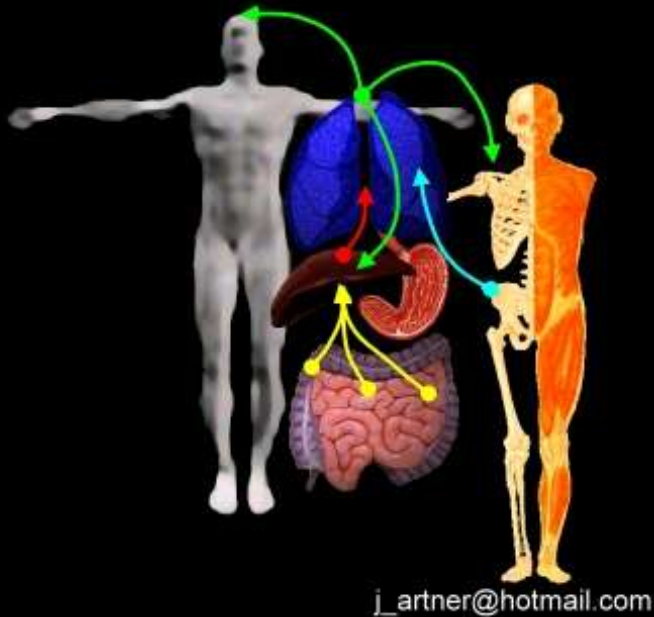


Value of whole body diffusion-weighted MRI in (digestive) cancer

V. Vandecaveye, F. De Keyzer, S. Pans

Department of Radiology
University Hospitals Leuven, Leuven, Belgium

Whole body MRI in oncology



T-staging:

Primary - second primary

M-staging:

Distant metastatic disease (potentially curable?)

Hepatic , peritoneal, lung, skeletal, etc...

N-staging:

Regional (potential curative) and systemic nodal disease

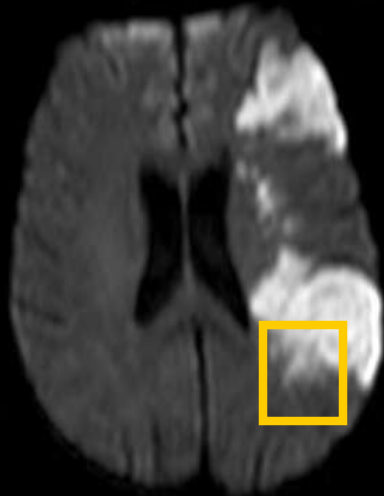
Treatment



RECIST versus functional “early” response evaluation

Diffusion-weighted MRI: What?

Brain infarction

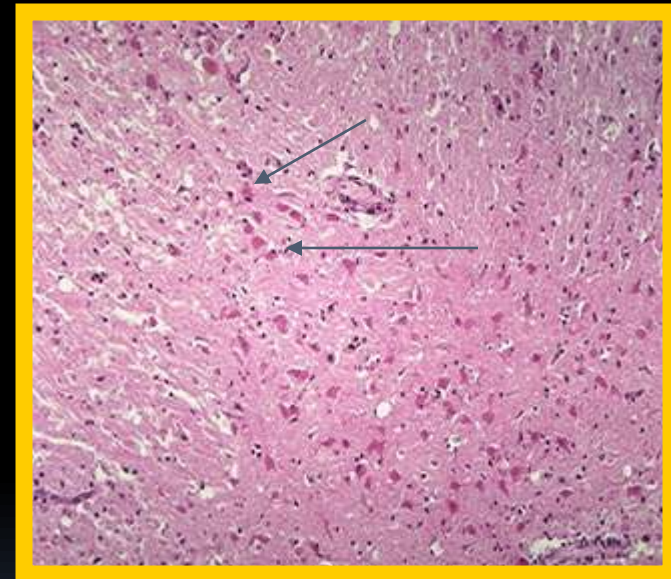


b1000



ADC

Water restriction due to
Hypoxic tissue swelling



The addition of two opposed magnetic field gradients makes the intensity signal dependent on the mobility of water molecules

The b-value determines the effect of gradient strength on diffusion-sensitivity → increase sensitivity of trapped water

Signal loss with increasing b-value in correlation to microstructural density
Quantified by the apparent diffusion coefficient (ADC)

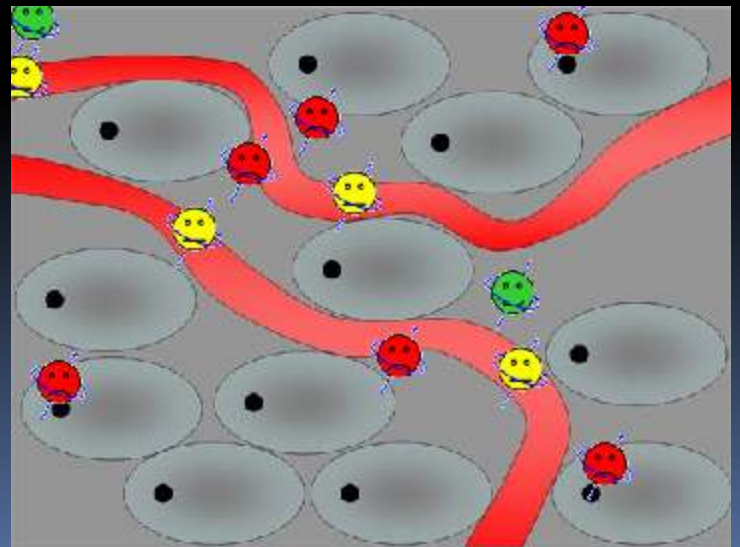
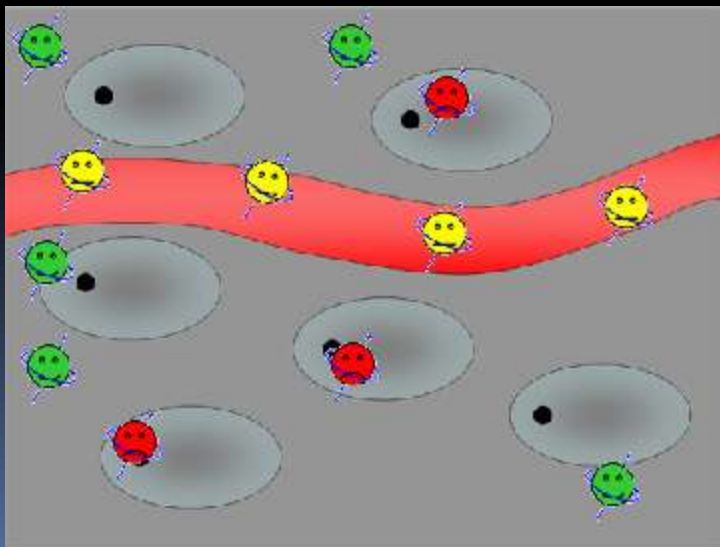
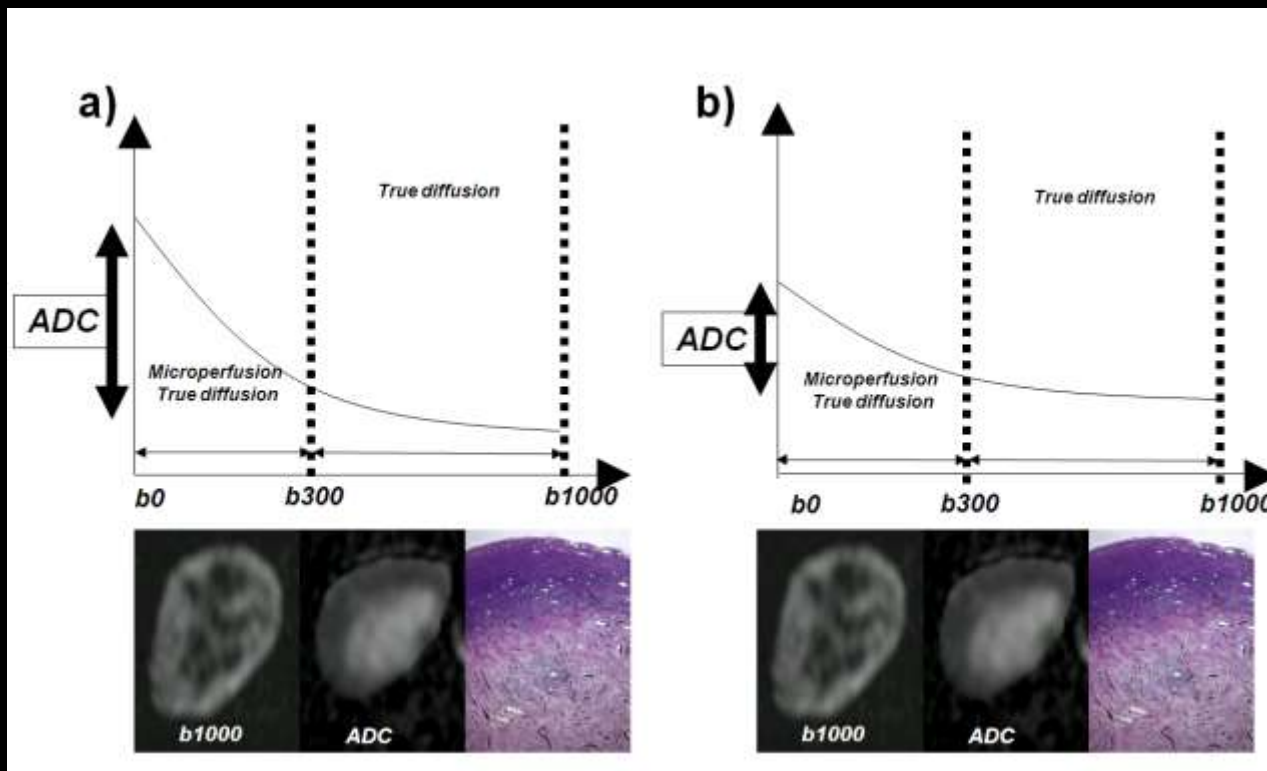
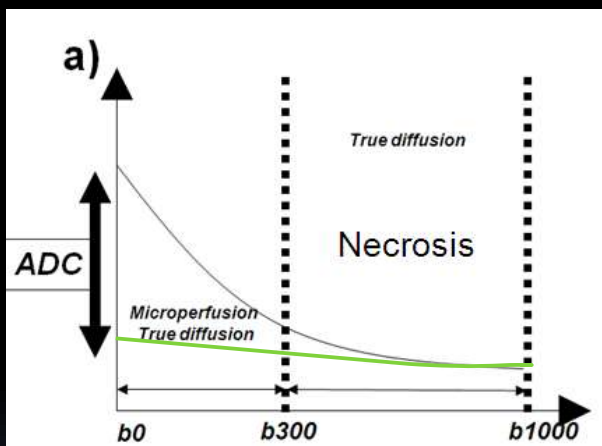
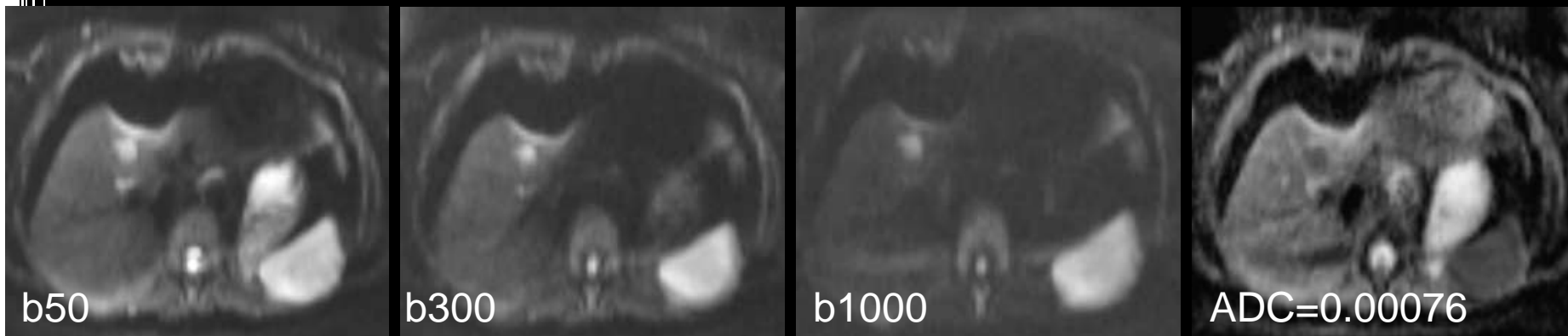


Image interpretation – whole body diffusion



Background noise

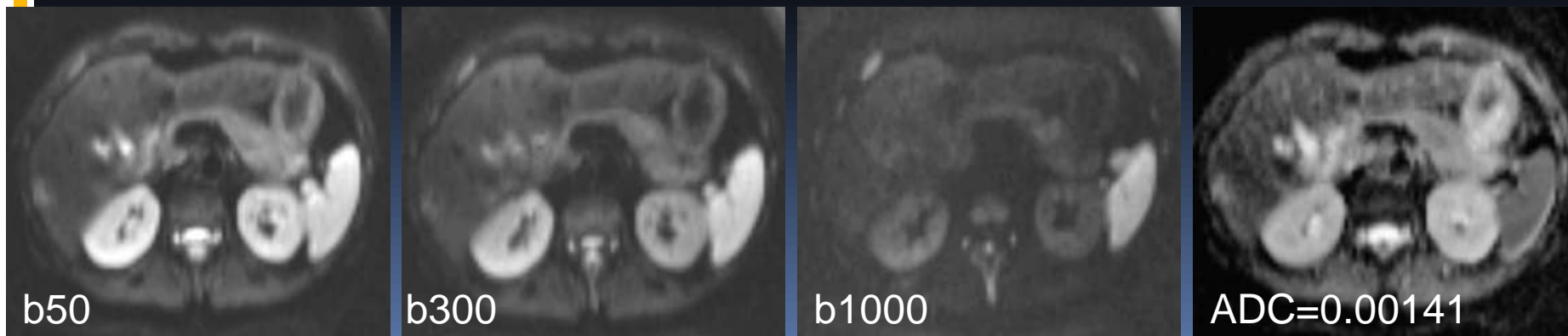
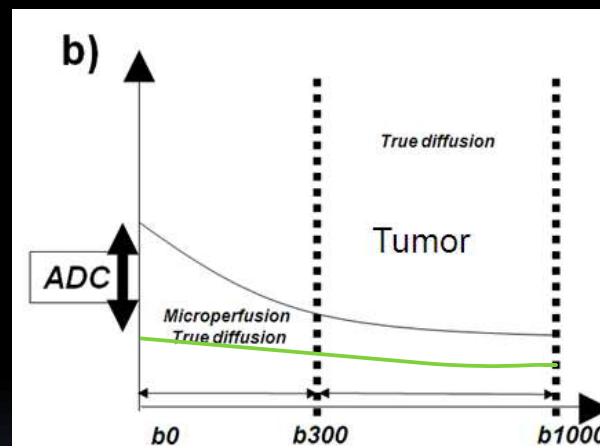


Image interpretation - whole body diffusion

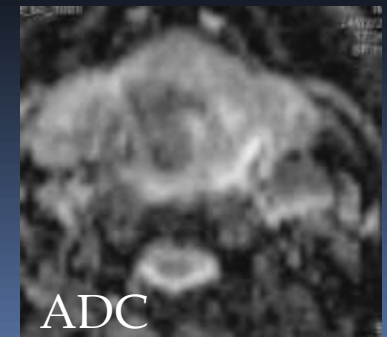
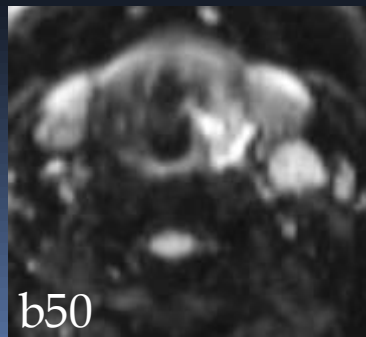
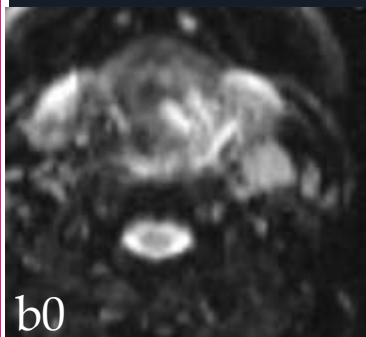
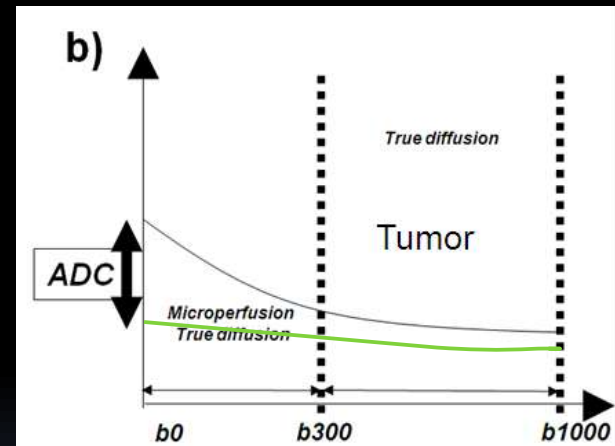
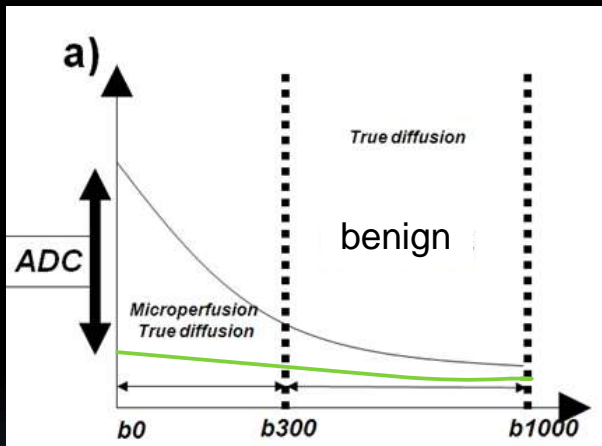
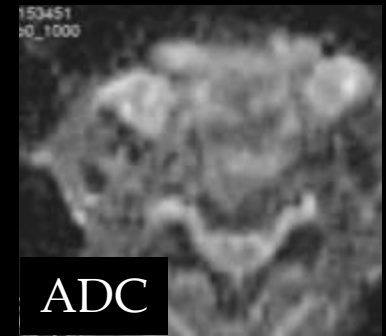
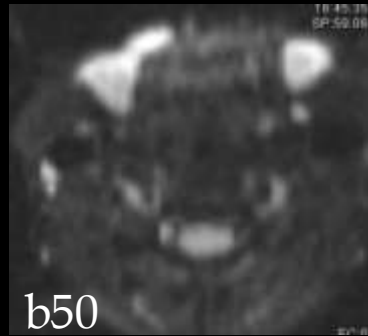
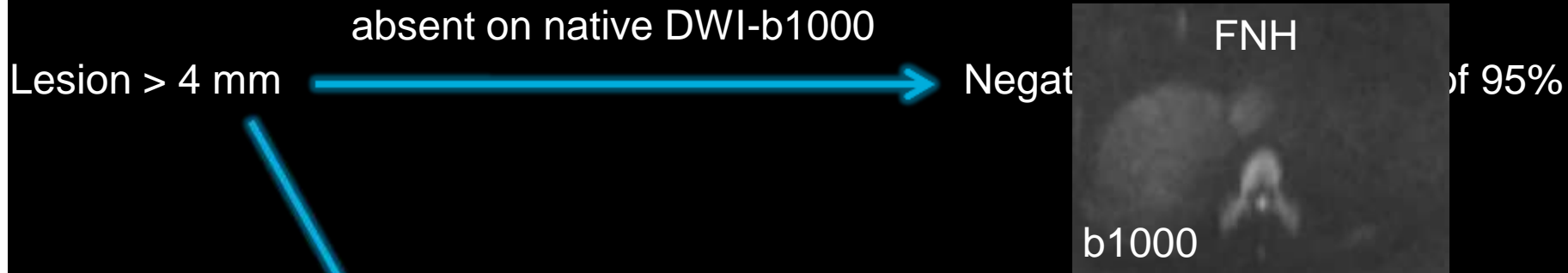
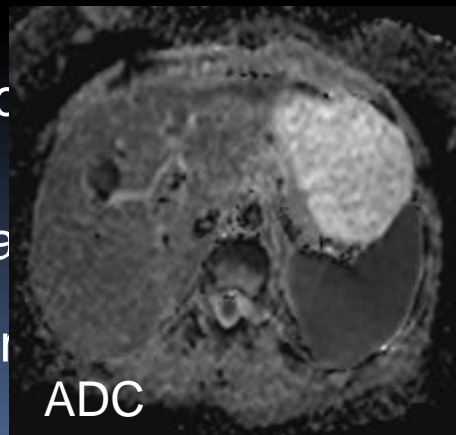
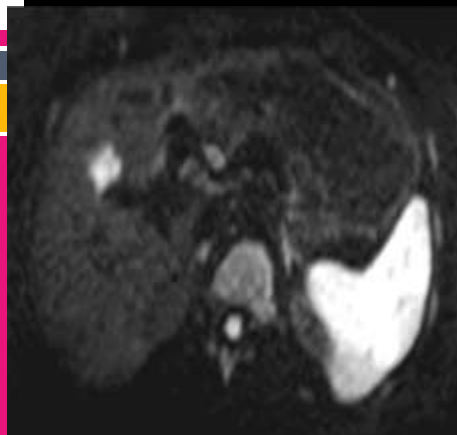


Image interpretation - whole body diffusion

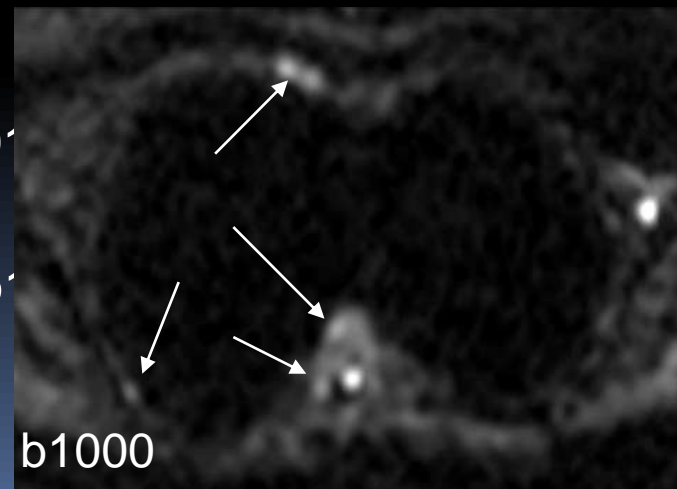


DWI-b1000 hyperintense

Lymph nodes: ADC \rightarrow malignant $< 0,00094 <$
benign



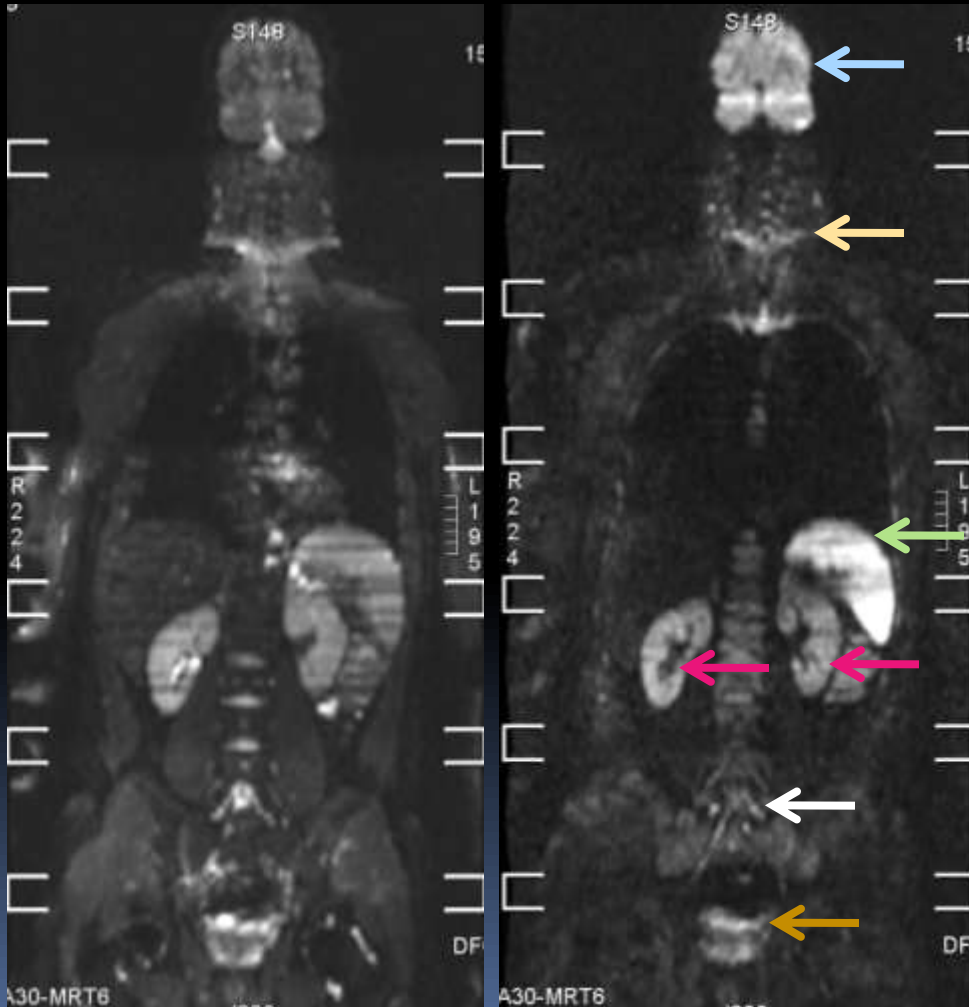
$< 0,001$
asis: b'



$b1000 + (ADC < 0,0014)$

Diffusion-weighted anatomy

1/ organs physiological high signal on b1000 image



← Brain

← artefact

← spleen

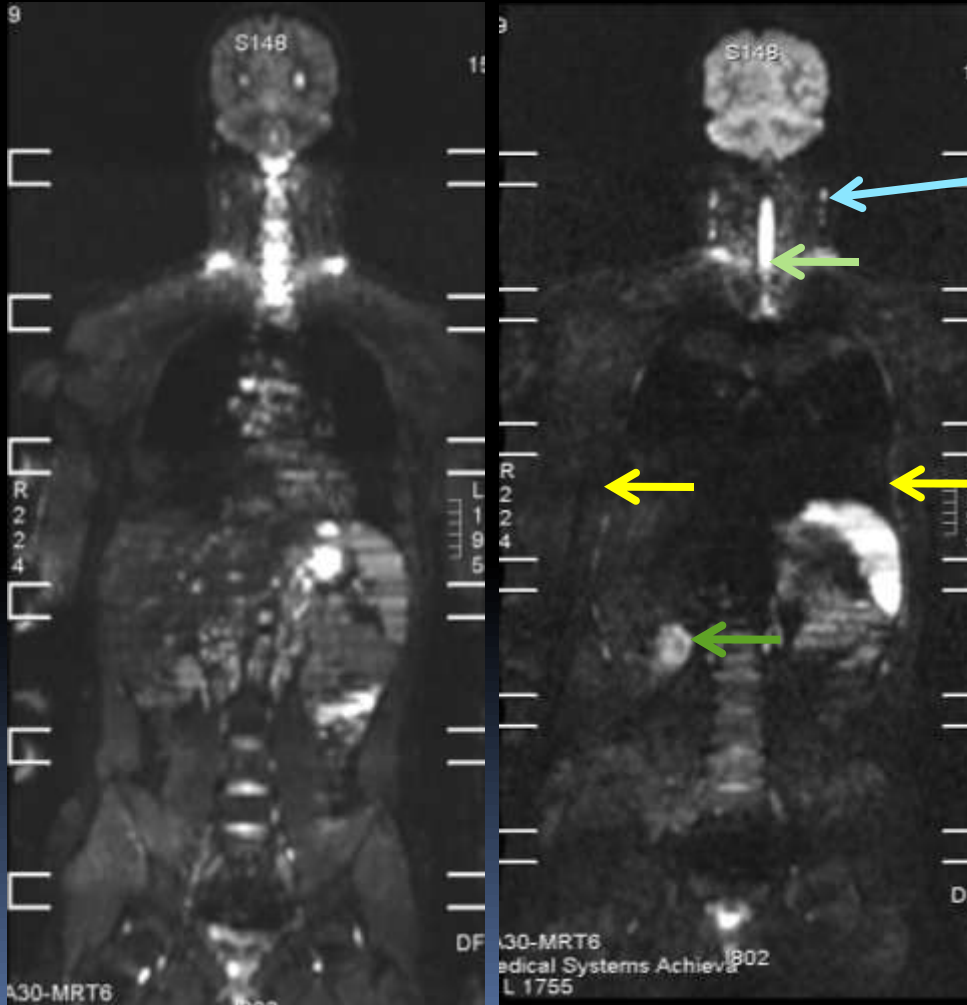
← kidney

← Nerve roots

← T2 shine through
Fluid in bladder

Diffusion-weighted anatomy

1/ organs physiological high signal on b1000 image



← Normal lymph node

← Spinal cord

← Rib cartilage

← T2 shine through
gallbladder

Primary tumor detection

- Potential additional value of DW-MRI to FDG-PET for tumor types with variable FDG-uptake or where value of FDG-PET for T-staging is limited?

Bruzzi JF, Radiographics 2007

- Compared to anatomical imaging, DW-MRI using b-values ranging from b500 to b1000, improves the detection of small nodal metastases and tumoral deposits in the peritoneum, bowel serosa, omentum and mesentery.

Low R et al; J Magn Reson Imaging 2007

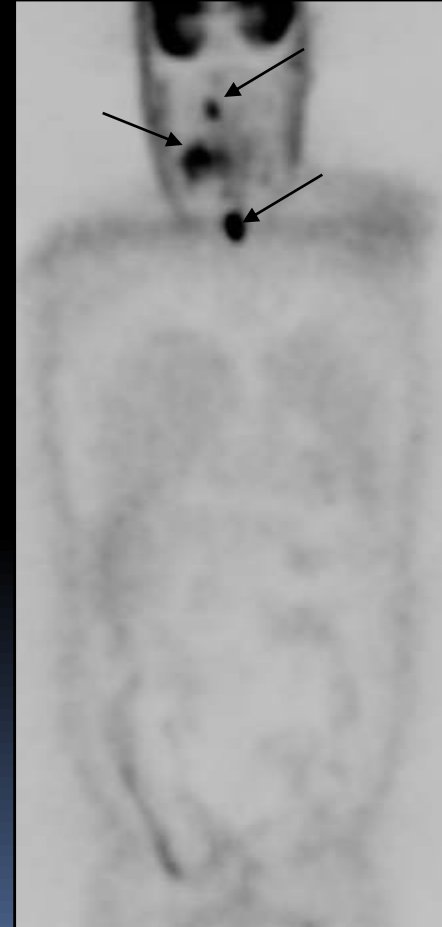
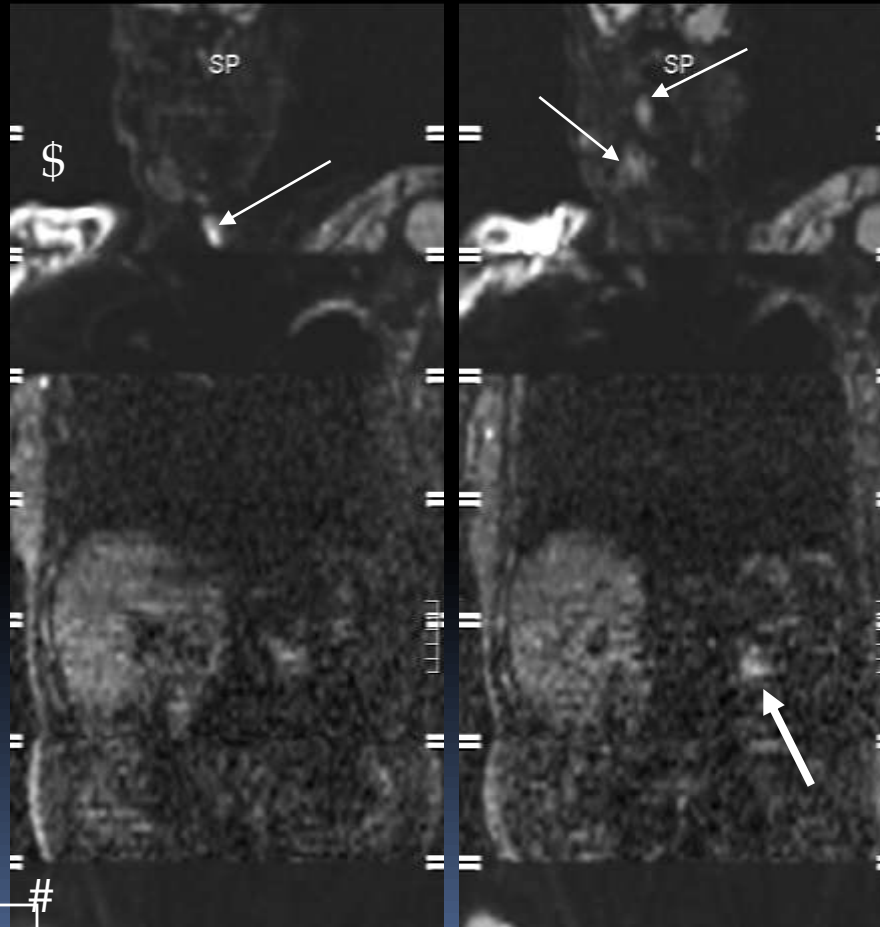
Can DWI help to improve lesion conspicuity?

- Second primary tumors and unknown primary
- patients at risk or with common cancerogenic risk
 - *Head and neck cancer*
 - *Lung cancer*
 - *Esophageal cancer*
 - *Colorectal cancer*

(Second) primary tumor

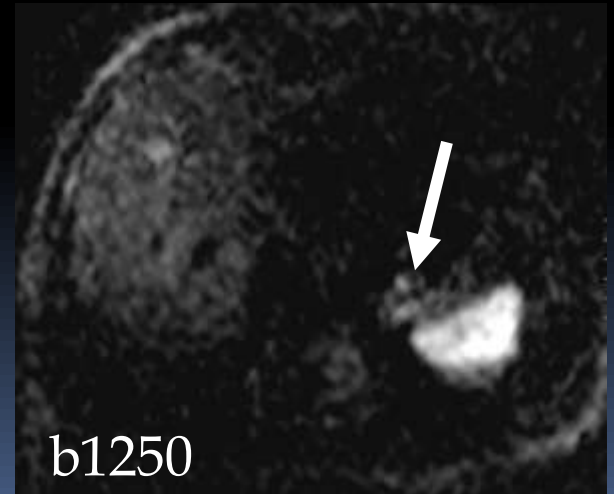
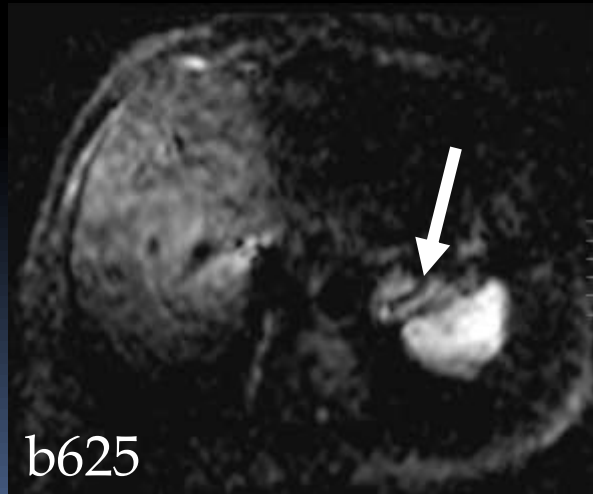
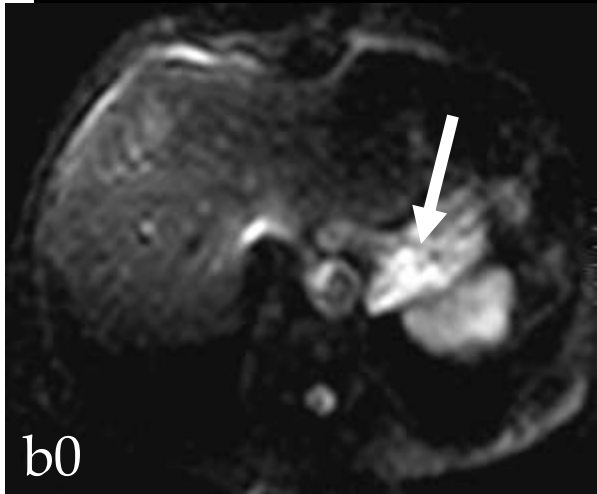
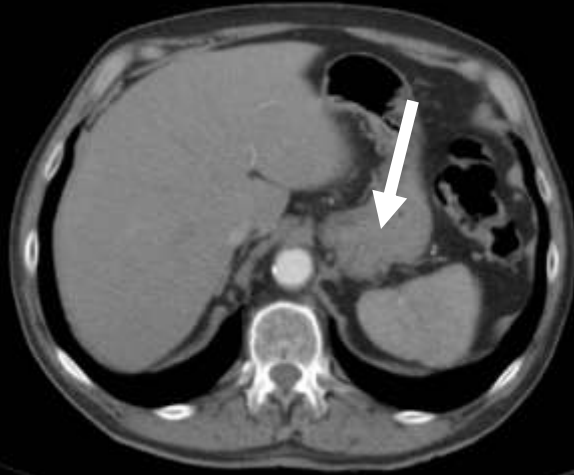
Potential additional value of DW-MRI to FDG-PET for tumor types with variable FDG-uptake or where value of FDG-PET for T-staging is limited

Bruzzi JF, Radiographics 2007



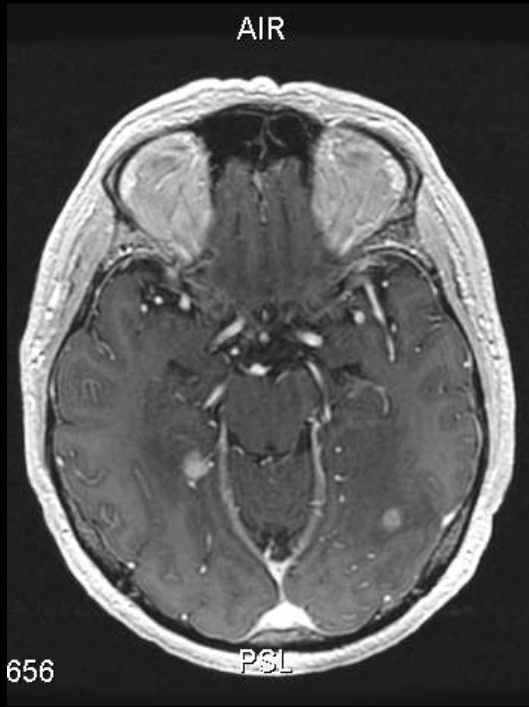
\$ Titanium shoulder prosthesis
Titanium hip prosthesis

(Second) primary tumor



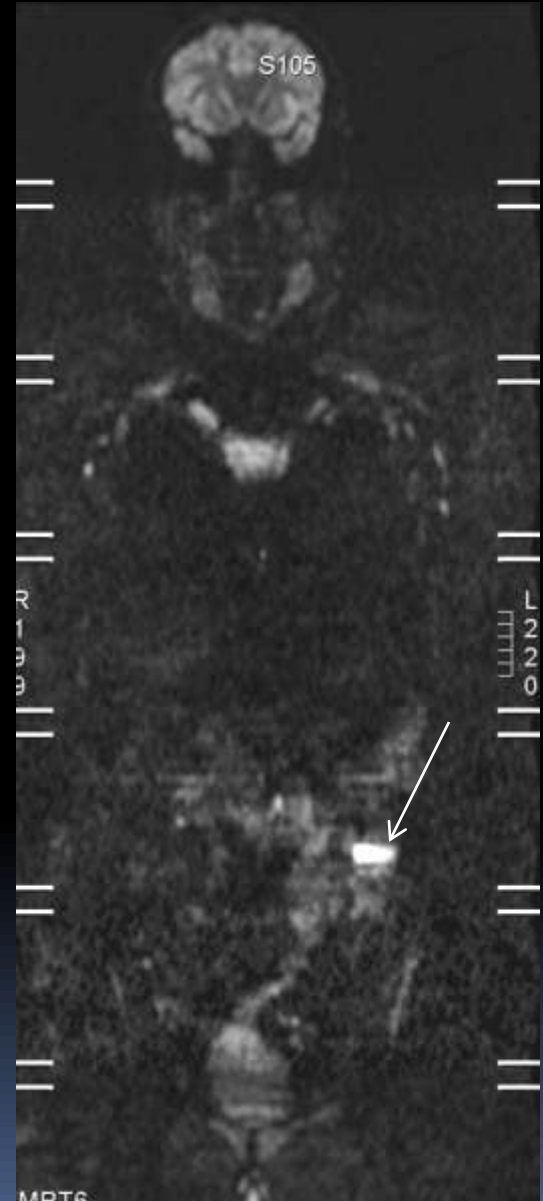
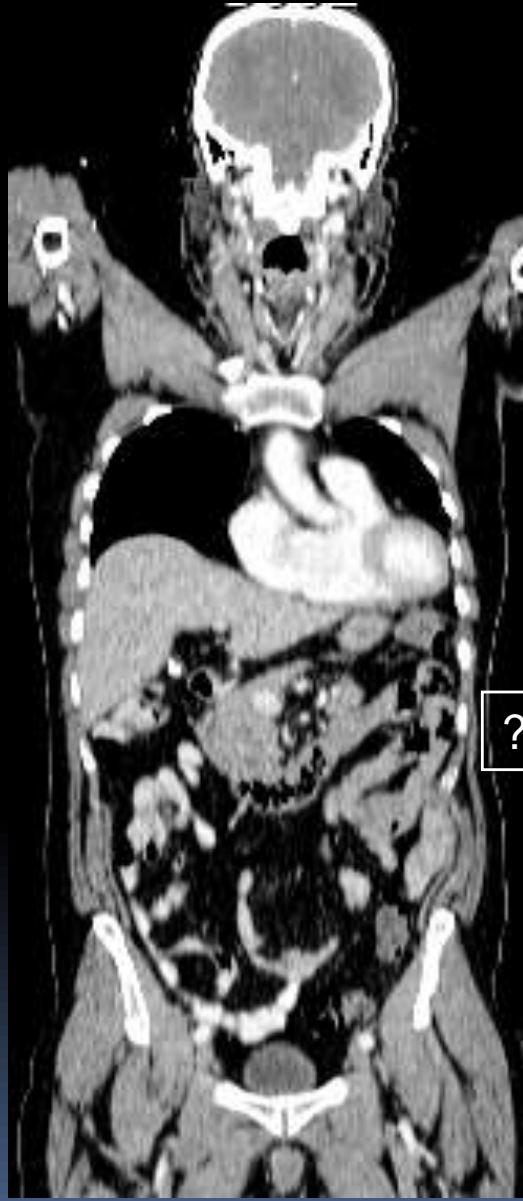
Biopsy proven gastric adenocarcinoma

Primary tumor: microstructural/metabolic fusion

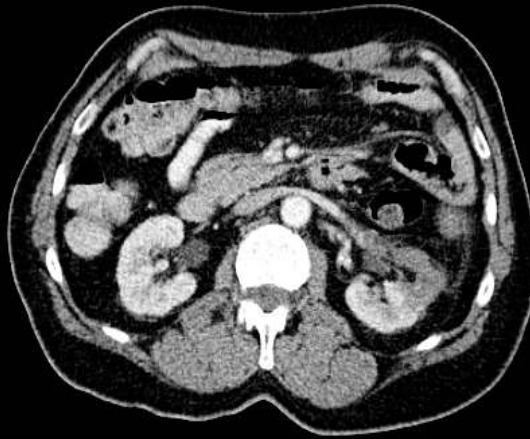
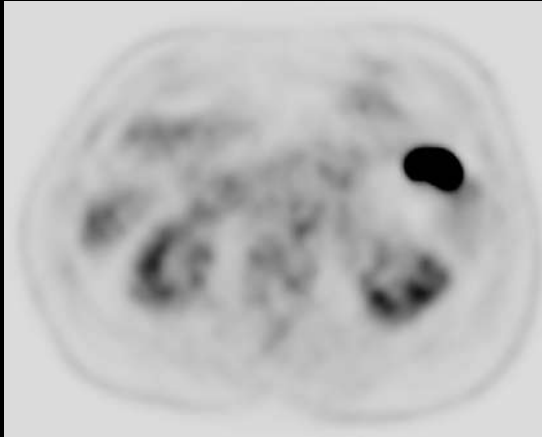


Primary tumour?

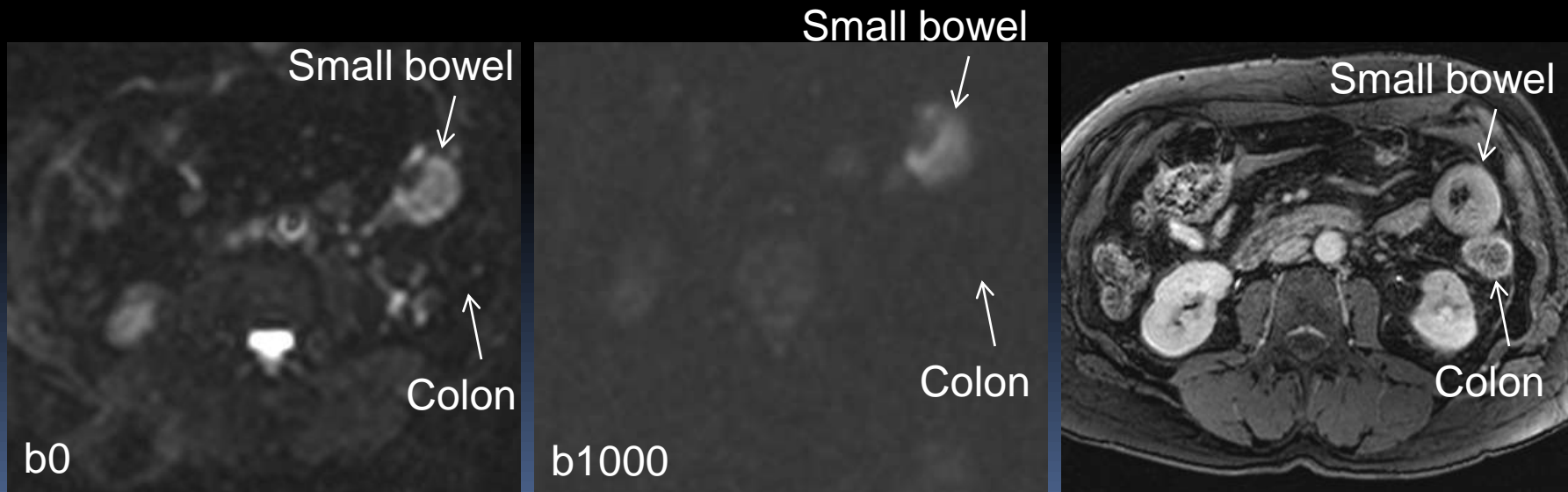




Primary tumor: microstructural/metabolic fusion



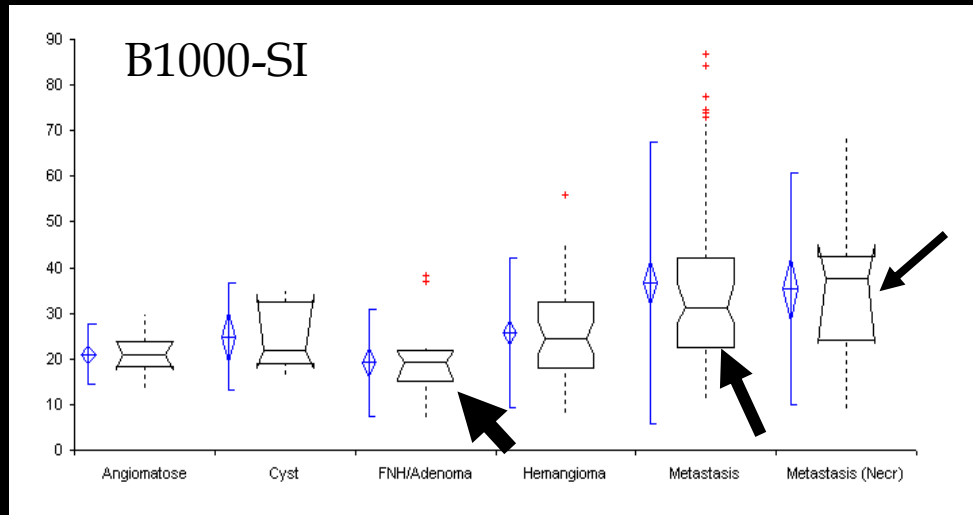
Improved lesion conspicuity – availability of functional and anatomical data



Non-invasive background correlation for PET with rapid acquisition

Systemic metastases: liver

56 patients with primary tumor
 Sens = 96,6%
 Spec = 93%

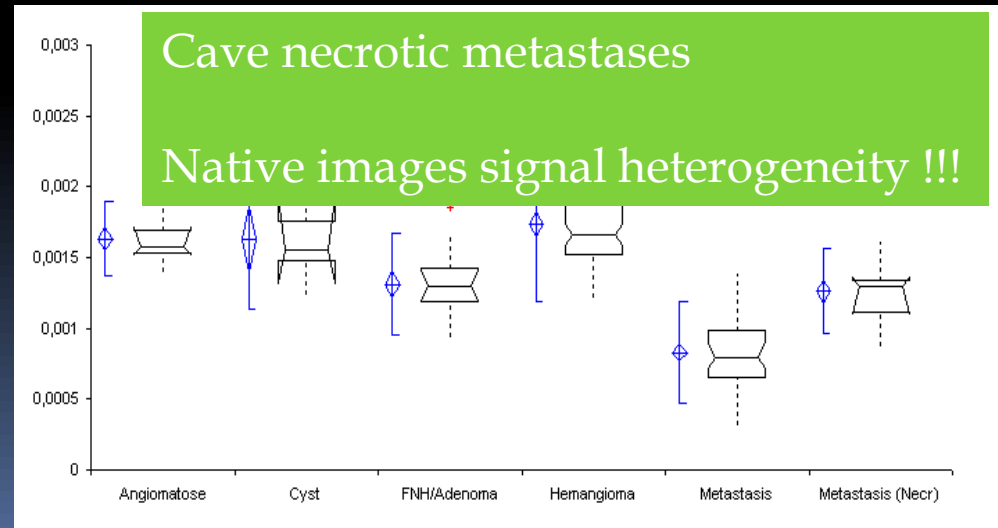


Metastases: Native DWI b50-b1000

b1000 - => NPV > 90%
 STOP

b1000 + => ADC
 => $T2_{(Te63/Te263)}$

Metastases - hemangioma - FNH/adenoma



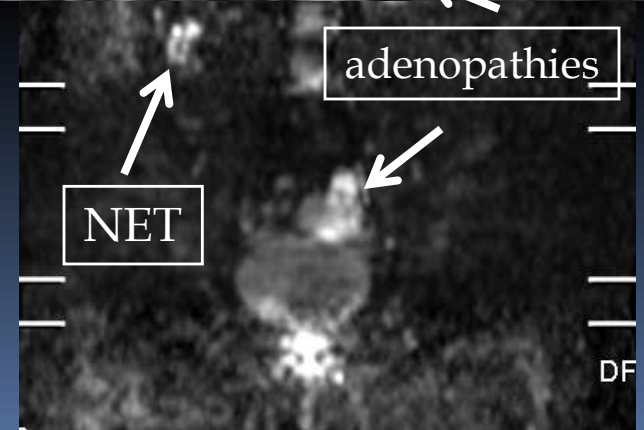
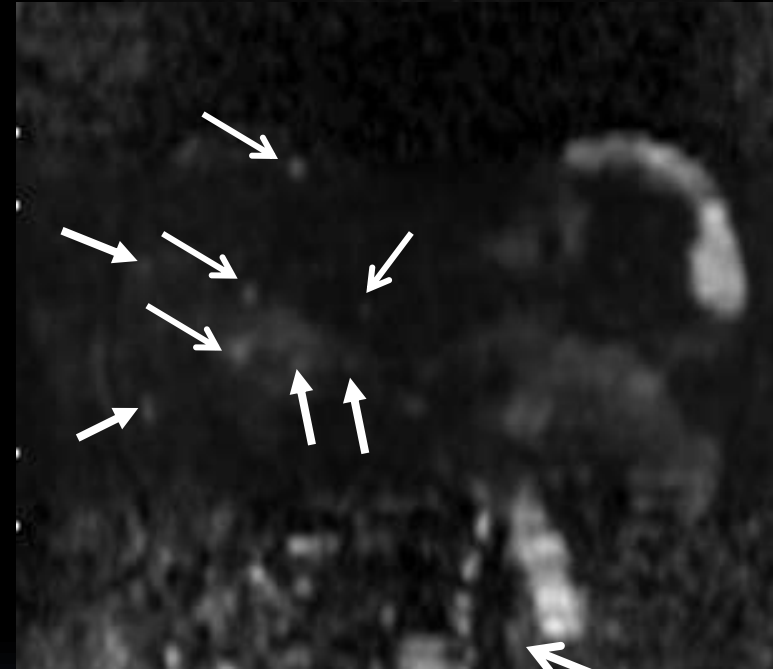
Systemic metastases: liver

Disease extent in neuro-endocrine tumor :
carcinoid syndrome - hepatic metastases?



Lower resolution limit of 4 mm maintained in
Whole-body imaging protocols

High lesion to background conspicuity →
High accuracy for liver metastases screening



Systemic metastases: liver

Patient treated with SIRS for isolated hepatic metastases of rectal cancer

Significant increase of liver enzymes and (direct) bilirubine
Jaundice

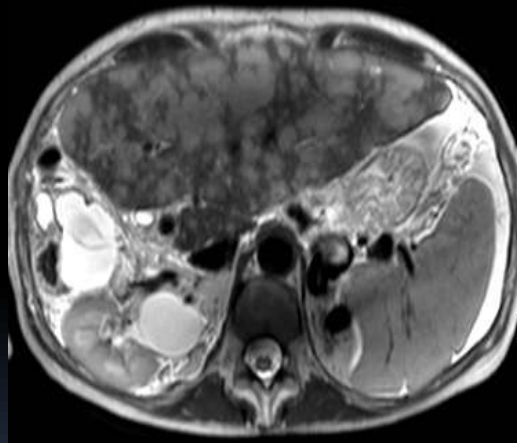
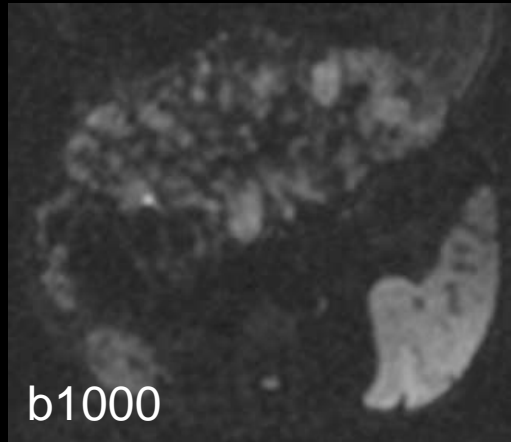
Tumoral progression versus biliary obstruction versus toxic hepatitis



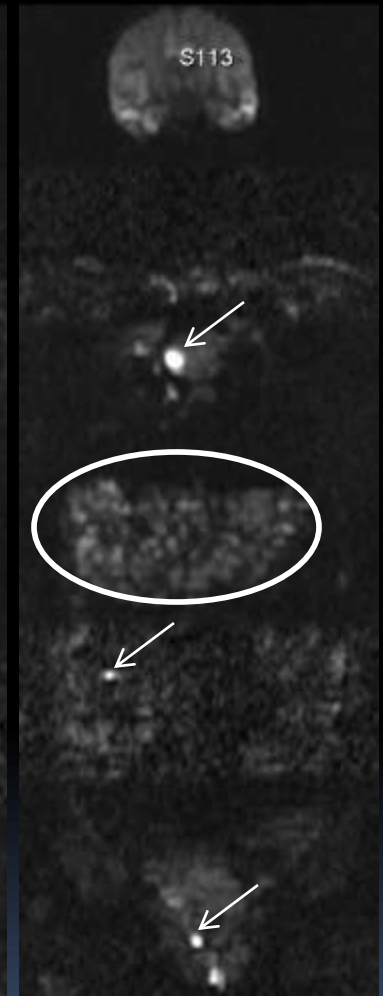
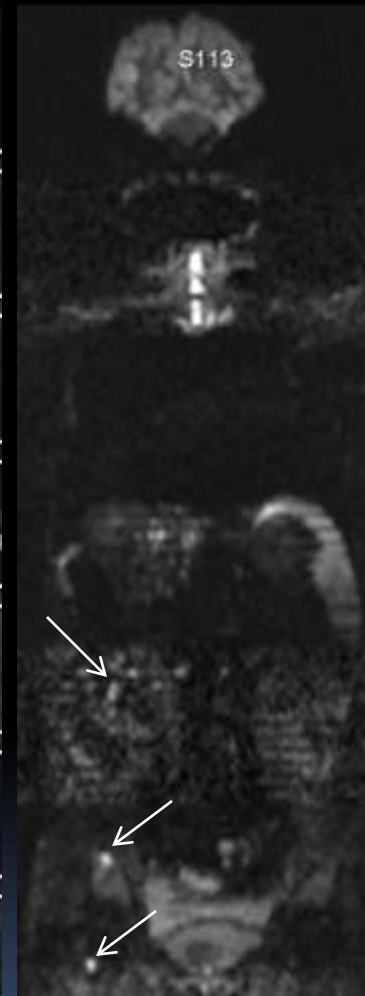
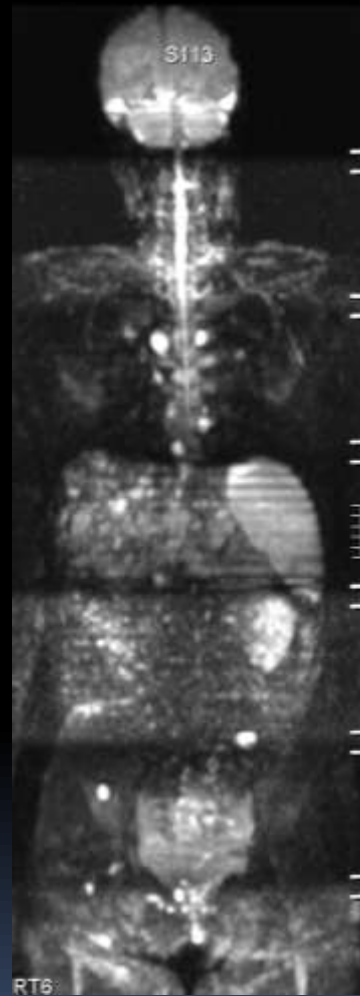
MRI liver → MRI whole-body: - Assess liver parenchyma
- Distant metastases? Change to systemic Chemotherapy

Systemic metastases: liver

b1000: liver – peritoneal – skeletal M+

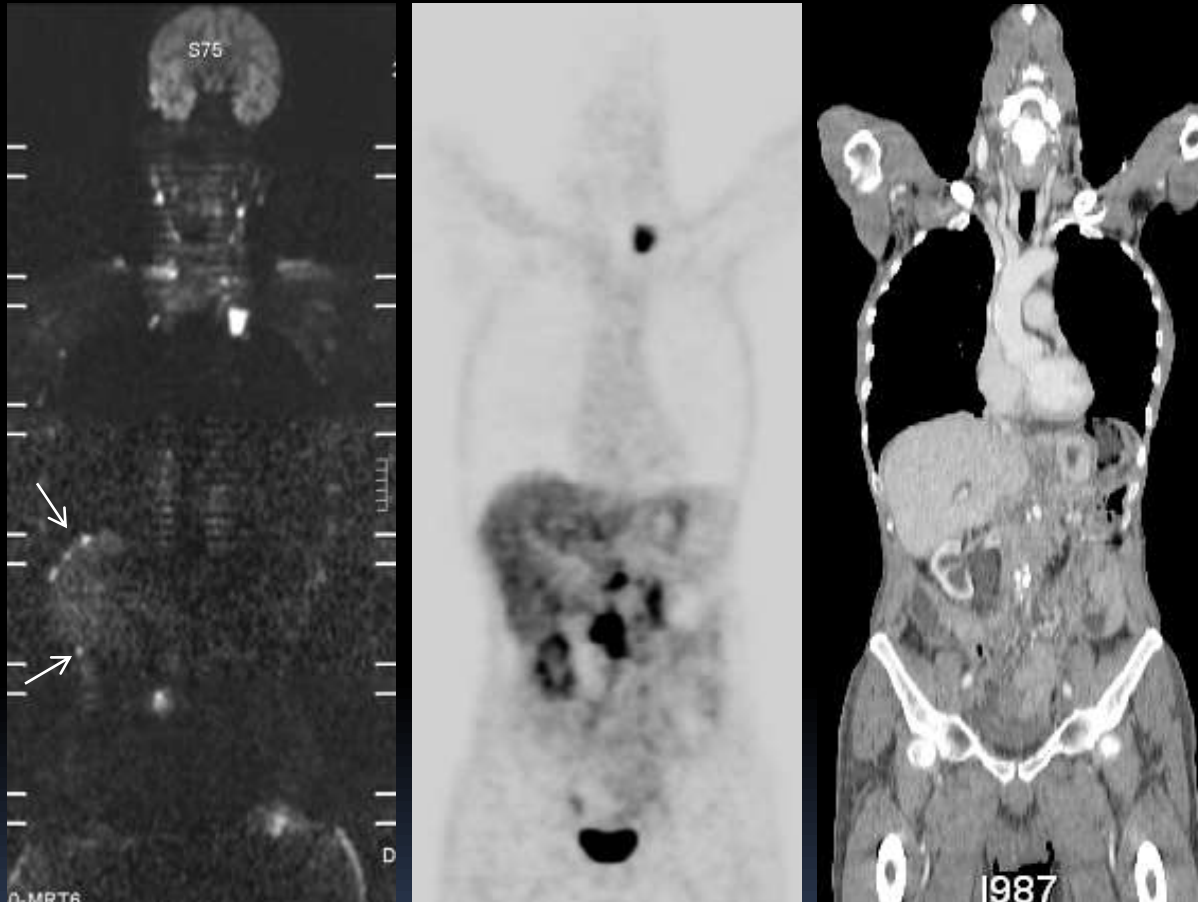


Diffuse liver metastases



20 minutes scanning time: hepatic evaluation and mapping of distant metastases
→ treatment modulation

Systemic metastases: peritoneal disease



DWI shows increased accuracy for detection of peritoneal metastases:
Preferentially in combination with anatomical imaging
Improved lesion conspicuity by DWI

Systemic metastases: lung

Currently unknown what to expect with DWI.

No major series in literature

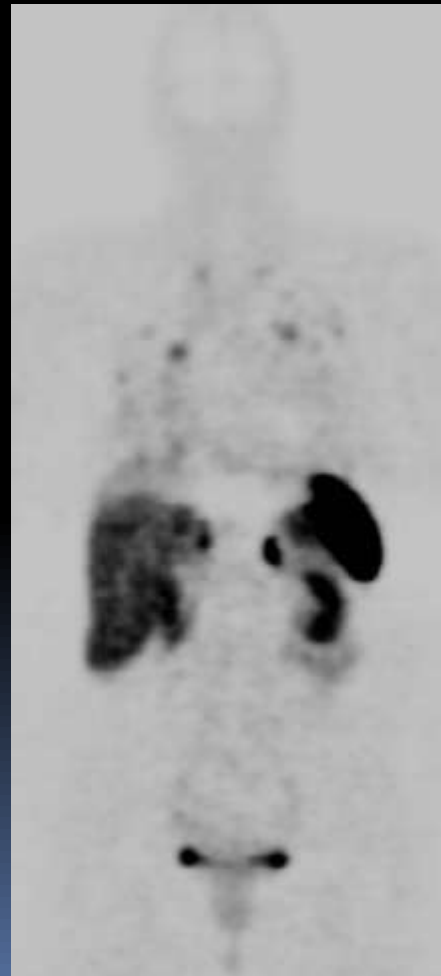
Artefacting due to air versus signal-to-noise ratio ?

Resolution?

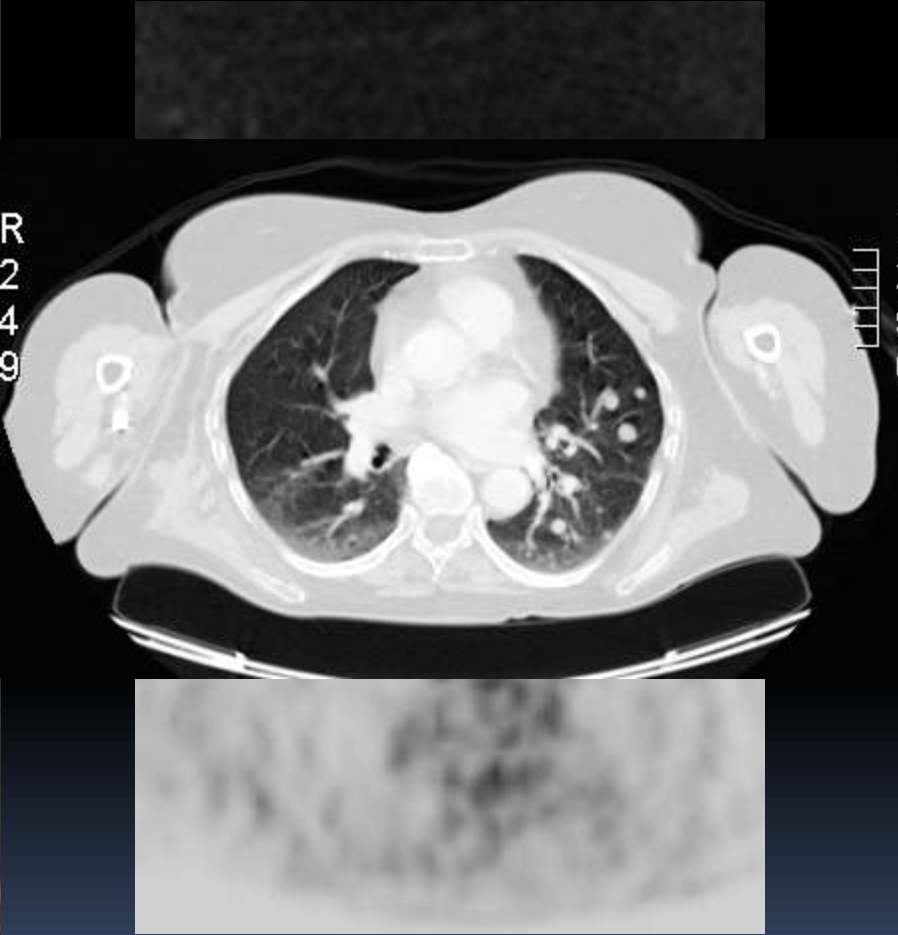
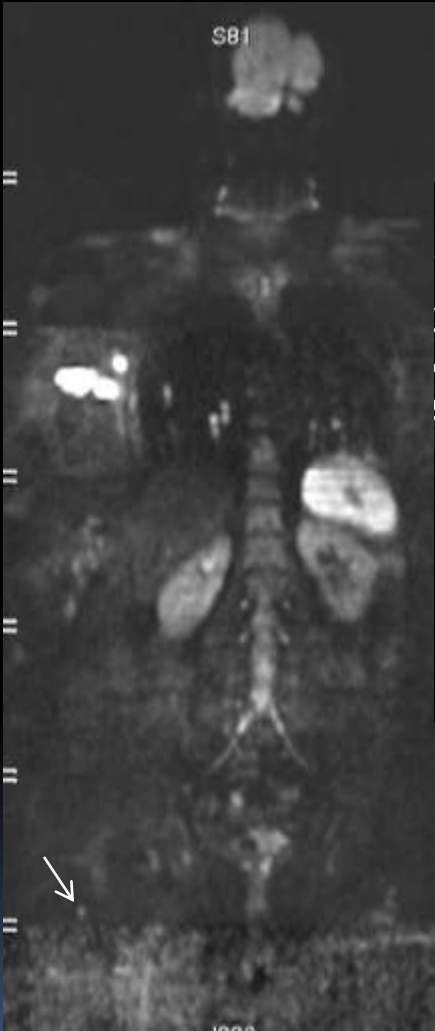
However.....

DWI versus FDG-PET:

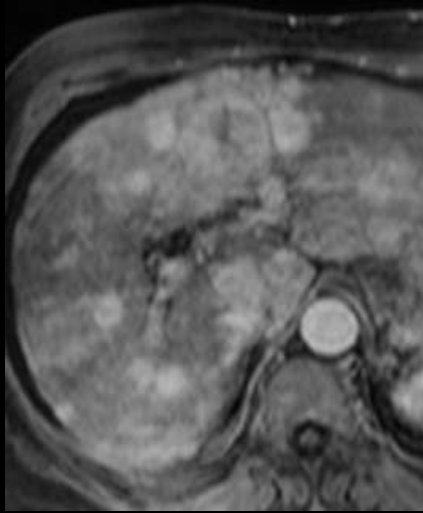
- Independent of metabolic activity
- Relatively high resolution for functional imaging modality
- Maximize signal to noise
 - 3 Tesla
 - Maximum gradient strength
- Add chest CT or high resolution 3D gradient echo T₁ sequence



Systemic metastases: lung



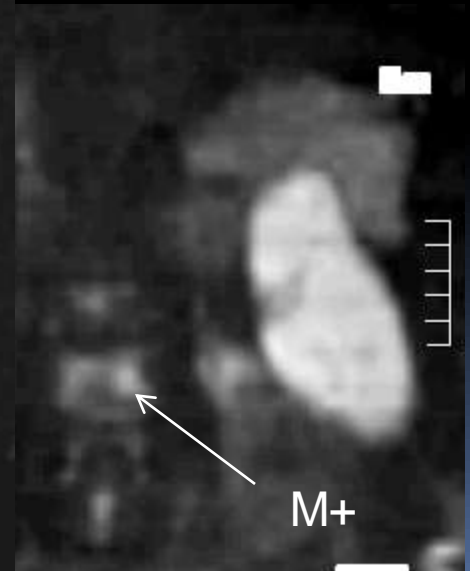
Systemic metastases: skeletal



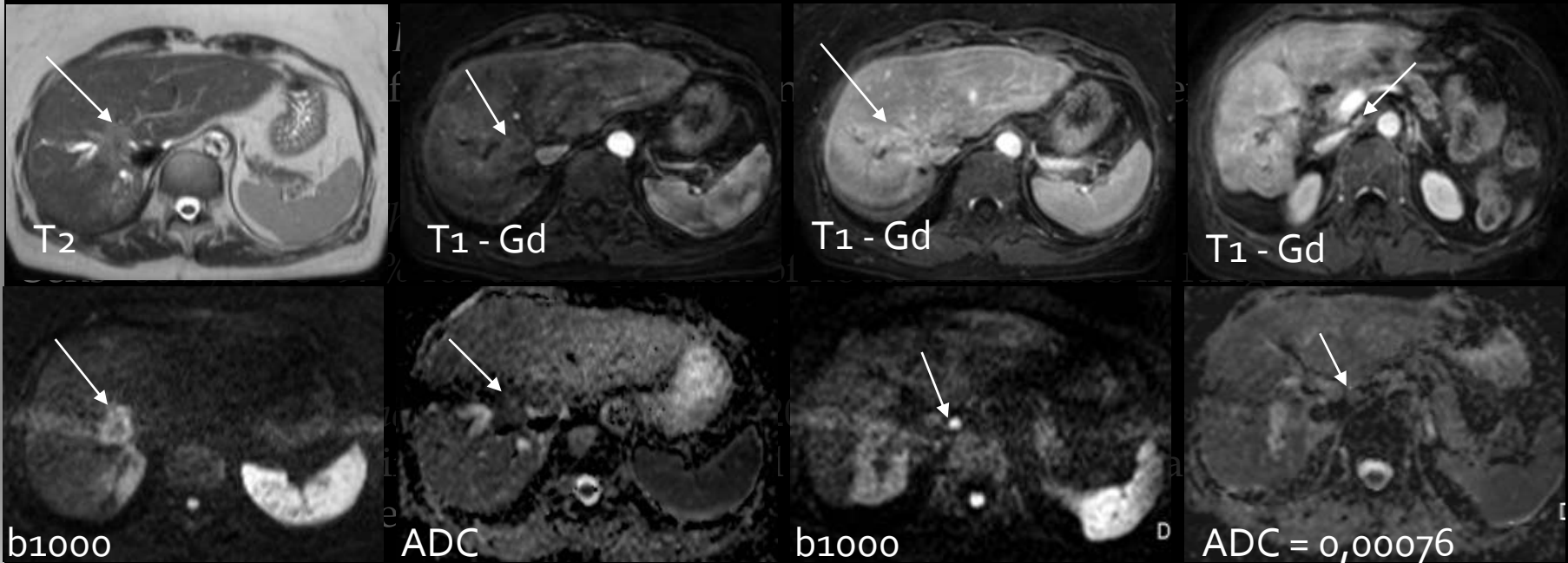
Diffuse HCC → chem



3 months follow-up – systemic therapy



Nodal staging – ADC



Sakurada A et al *Eur Radiol* 2009

Sens=78%; spec=56% for differentiation of nodal metastases in esophageal cancer

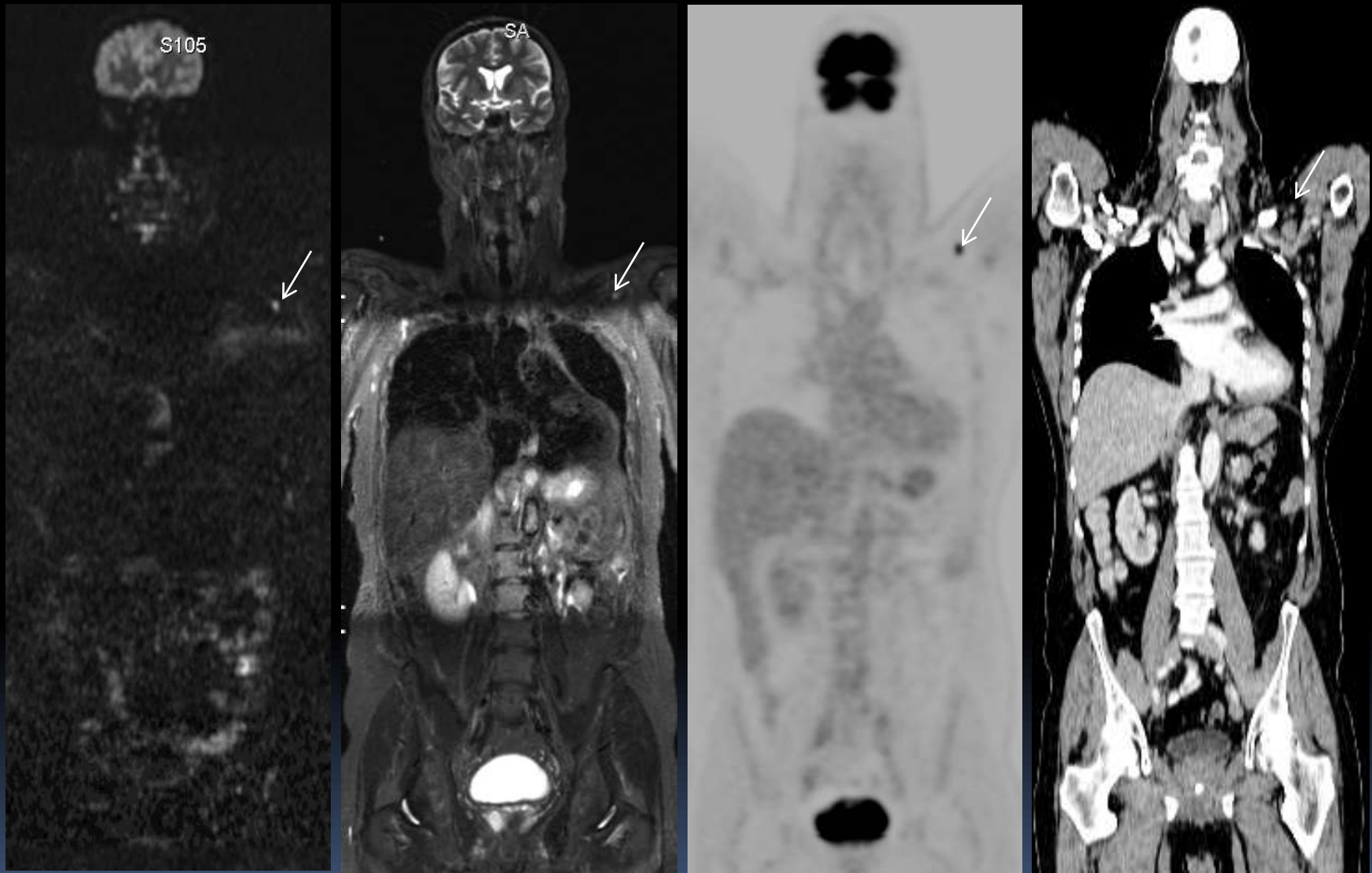
Vandecaveye V et al *Radiology* 2009

Sens=84 %; spec=94% for differentiation of nodal metastases in head and neck cancer

Influence of chosen b-values -----> at least b0-b1000, multiple b-values

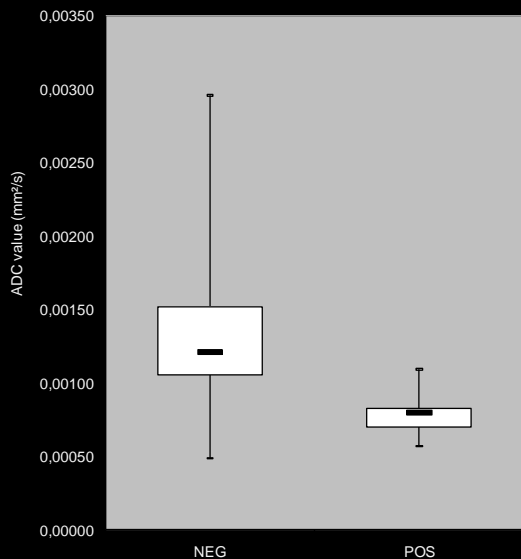
Tumor type related – “diffusion avidity”?

Nodal staging – ADC



Improved detection and nodal differentiation (subcentimetre)
Correlation with metabolic imaging

Nodal staging: Lymphoma



□ DWI in relation to FDG-PET

Sensitivity and specificity

- Nodal disease: 95% / 92% (ADC)
- Extranodal disease: 95% / 90% (b1000)

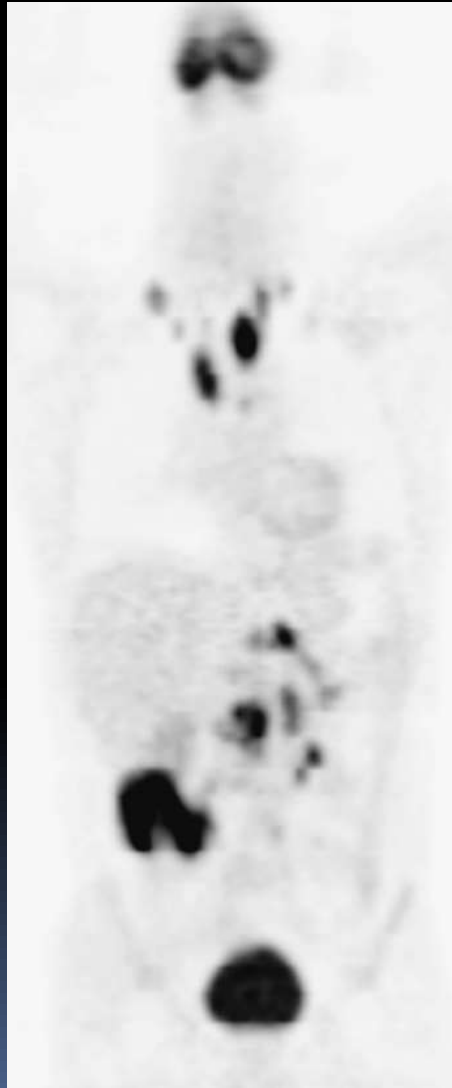
□ Ann-Arbor Classification

- Full concordance between WB-DWI and (18)FDG-PET-CT staging

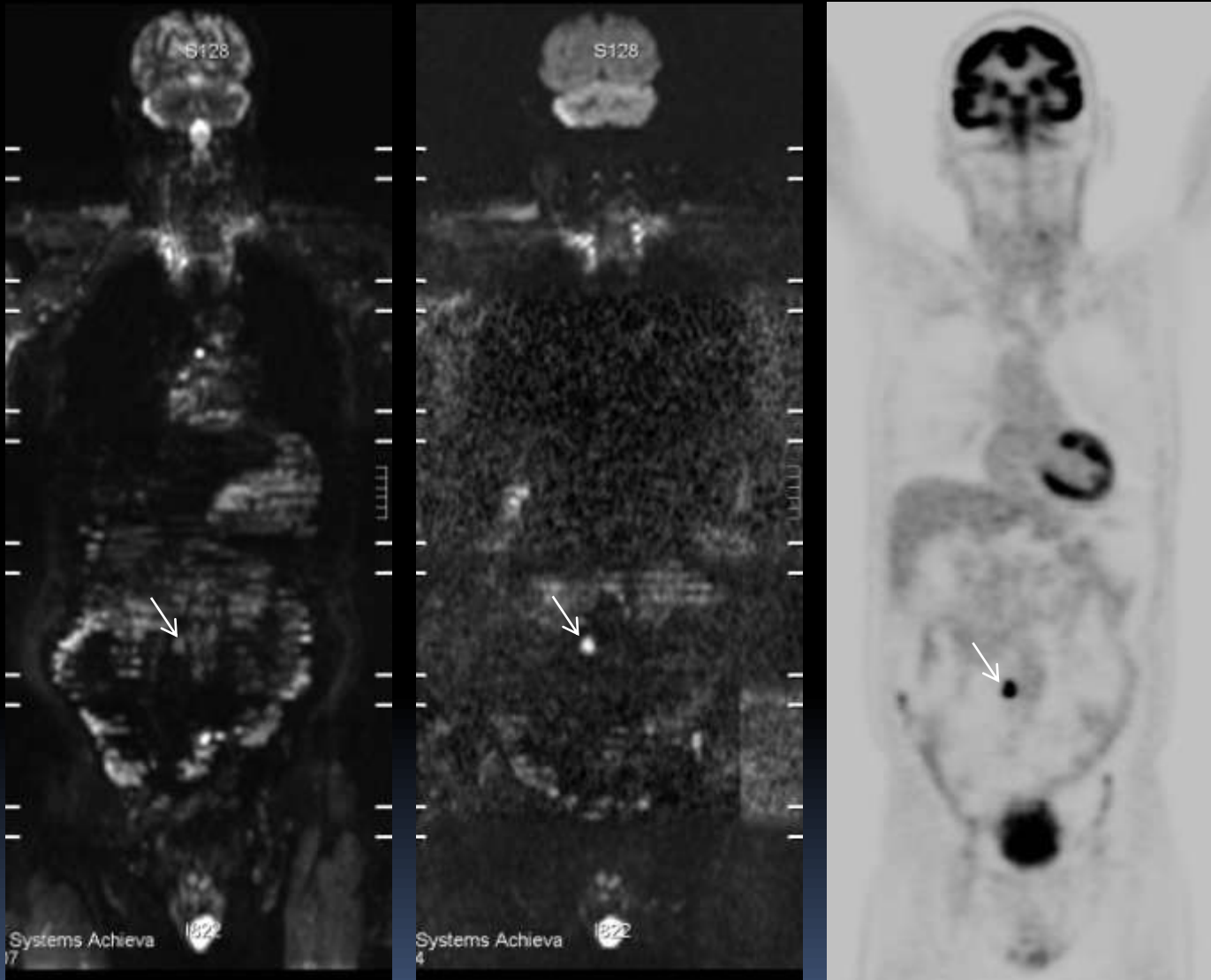
Patient	Whole body-DWI staging							(18)FDG-PET-CT staging							Clinical staging
	Infradiaphragmatic	Supradiaphragmatic	Bone invasion	Organ invasion	Single localisation	Multiple localisation	Ann Arbor staging	Infradiaphragmatic	Supradiaphragmatic	Bone invasion	Organ invasion	Single localisation	Multiple localisation	Ann Arbor staging	
1	0	0	0	0	0	0	I	0	0	0	0	0	0	I	+
2	1	1	0	1	0	1	IIIS	1	1	0	1	0	1	IIIS	IV**
3	1	1	0	1	0	1	IV	1	1	0	1	0	1	IV	IV
4	1	0	0	0	0	1	II	1	0	0	0	0	1	II	II
5	1	0	0	1	1	0	IV	1	0	0	1	1	0	IV	IV
6	1	1	1	1	0	1	IV	1	1	1	1	0	1	IV	IV
7	0	1	0	0	0	1	II	0	1	0	0	0	1	II	II
8	1	1	0	1	0	1	IV	1	1	0	1	0	1	IV	IV
9	0	1	0	0	1	0	I	0	1	0	0	1	0	I	I
10	1	1	0	0	0	1	III	1	1	0	0	0	1	III	IV**
11	1	0	1	0	0	1	IIIE	1	0	1	0	0	1	IIIE	II
12	1	1	0	1	0	1	IV	1	1	0	1	0	1	IV	*
13	1	1	1	1	0	1	IV	1	1	1	1	0	1	IV	IV
14	0	1	0	0	0	1	II	0	1	0	0	0	1	II	II

* no clinical staging found
** undetectable skin / bone invasion

Lymphoma: Stage IV

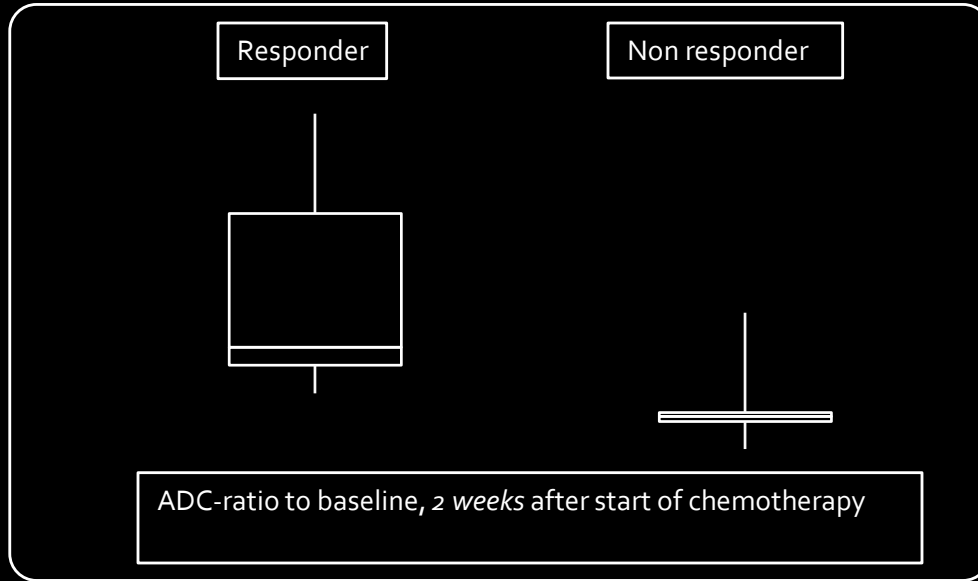


Lymphoma: Stage I



B1000 based detection → ADC based differentiation

Early response assessment



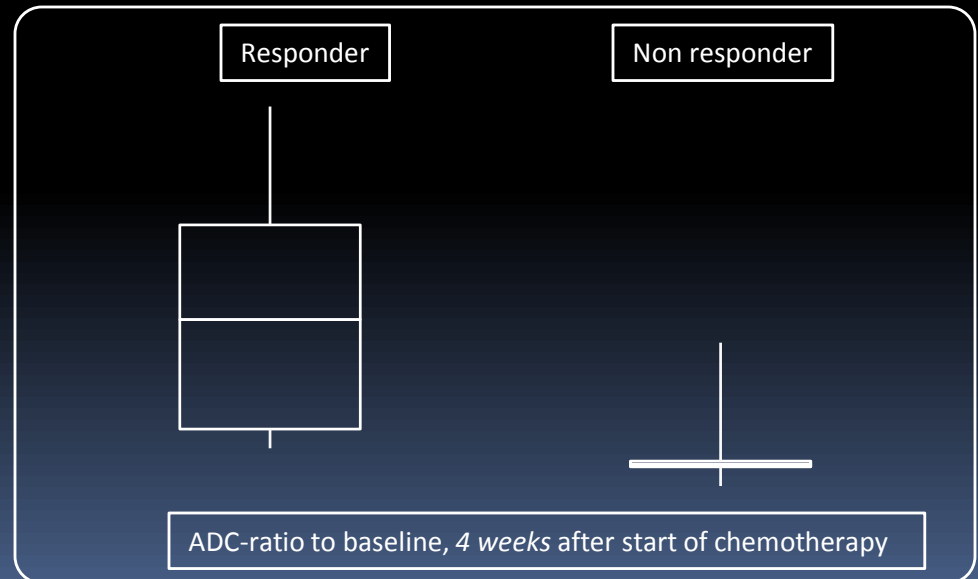
20 patients with non-Hodgkin Lymphoma
Baseline – 2 weeks – 4 weeks

Correlation to FDG-PET at 6 months

Predictive value of early ADC changes in correlation to baseline?

$p=0.001$

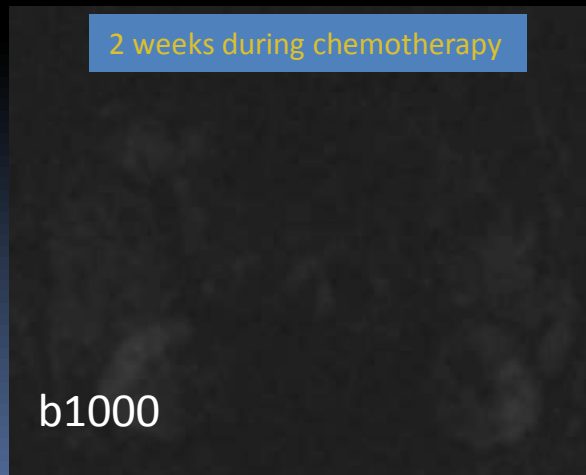
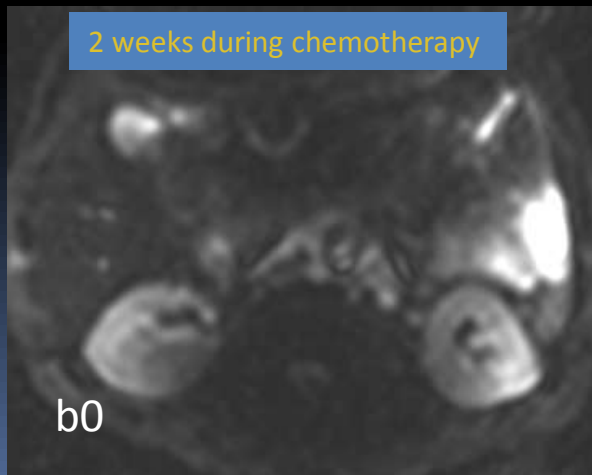
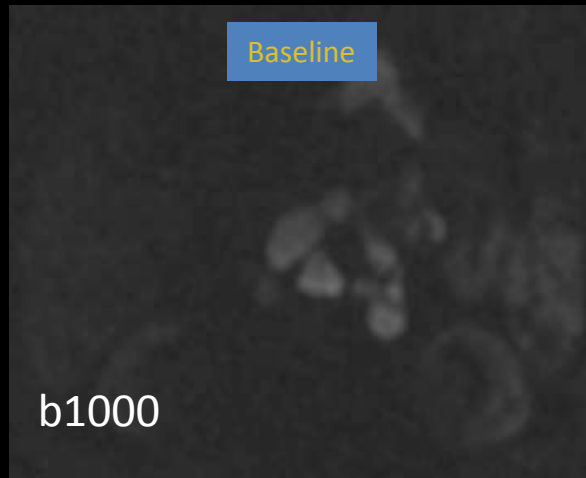
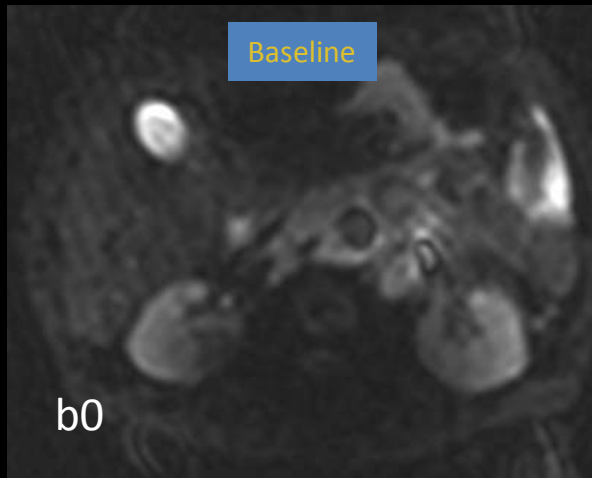
Whole body assessment of Curative systemic treatment of multifocal disease



$p=0.003$

treatment prediction at response **2 weeks**

→ Correlation between early microstructural response and later metabolic response



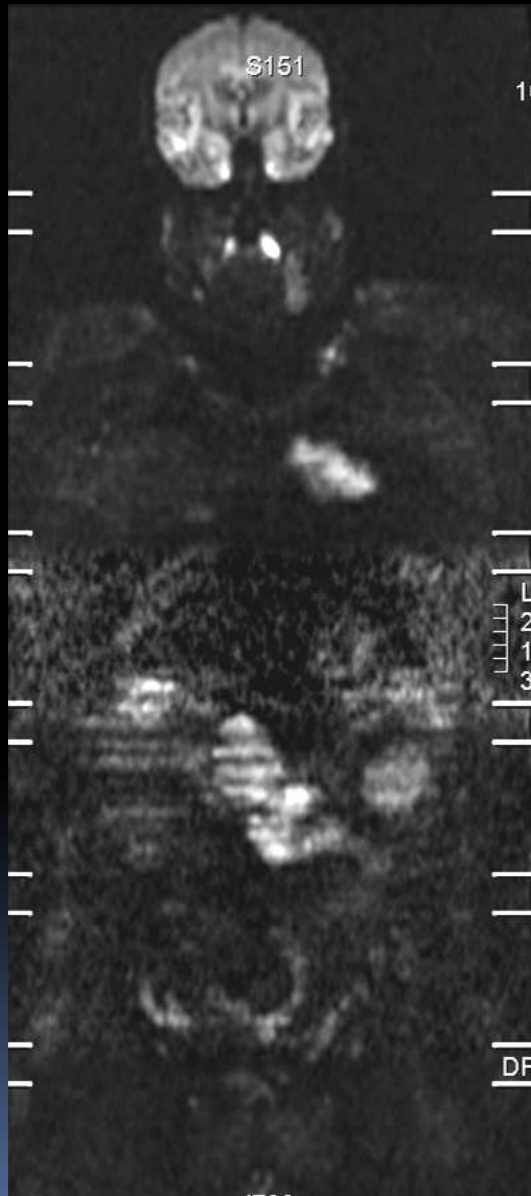
treatment prediction at response **2 weeks**

→ Correlation between early microstructural response and later metabolic response

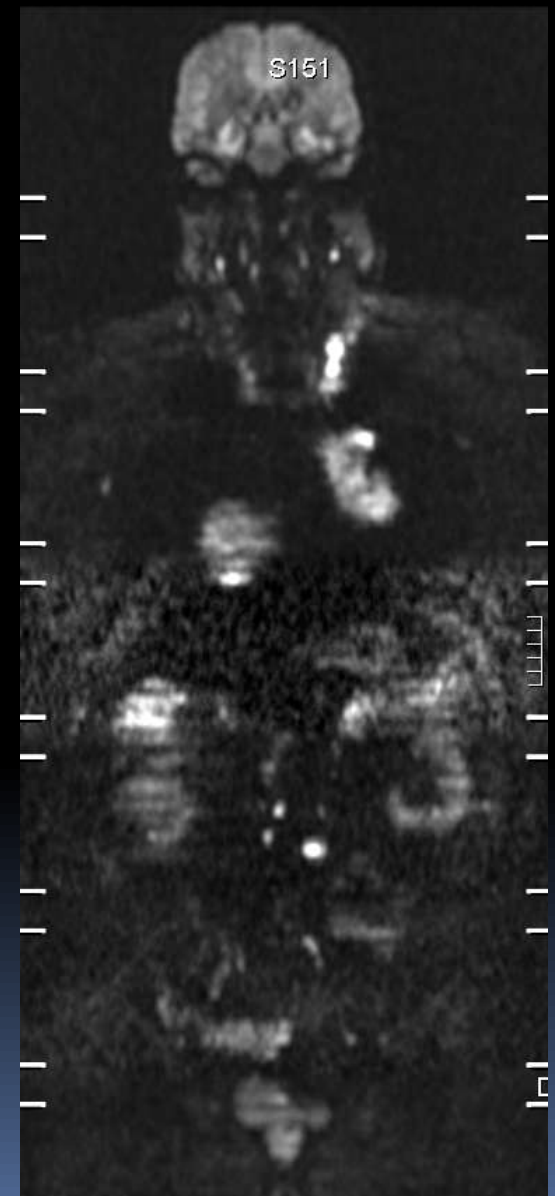


treatment prediction at response **2 weeks**

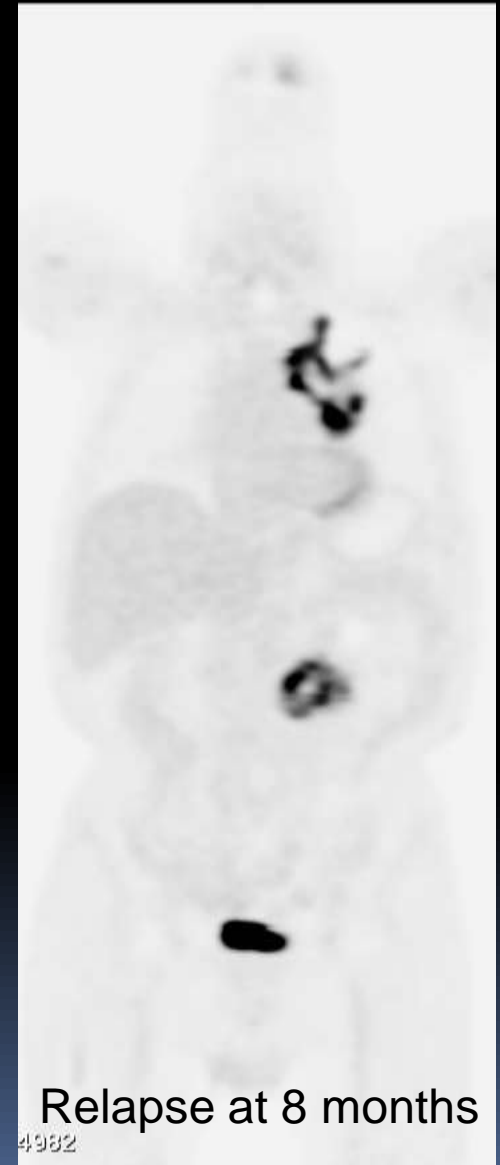
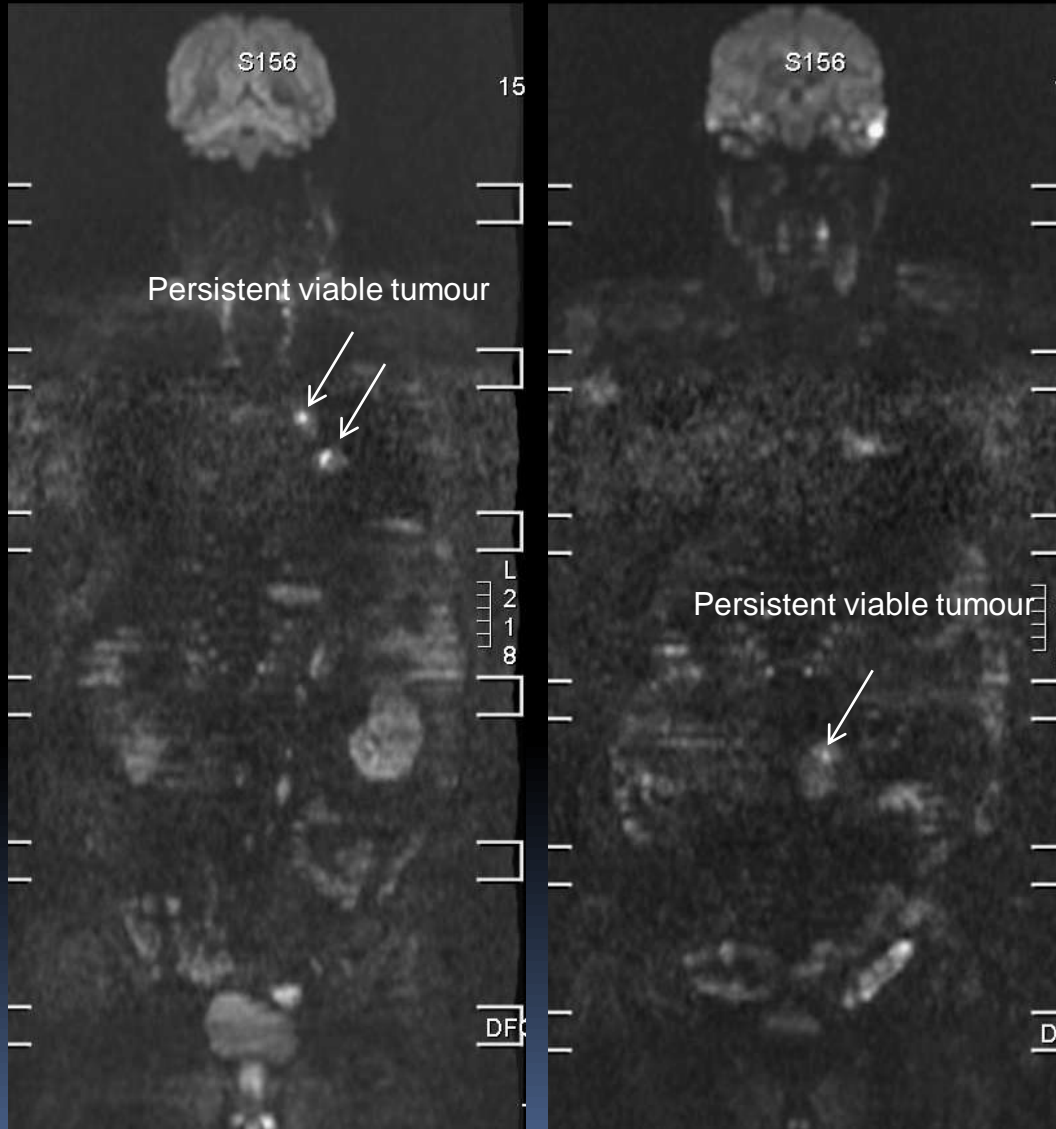
→ Correlation between early microstructural response and later metabolic response



Baseline DWI:
Lymphoma stage III



DWI after 1 cycle CHOP: heterogeneous b1000 – low ADC – incomplete eradication



Where are we now?

- Work in progress

Sequence standardization: According to field strength

According to indication (need of anatomical sequences?)

Image analysis standardization: high b-value

ADC

Thresholds

- T and M stage assessment

- N stage assessment: simplification of evaluation, tumour types?

- Image fusion: providing a microstructural background to metabolic imaging rather than anatomical background.

Improved lesion conspicuity combined with ability for characterization in 1 sequence



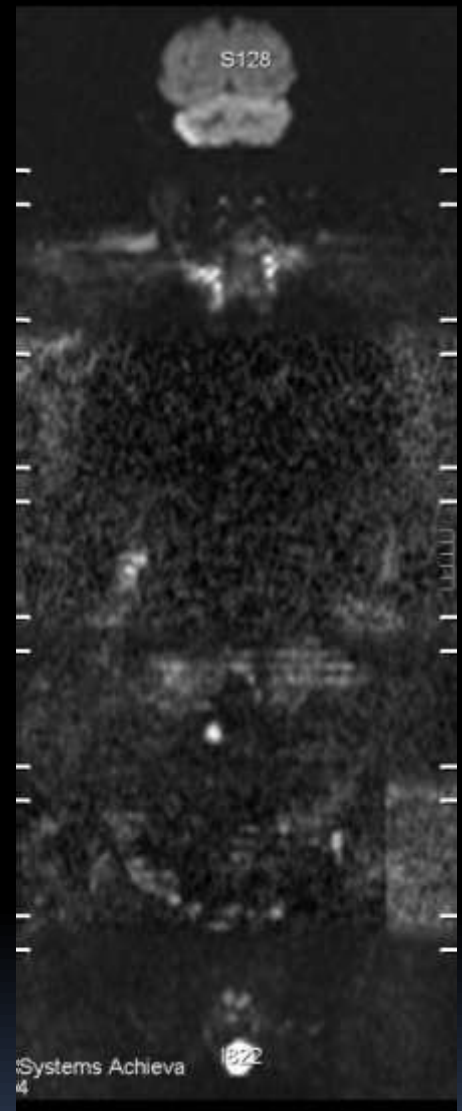
Different correlation between tumor physiology/structure and image generation

*Combine advantages of metabolic and microstructural imaging
Microstructural background to targeted tracers?*

Improved lesion detection compared to conventional Anatomical imaging modalities

Complementary value towards lesion differentiation

*Example: Post-treatment: inflammation does not cause false positive on DWI
Nodal differentiation (subcentimetre)*



Ceci n'est pas un PET