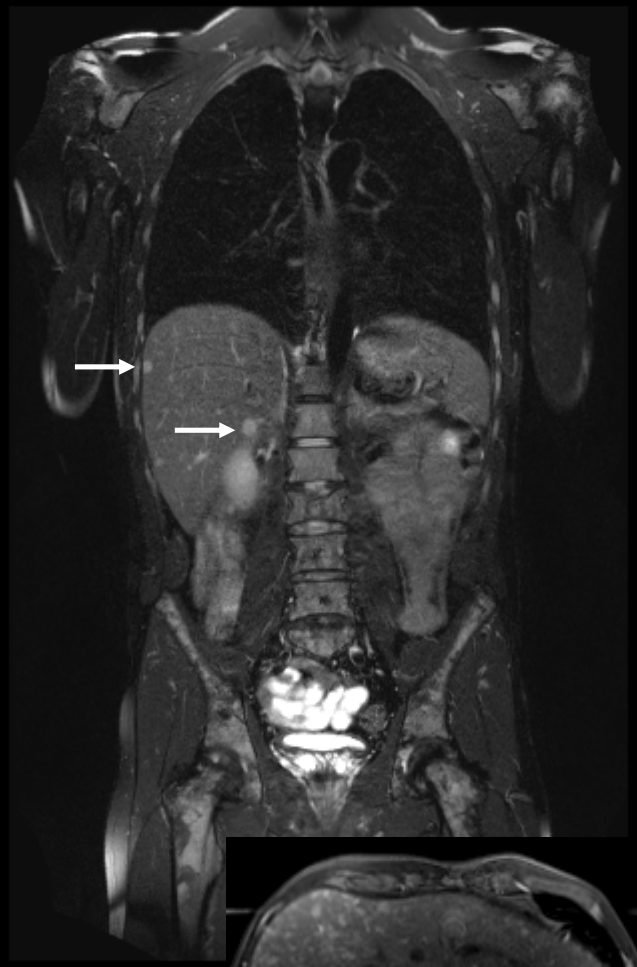
Detection of Extra-medullary Disease and other lesions

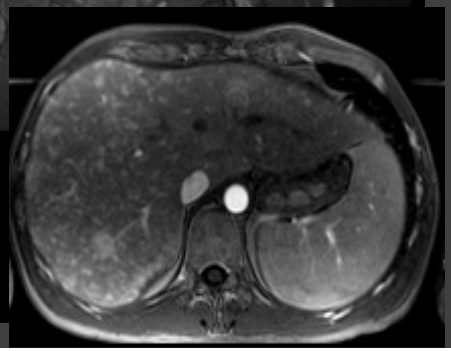
35 y/o man, non-secretory MM

post autologous stem cell transplant one year ago

Newly-onset low back pain

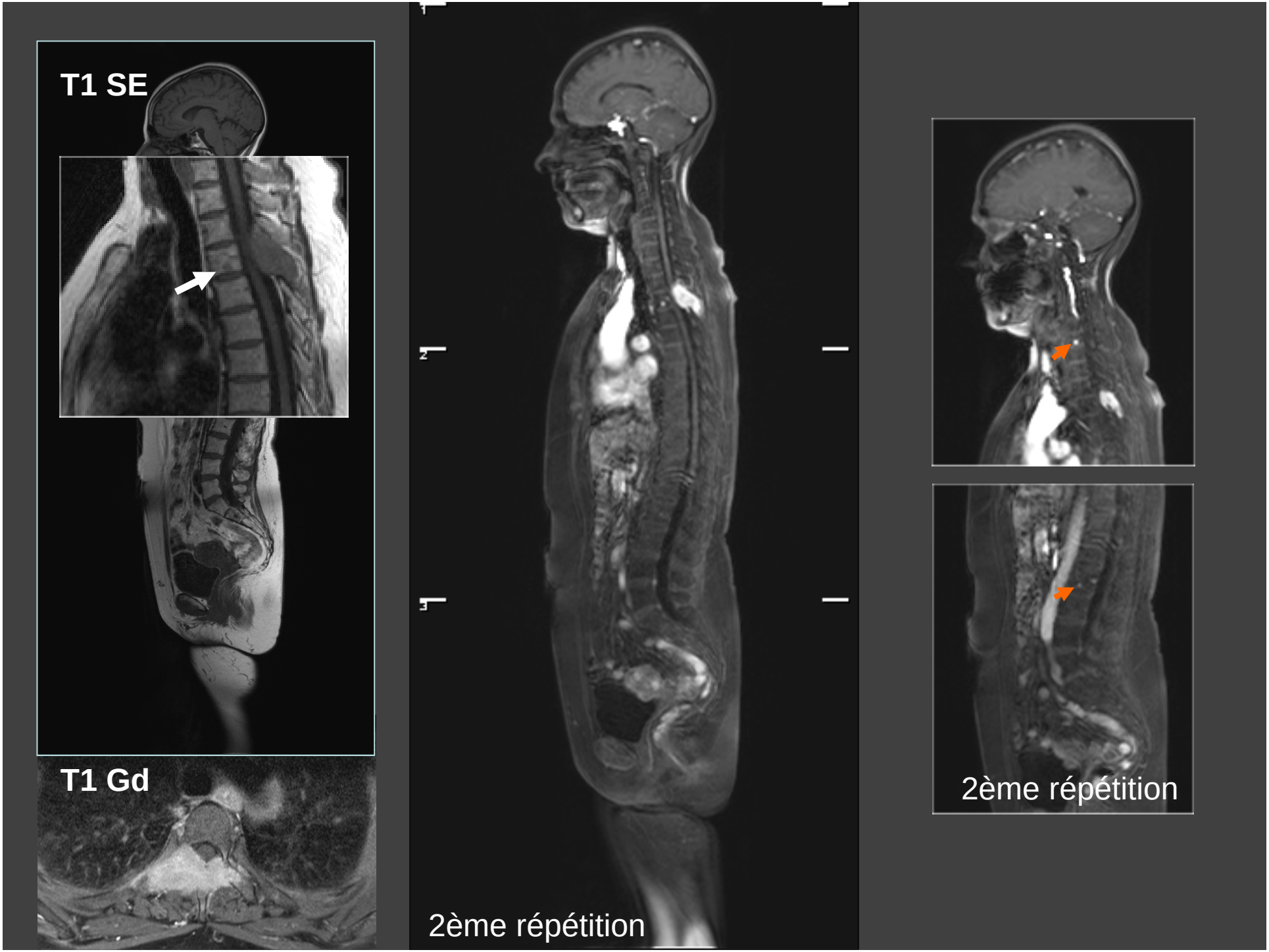
Diffuse marrow infiltration
+ hepatic nodules
(**incidental findings**)



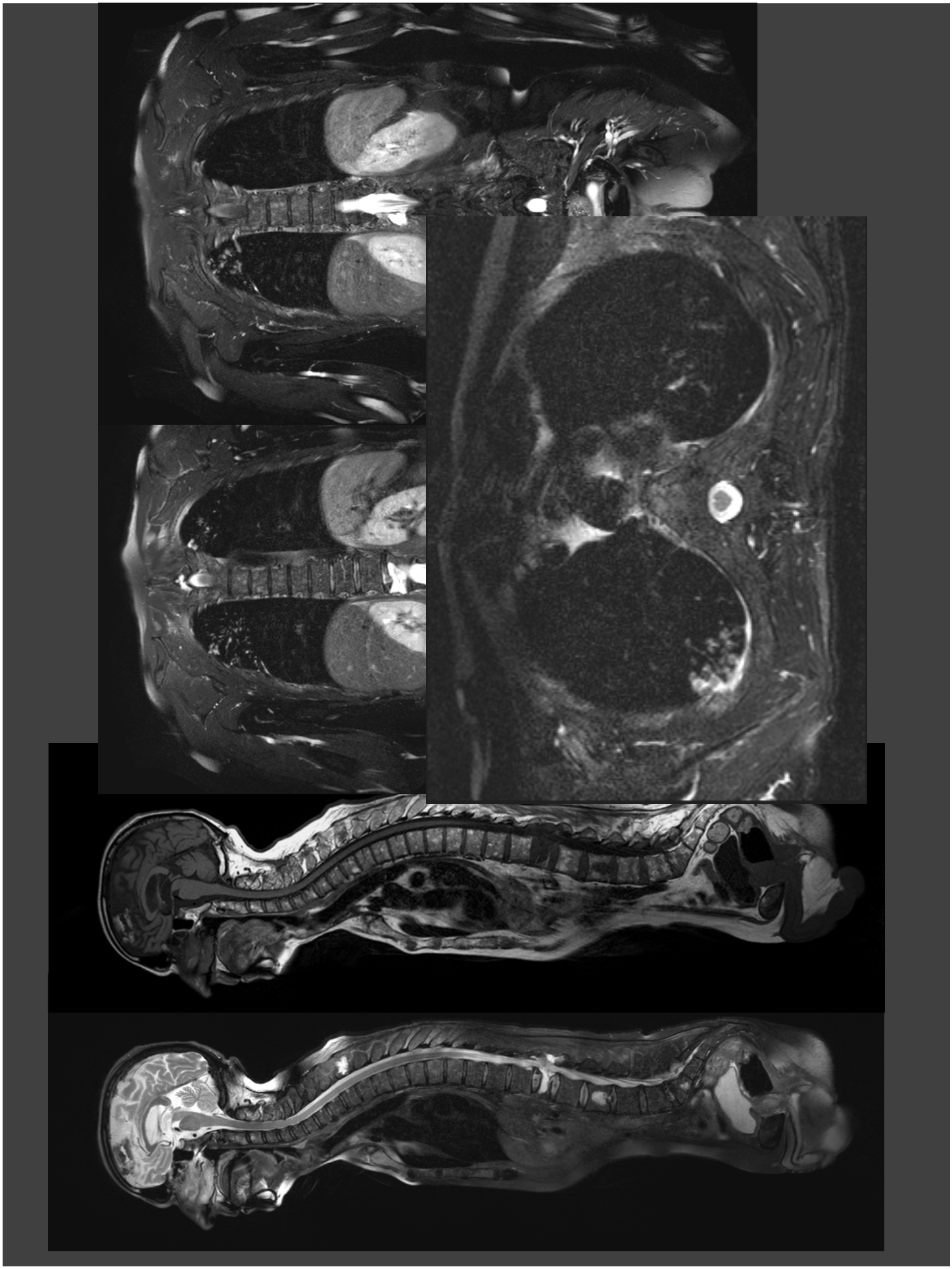


57y/o woman, MM with right sacral mass. Bone marrow transplant 2 years ago

Follow-up exam, clinically mild right shoulder pain


T1 SE
T1 Gd
2ème répétition
2ème répétition

60y/o man, MM after 4 cycles
Incidental findings



Conclusions

- What’s new?
- Local functional MR techniques, i.e dynamic contrast enhanced reflecting angiogenesis and diffusion weighted imaging reflecting cellularity can be now applied at a whole body scale
- Better characterization and understanding of myeloma lesions also include metabolic imaging using FDG and other tracers