

# Stereotactic body radiotherapy in the management of liver tumours

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# Role of PET/CT in SBRT?

## **Dose-painting: diagnostic target of PET/CT = lesion**

- Heterogeneous dose distribution: radioresistant sub-volumes of the tumour are planned to receive higher doses than averagely sensitive sub-volumes as defined by functional imaging
- To avoid high doses of radiation to the best functioning parts of the normal tissue surrounding a tumour in order to spare organ function

## **Functional treatment planning (FTP): diagnostic target of PET/CT = surrounding normal tissue**

- inclusion of functional imaging of normal tissue into the treatment planning process in contrast to anatomical treatment planning (ATP) that only considers anatomical structures

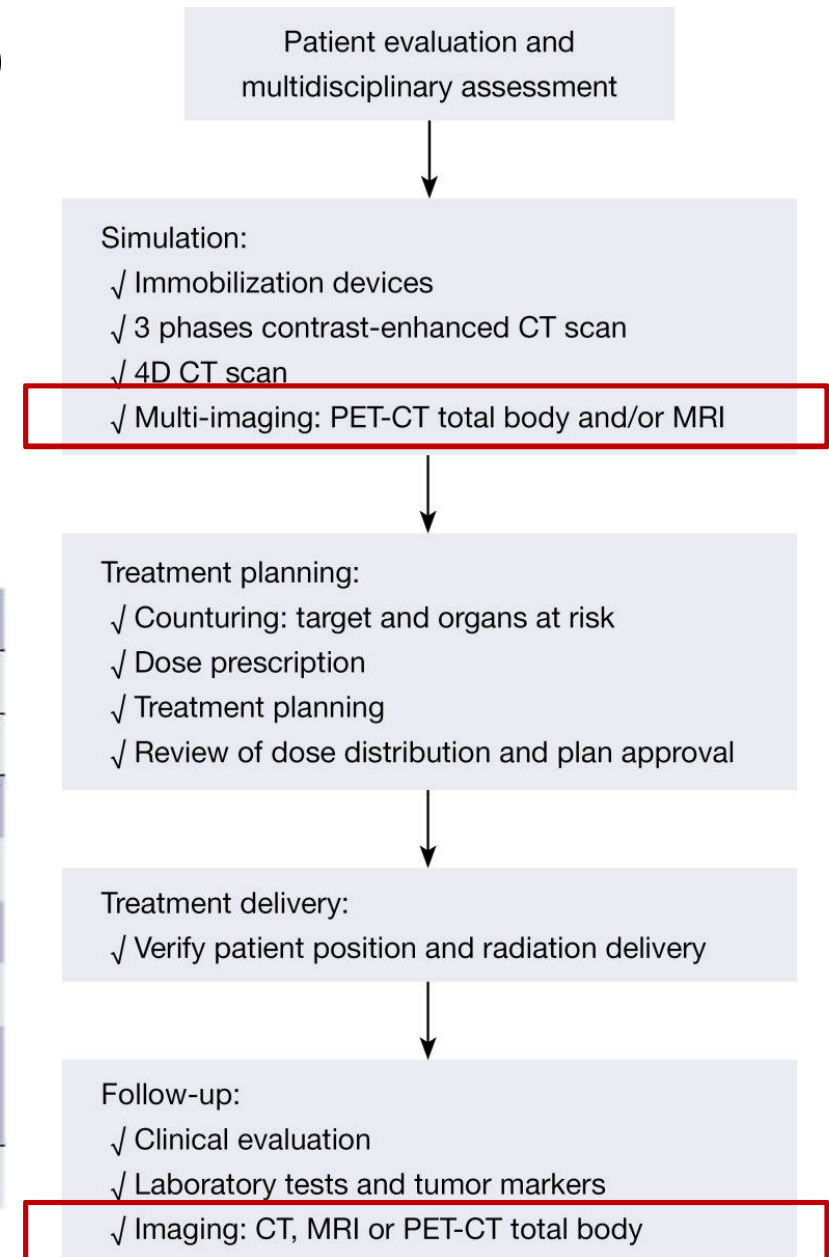
# Role of PET/CT in SBRT?

- Primary liver tumours (HCC, CAC)
- Metastatic liver tumours (CRC, breast cancer, lung cancer, other...?)
- Which radiopharmaceutical?
- Which diagnostic target?
- Selection criteria for patients?

**Table 2** Selection criteria for SBRT

Selection criteria	Patients categories		
	Suitable	Cautionary	Unsuitable
Lesion number	<3	4	>4
Lesion diameter (cm)	1-3	>3 and ≤6	>6
Distance from OARs (mm)	>8	5-8	<5
Liver function	Child A	Child B	Child C
Free liver volume (cc)	>1,000	<1,000 and ≥700	<700

SBRT, stereotactic body radiation therapy; OARs, organs at risk.



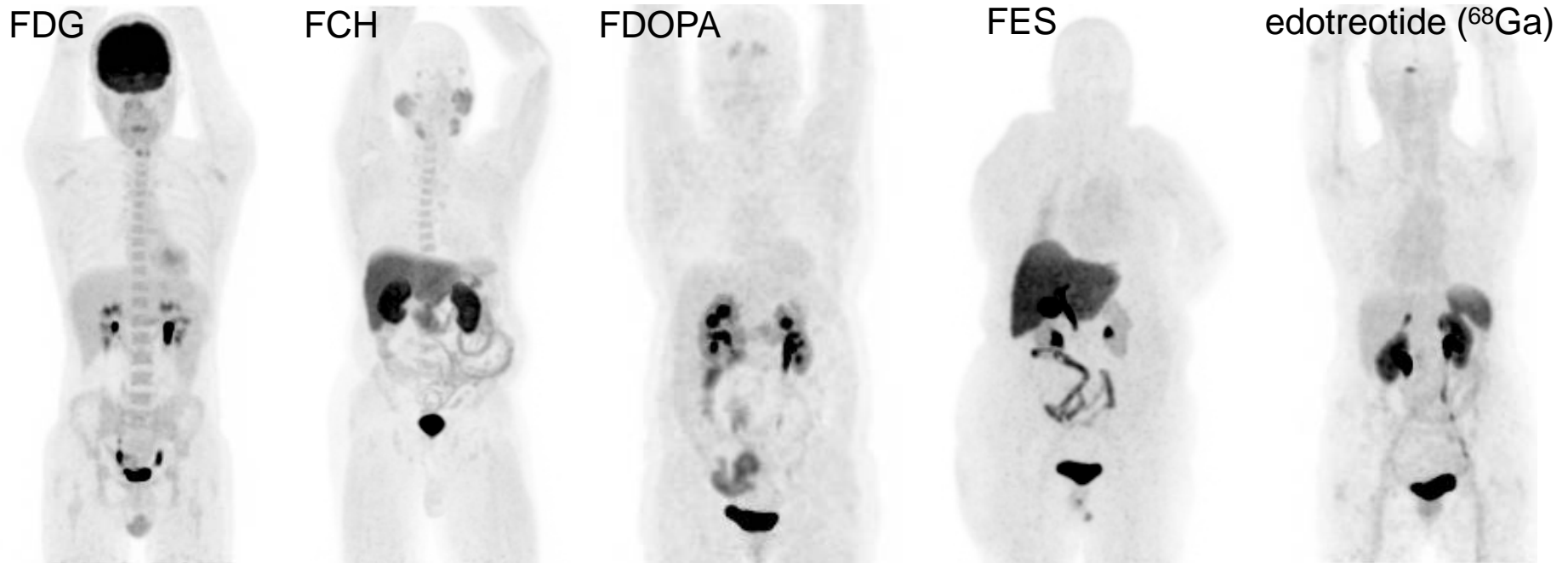
# Role of PET/CT in SBRT?

## Direct visualisation of tumour mass – metabolic tracers

- ✓ Fluorodeoxyglucose ( $^{18}\text{F}$ ) (FDG)
- ✓ Fluorocholine ( $^{18}\text{F}$ ) (FCH)
- ✓ Fluorodihydroxyphenylalanine ( $^{18}\text{F}$ ) (FDOPA)

## Direct visualisation of tumour mass – receptor imaging

- ✓ Fluoroestradiol ( $^{18}\text{F}$ ) (FES)
- ✓ Somatostatin analogues ( $^{68}\text{Ga}$ ) (edotreotide ( $^{68}\text{Ga}$ ))



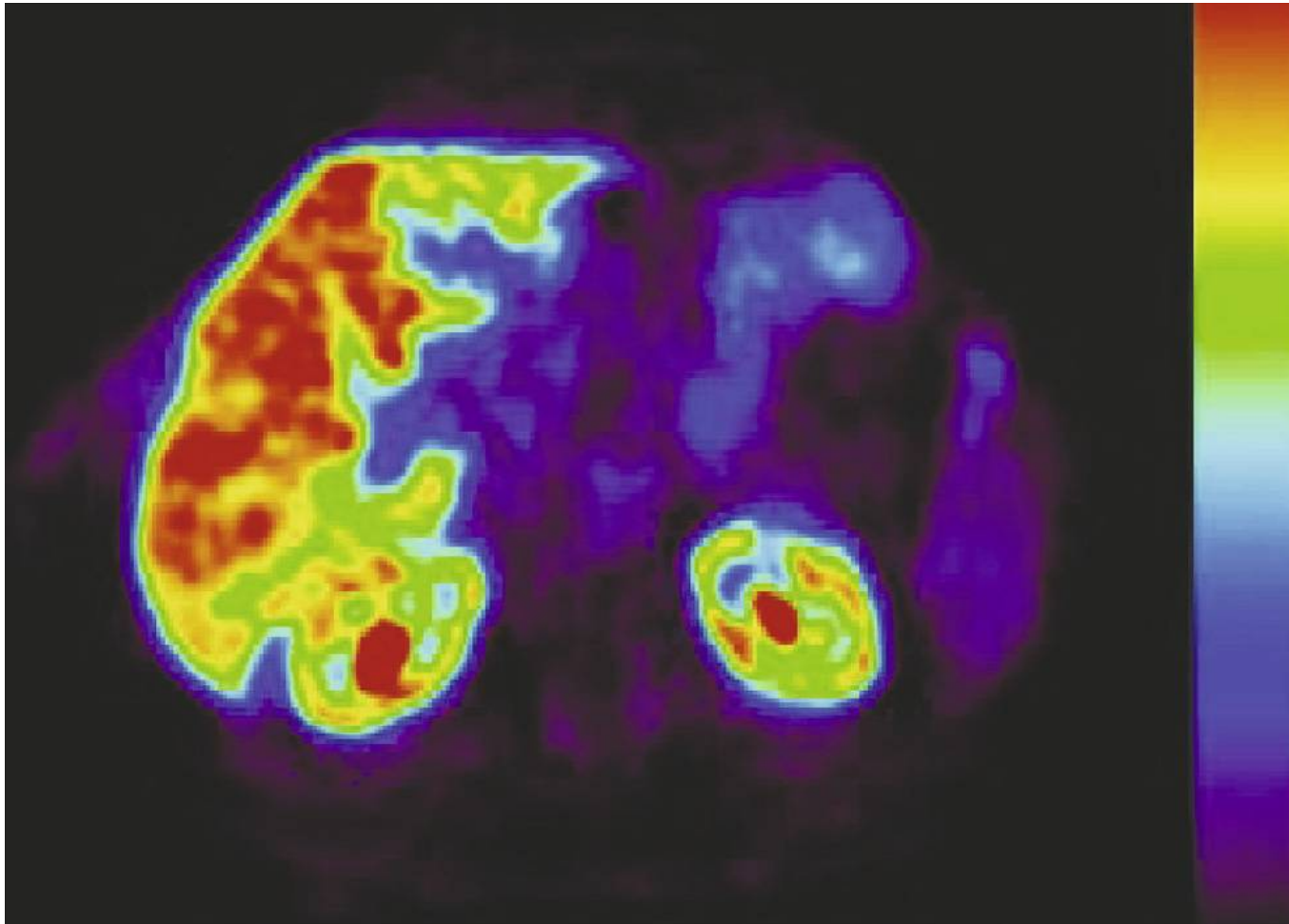
# SBRT in liver tumours according to primary

Authors	Study design	Nb of patients	Histology	Nb of lesions
<i>Herfarth, et al. 2004</i>	Phase I-II	35	Not reported	
<i>Hoyer, et al. 2006</i>	Phase II (CRC oligomets)	64	CRC [44]	141 (lung + liver + other)
<i>Mendez Romero, et al. 2010</i>	Phase I-II (HCC and Mets)	25	CRC [14], lung [1], breast [1], carcinoid [1]	34
<i>Lee, et al. 2009</i>	Phase I-II	68	CRC [40], breast [12], gallbladder [4], lung [2], anal canal [2], melanoma [2], other [6]	143
<i>Rusthoven, et al. 2009</i>	Phase I-II	47	CRC [15], lung [10], breast [4], ovarian [3], esophageal [3], hcc [2], other [10]	63
<i>Ambrosino, et al. 2009</i>	Prospective cohort	27	CRC [11], other [16]	Not reported
<i>Goodman, et al. 2010</i>	Phase I	29	CRC [6], pancreatic [3], gastric [2], ovarian [2], other [6]	40
<i>Scorsetti, et al. 2013</i>	Phase II	61	CRC [29], breast [11], gyn [7], other [14]	76

# Role of PET/CT in SBRT?

- Fluorodeoxygalactose (FDGal) PET guided FTP of SBRT
- Metabolism of galactose and FDGal is almost exclusively confined to the liver by the enzyme galactokinase
- FDGal has been proposed as a PET tracer for non-invasive measurement of regional metabolic liver function in healthy and cirrhotic human liver
- FTP: diagnostic target = normal functioning liver tissue
- FTP in which (proposed) sub-volumes of 10%, 20% and 30% of the best functioning liver tissue derived from FDGal PET/CT included in the optimisation
- ATP: only anatomical structures used for optimisation

## FDG PET & SBRT in mCRC segment IV



Heterogeneous distribution of FDG before SBRT



# FDGal PET & SBRT in mCRC sIV

ATP vs. FTP: Sub-volumes of iso-functioning liver were contoured as 10% (pink), 20% (brown) and 30% (blue) of the best functioning liver tissue at FDGal PET and the contours were transferred to the planning CT.

A: DVH: 10%, 20%, 30% of the best functioning liver tissue, liver-CTV (green);

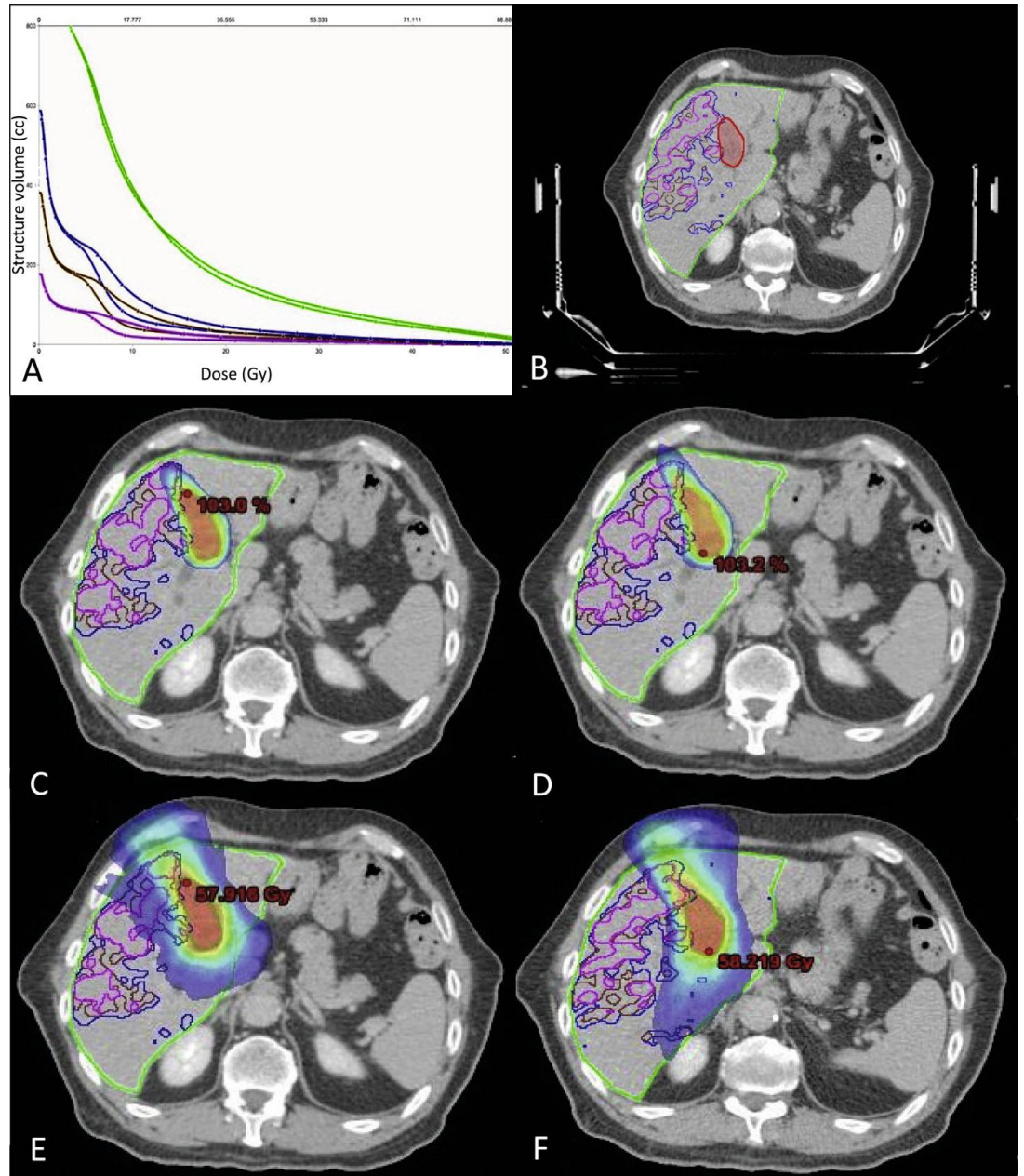
B: 10%, 20%, 30% of the best functioning liver tissue at FDGal PET, CTV (red);

C: Dose colour wash at 67% iso-dose (37.5 Gy), ATP;

D: Dose colour wash at 67% iso-dose (37.5 Gy), FTP;

E: The volume of the liver (CTV excluded) that received less than 15 Gy (VD<15Gy), ATP;

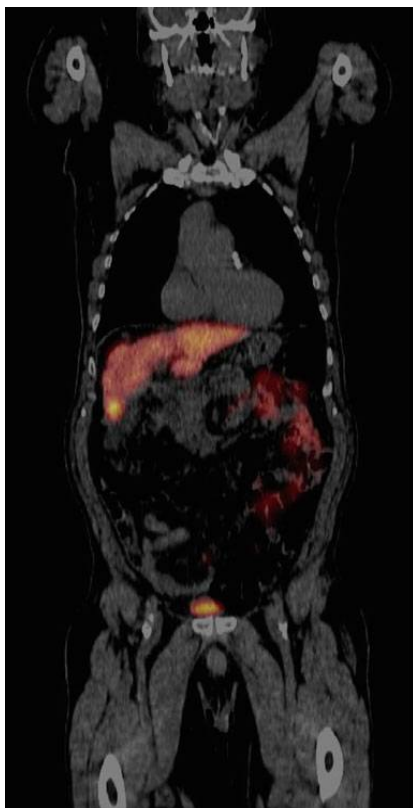
F: VD<15Gy, FTP.





# Non-FDG radiopharmaceuticals beyond tracers of lipid metabolism for imaging HCC: fluorodeoxygalactose (FDGal ( $^{18}\text{F}$ ))

- FDGal as a tracer for evaluation of liver function was first time published by Fukuda et al. 1987



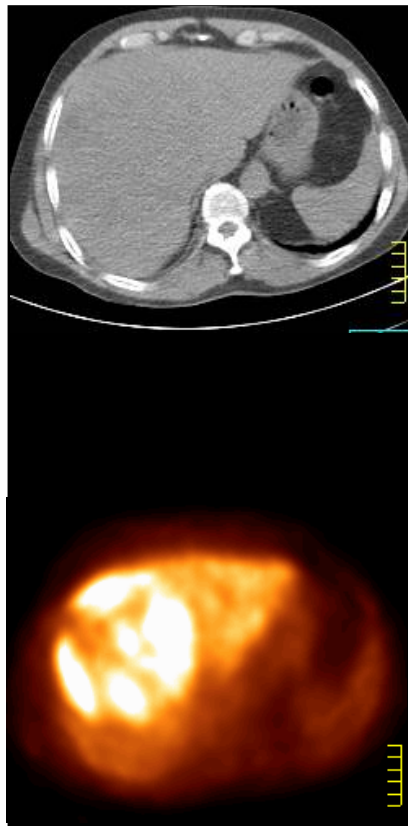
FDGal+ HCC



FDGal hypoactive  
medium differentiated HCC

- Feasibility study (2011): FDGal PET/ CT is a promising imaging modality for detection of HCC.
- Its clinical impact PET/CT needs to be validated in a prospective clinical study

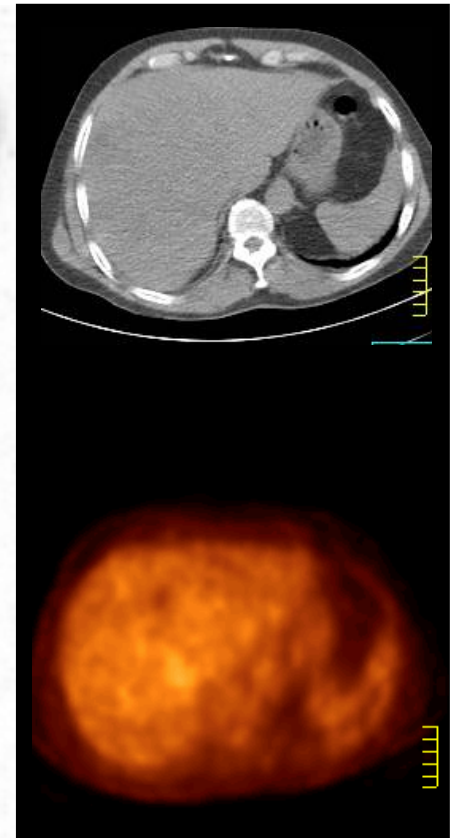
# Well-differentiated HCC



FCH +

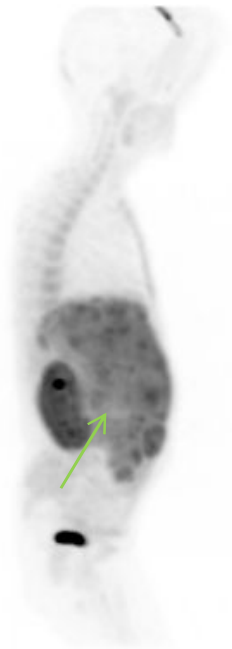
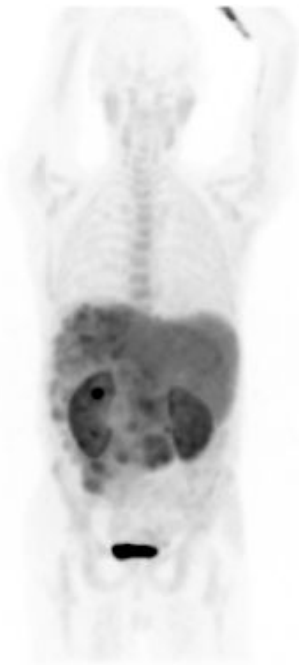


FDG -

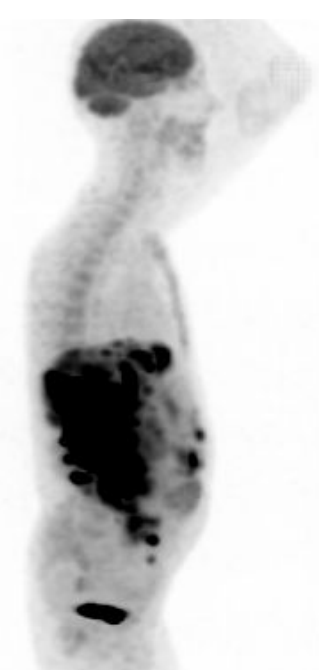
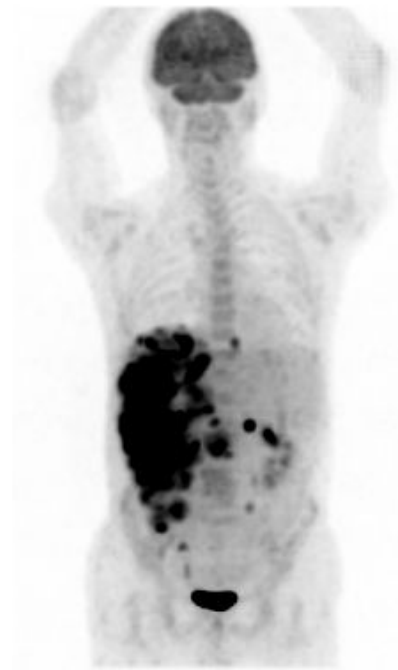


## Poorly differentiated HCC

FDG avid and partly photopenic with FCH:  
bad prognosis (died within 2 months)

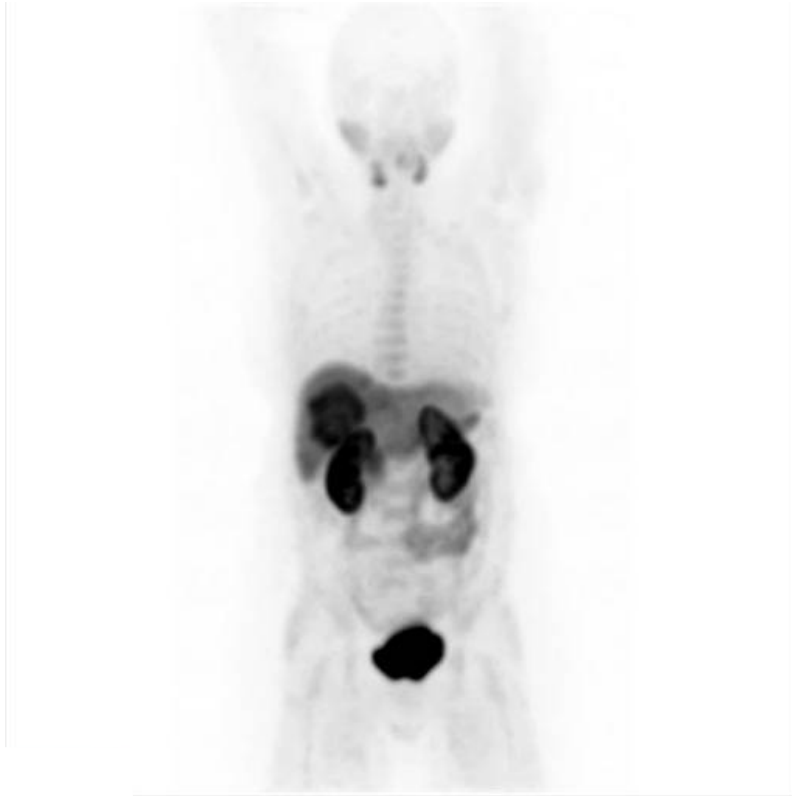


FCH

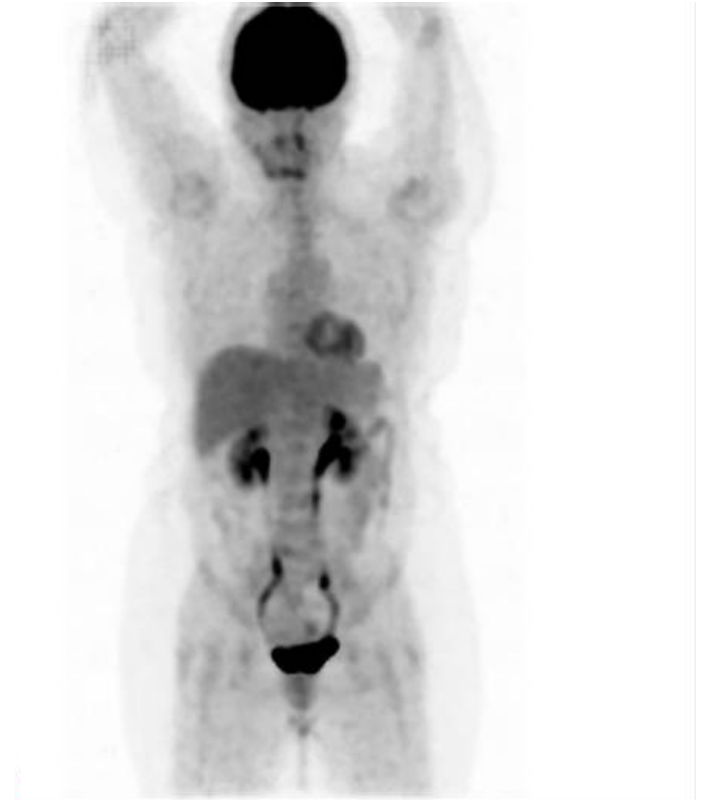


FDG

# Focal nodular hyperplasia



FCH +

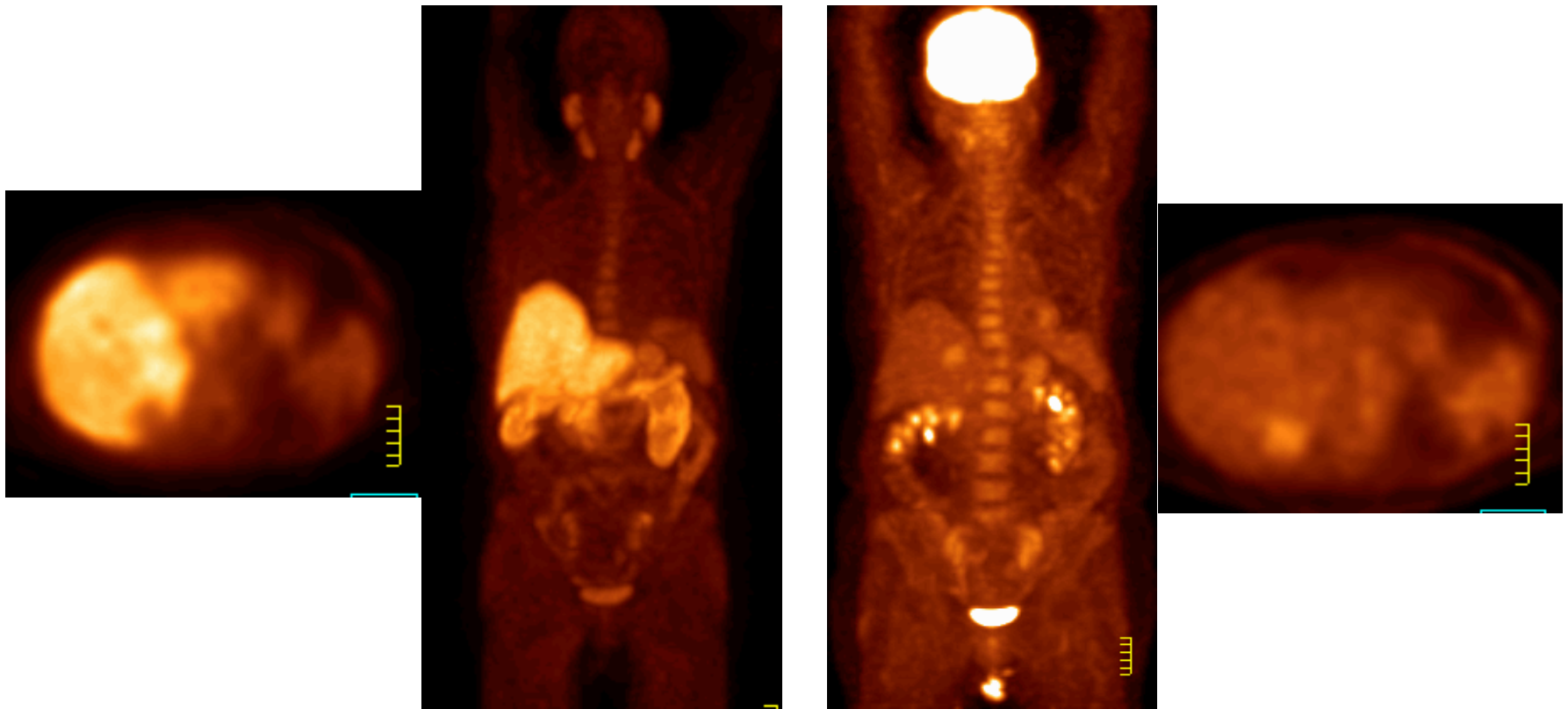


FDG -

# Liver metastasis

FCH photopenic lesion

FDG avid lesion



Isolated hepatic metastasis (confirmed by histology) in a patient with history of rectal cancer



# Role of PET/CT in SBRT?

## Conclusion

- The feasibility of incorporating FDGal PET/CT in planning SBRT of liver tumours has been demonstrated
- FTP lead to sparing of a substantial proportion of the best functioning liver tissue and this approach may allow for SBRT of patients with very large liver tumours
- In addition, FDGal PET/CT may have a potential for prediction of normal tissue effects and for selection of patients for SBRT
- The method needs to be investigated and validated in prospective studies