



PET/CT in Children

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WB PET-PET/CT in Children

- How to perform?
 - Patient preparation
 - Acquisition Protocols
- FDG biodistribution in children
- Indications & Performance

Patient Preparation

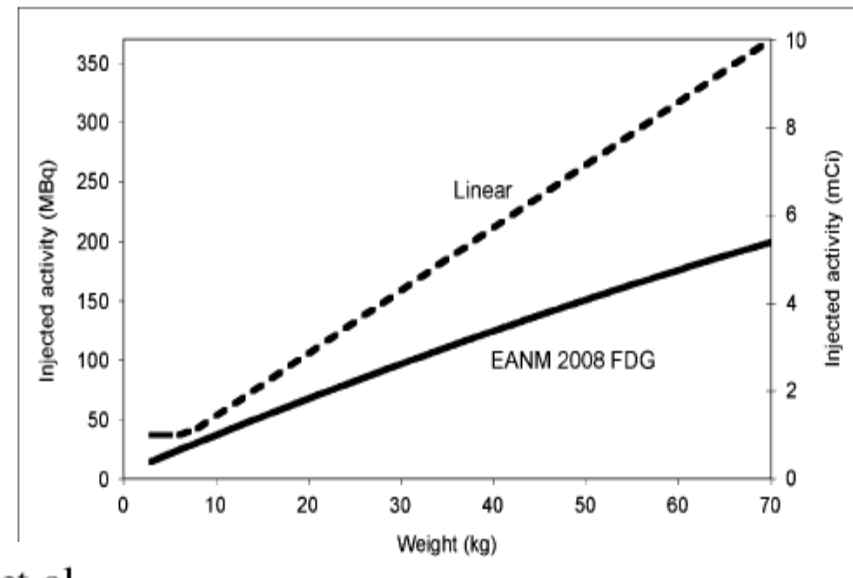
- Good information and communication
 - Visit to camera prior to FDG injection
- Fasting 4h, free access to water
- Glucose level < 180 mg%
- IV line by pediatric department
- Reduce muscle uptake as much as possible
 - Reading, music, movie

Patient Preparation

- Pre-medication
 - Propranolol
 - only oral (20 mg) and weight > 15 kg
 - Valium for muscle relaxation (rare!)
 - > 6y; 0.1 mg/kg with a max of 5 mg
 - Lasix° (always)
 - 1 mg/kg with a max of 20 mg
 - Sedation (chloralhydrate)
 - Shift to general anesthesia

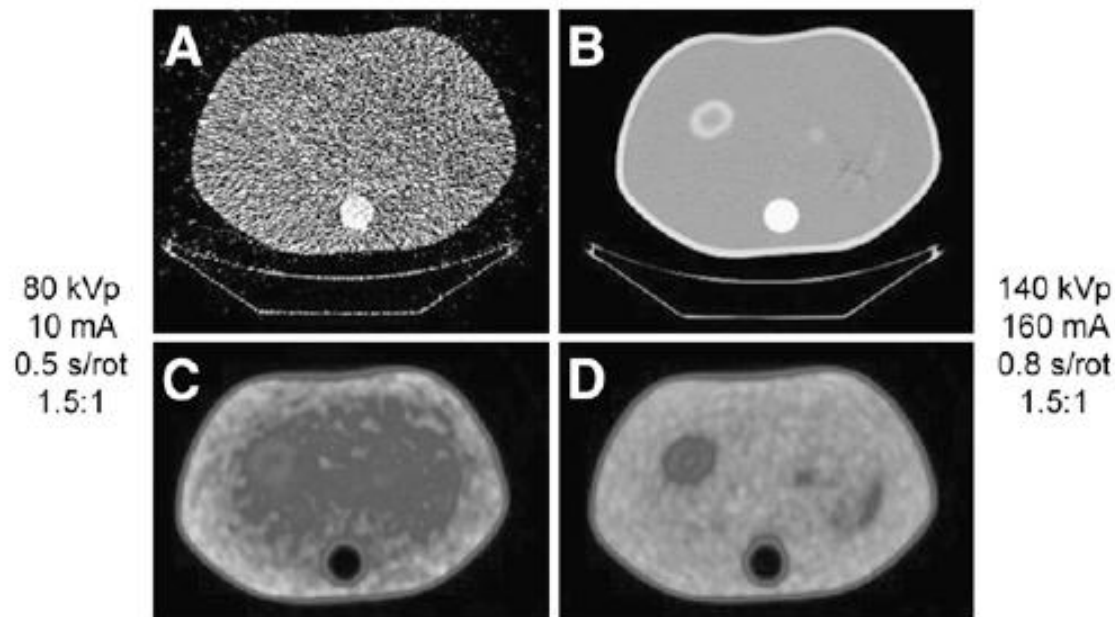
FDG dose

- Two methods for dose calculation
 - Fixed dose per kg/body weight (3 -7.5 MBq/kg)
 - EANM dose chart (takes into account the higher susceptibility for radiation induced cancers in younger persons)
- ALARA
 - trade off between scan time and dose



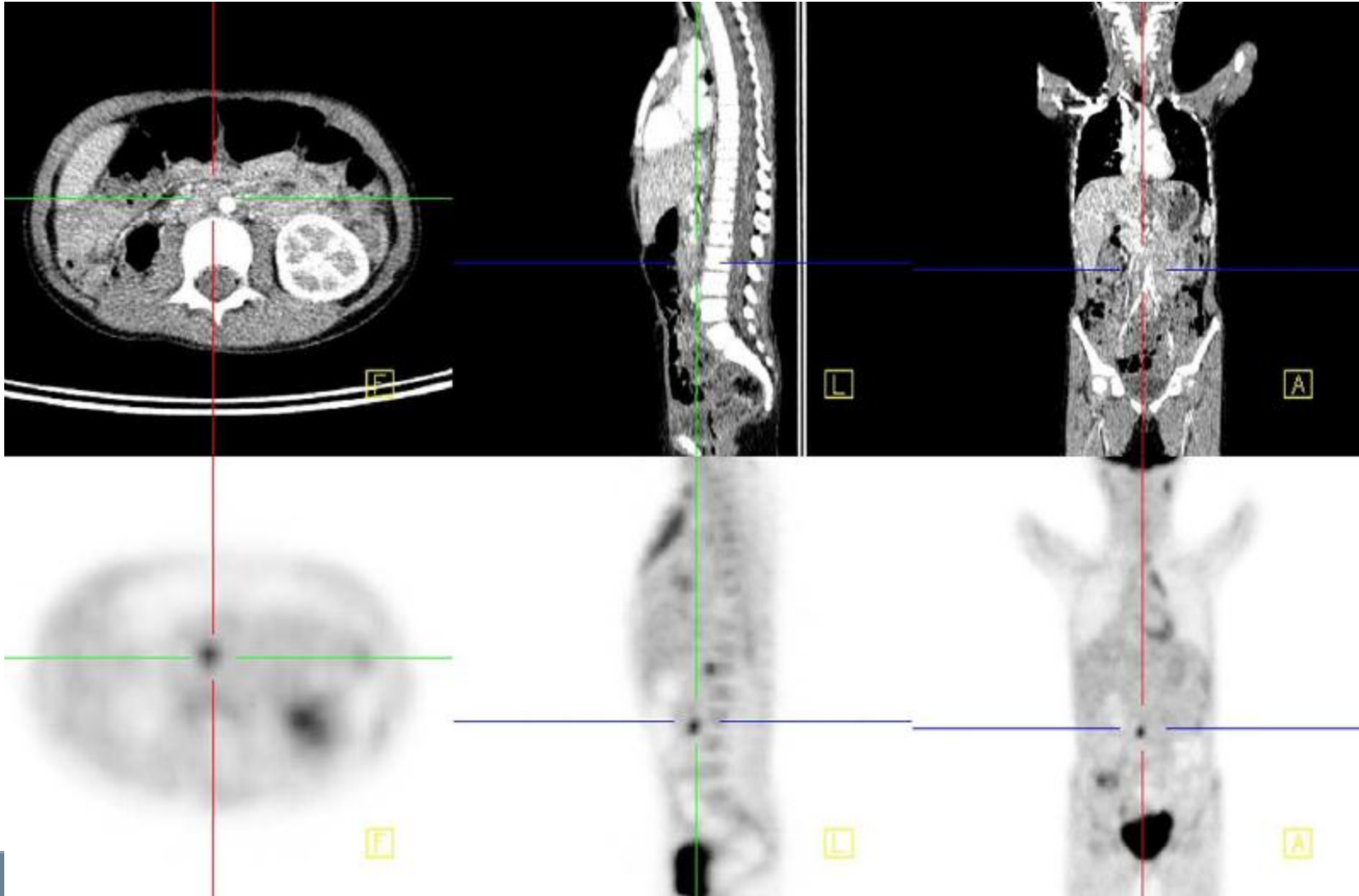
CT acquisition Protocol

- if possible with Diagnostic CT
 - One stop shop
 - Increased diagnostic confidence
 - Better PET image quality



FDG biodistribution in children

Less tissue contrast (no fat)



CT acquisition Protocol

Children are more radiosensitive and have a longer live span, so change of radiation induced cancer are higher

TABLE 1. Excess Attributable Risk (Deaths) from All Solid Tumors per 10,000 People per Year per Sievert at Age 60 Years

Age at exposure (y)	Excess Attributable Risk (mortality)	Relative to >30 y
1	35.1	2.92
5	30.3	2.52
10	25.2	2.1
20	17.4	1.45
>30	12	1

Data are based on models presented in *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 (15)*.

According to this table, if 1,000,000 10-y-old children receive 10 mSv, 25 children will die as a result of this exposure at the age of 60 y. This risk is 2.1 times higher than that for an individual receiving the same irradiation at an age older than 30 y.

Is the dose important?

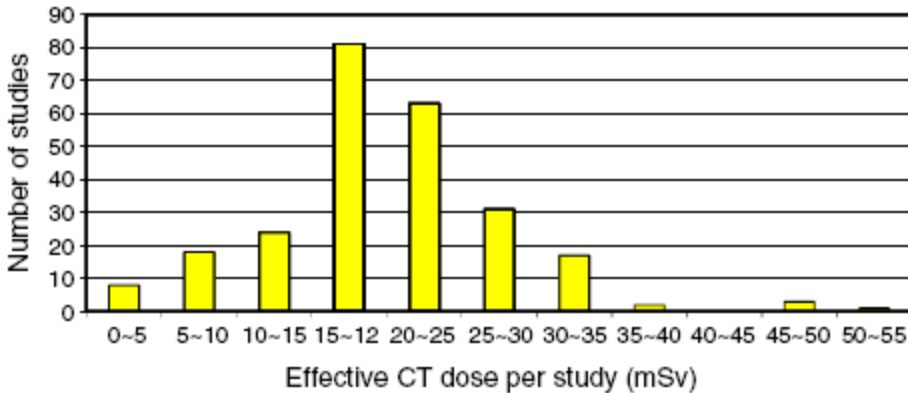
Soni C. Chawla & al, Pediatric Radiology

- Retrospective analysis of the Estimated cumulative radiation dose from PET/CT in children with malignancies: an analysis in 248 patients patients.
- Siemens Emotion Duo
 - no dose care
 - Low dose CT with additional breath hold CT in selected cases
- PET 7,5 MBq/kg
- CT 110-130 kVp and 43 mAs -170 mAs skull to mid thigh

Is the dose important?

Soni C. Chawla & al, Pediatric Radiology

Effective dose (mSv) of an individual CT study
(Average 20.3, Range 2.7 - 54.2)



Effective dose (mSv) of an individual PET study
(Average 4.6, Range: 0.4 - 7.7)

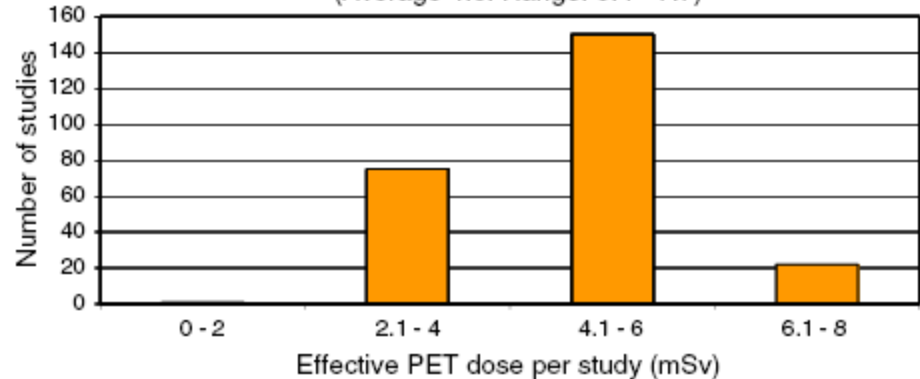
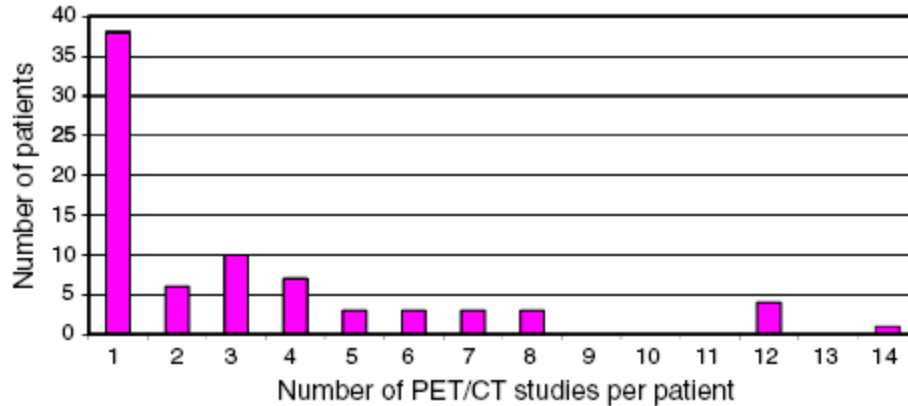


Fig. 4 Effective dose (mSv) of an individual PET study

Number of studies per patient
(Average 3.2 studies/pt, Range:1-14)



Cumulative dose (mSv) per patient from
PET/CT studies (Average 78.9, Range: 6.2 - 399)

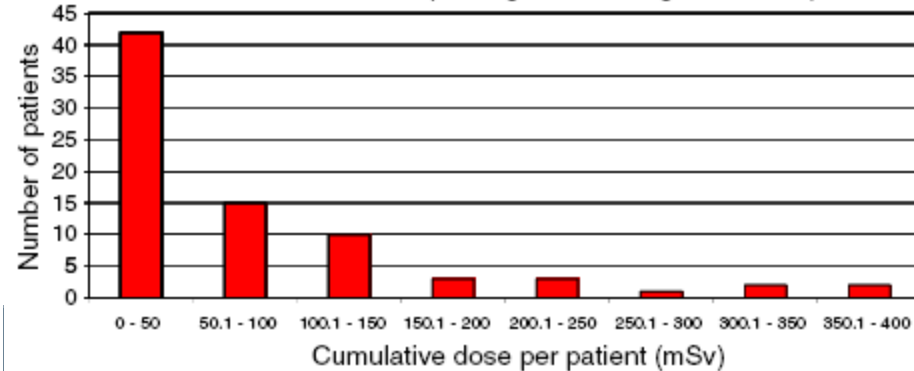


Fig. 8 Cumulative dose (mSv) per patient from PET/CT studies

Fig. 2 Study distribution

CT acquisition Protocol

Low dose protocol

- according to body weight
- Fixed Tube Voltage (110 kVp)

variable max Tube current 10 and 40 mAs, dose care

Diagnostic Whole-Body PET/CT Protocols Highlighting Acquisition Settings Varied for Each Weight Category

Patient		CT acquisition, maximum tube current for CT (mAs)	PET acquisition	
Weight range (kg)	Estimated whole-body scan range (mm)		Injected activity (MBq [mCi])	Scan time per FOV (min)
6–7.4	59.5–66.5	10	37 (1.0)	3
7.5–9.4	66.5–74	10	45 (1.2)	3
9.5–11.4	74–84.5	15	55 (1.5)	3
11.5–14.4	84.5–97.5	20	68 (1.9)	3
14.5–18.4	97.5–110	20	87 (2.4)	3
18.5–22.4	110–122	20	108 (2.9)	3
22.5–31.4	122–137	25	142 (3.9)	5
31.5–40.5	137–150	30	190 (5.1)	5
40.5–55	150–162	30	252 (6.8)	5
55–70	162–170	35	330 (8.9)	5
>70	>170	40	370 (10.0)	5

CT acquisition Protocol

Diagnostic CT protocol

TABLE 4. Acquisition Scheme for Pediatric CT

Weight	Tube current (mA)	
	Chest	Abdomen or pelvis
4.5–8.9 (10–19)	40	60
9.0–17.9 (20–39)	50	70
18.0–26.9 (40–59)	60	80
27.0–35.9 (60–79)	70	100
36.0–45.0 (80–99)	80	120
45.1–70.0 (100–150)	100–120	140–150
>70 (>150)	≥140	≥170

Weight data are represented in kilograms, with pounds in parentheses. This table summarizes example of weight-based acquisition scheme for pediatric CT. Tube voltage for these acquisitions is 120 kVp (22).

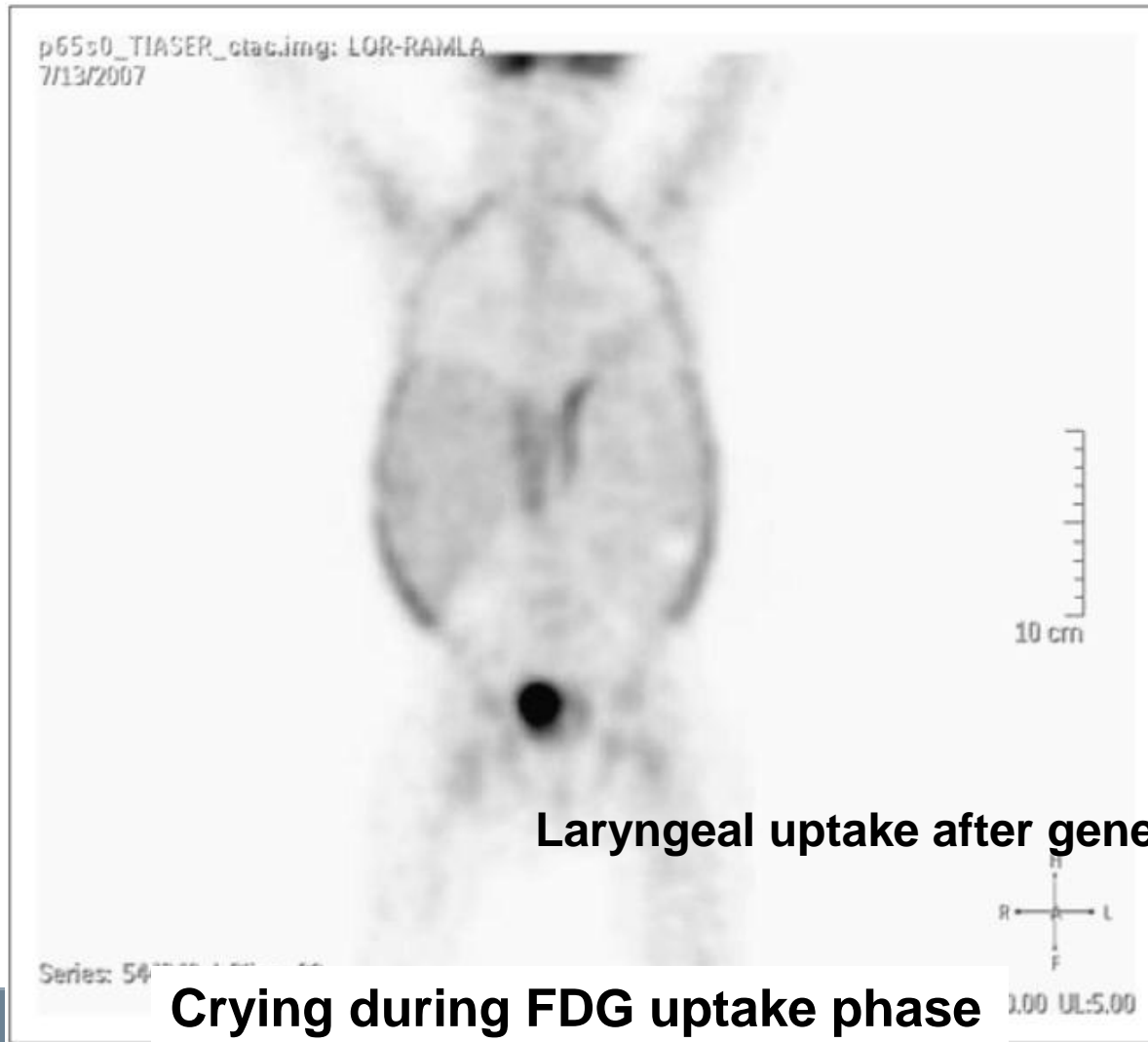
Dosimetry of Pediatric PET/CT*

Frederic H. Fahey

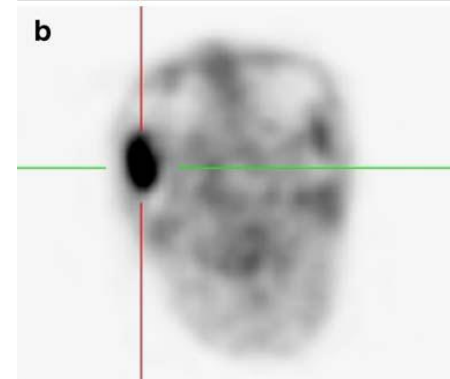
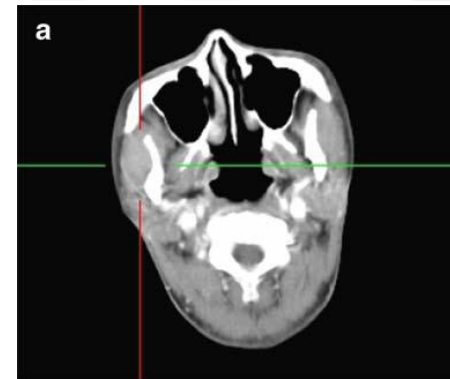
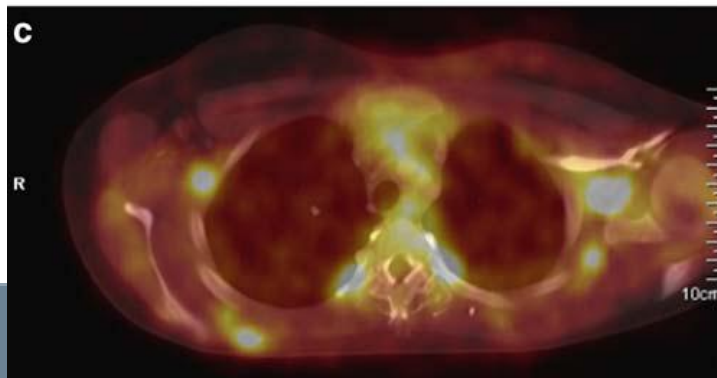
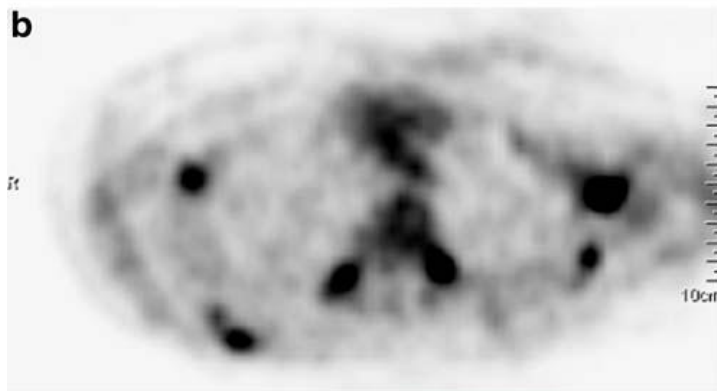
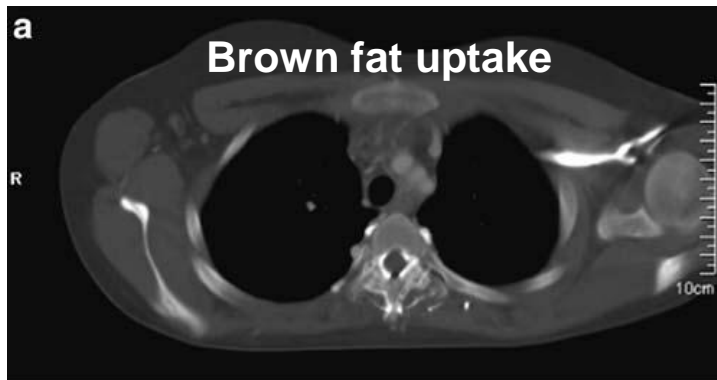
CT acquisition Protocol

- IV contrast
 - 3-4h fasting (empty stomach in case of vomiting)
 - Iomeron 350 mg/ml, heat before use to room temperature
 - Dosis 2 ml/kg max 120 ml
 - Manual injection in children < 14y (no pump!)
- No oral contrast, + water (negative contrast)
- Hydration after scan

FDG biodistribution in children

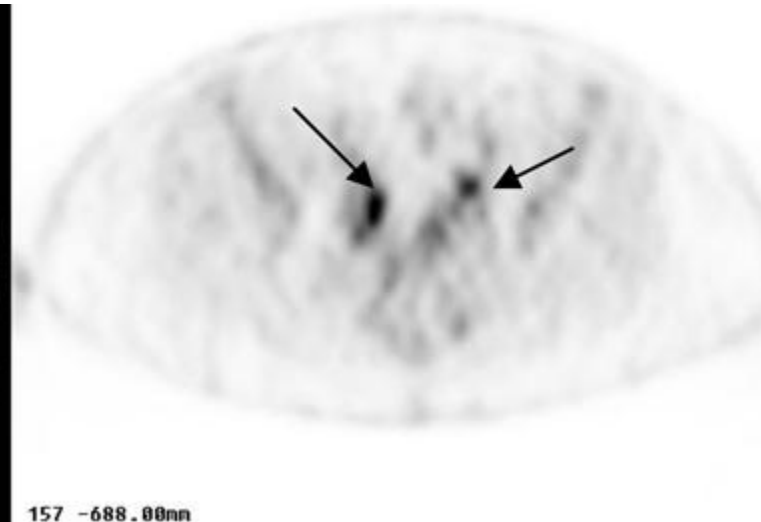


FDG biodistribution in children



FDG biodistribution in children

Fysiological uptake in the ovary



Pediatric PET/CT - Performance

Table 2 Sensitivities, specificities, PPV, NPV and diagnostic accuracies for the detection of pediatric malignancies using integrated ¹⁸F-FDG PET/CT, ¹⁸F-FDG PET and CT

Parameter	Procedure	TP	FP	TN	FN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	
Solid primary tumors	PET/CT	70	11	3	4	95	21	86	43	83	
	PET	54	1	13	20	73	93	98	39	76	
	CT	69	14	0	5	93	0	83	0	78	
Lymph node metastases	PET/CT	15	7	34	3	83	83	68	92	83	
	PET	15	20	21	3	83	51	43	88	61	
	CT	9	25	16	9	50	39	27	64	42	
Distant metastases	All	PET/CT	139	25	122	14	91	83	85	90	87
		PET	57	64	83	96	37 ^a	57	47	46	47
		CT	127	63	84	26	83	57	67	76	70
	>0.5 cm diameter	PET/CT	95	12	100	9	91	89	89	92	90
		PET	57	62	50	47	55	45 ^a	48	52	50
		CT	83	50	62	21	80	55 ^b	62	75	67
	<0.5 cm diameter	PET/CT	44	13	22	5	90	63	77	82	79
		PET	0	2	33	49	0	94	0	40	39
		CT	44	13	22	5	90	63	77	82	79
Pulmonary	PET/CT	44	17	29	5	90	63	72	85	77	
	PET	7	10	36	42	14 ^a	78	41	46	45	
	CT	40	16	30	9	82	65	71	77	74	
Bone	PET/CT	71	2	0	7	91	0	97	0	89	
	PET	30	1	1	48	39	50	97	2	38	
	CT	63	2	0	15	81	0	97	0	79	
All malignant lesions	PET/CT	223	42	160	22	91	79	84	88	86	
	PET	126	85	117	119	51 ^a	58	60	50	54	
	CT	205	102	100	40	84	50	67	71	68	

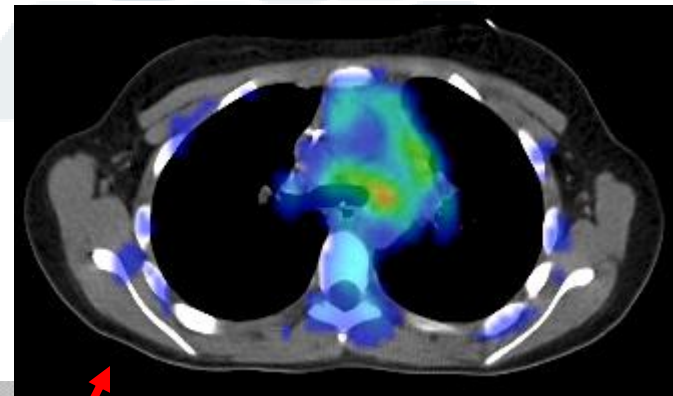
^a Difference between PET/CT and PET statistically significant ($p < 0.05$)

^b Difference between PET/CT and CT statistically significant ($p < 0.05$)

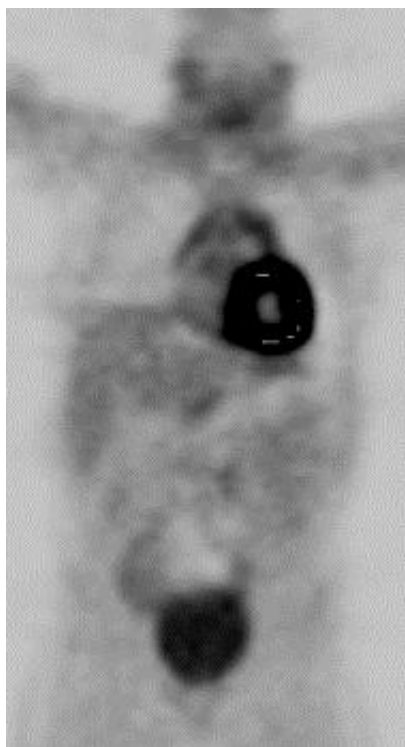
PET for detection of residual disease

♂ ° 1989

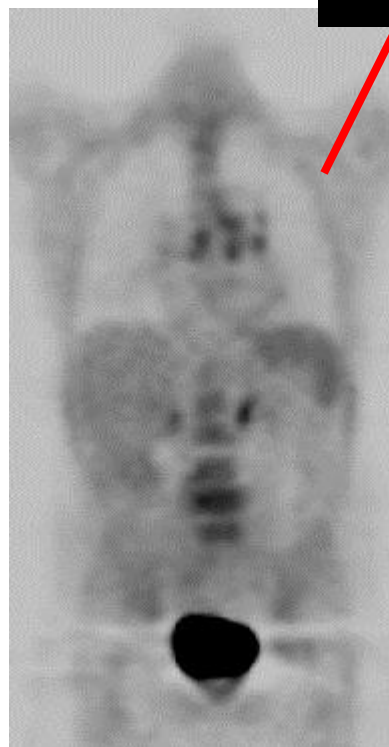
Hodgkin Disease, NS



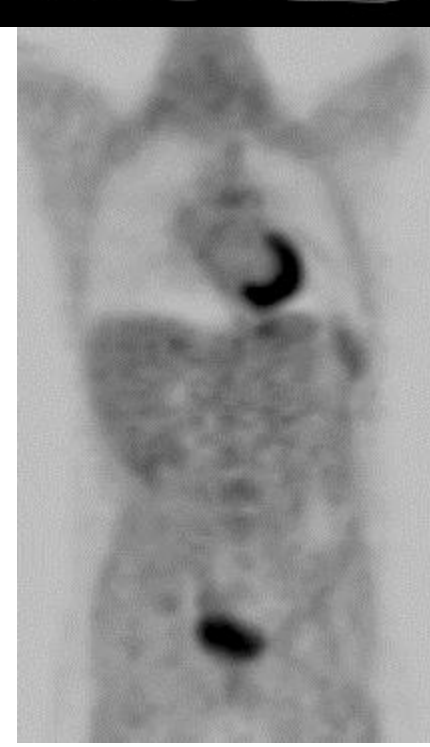
11/2002
Initial staging
IVa



7/2003
Thymus



2/2005
Recurrence?



3/2005

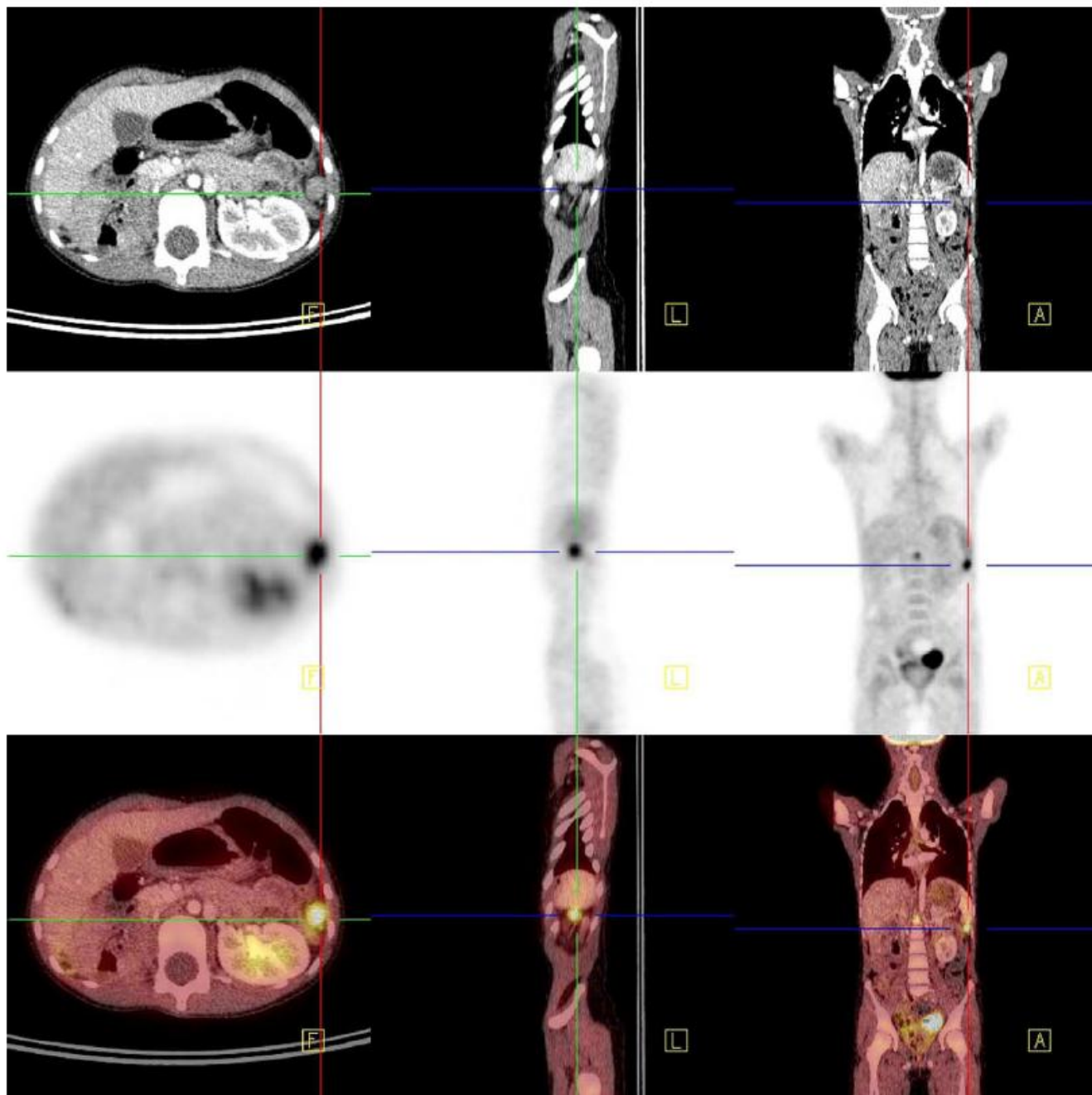


Fig. 3 Recurrent anaplastic Wilms' tumor. Left upper quadrant omental tumor. Standard CT scan (top). PET scan (middle). PET/CT scan (bottom).

PET/CT in Pediatric Oncology

- PET interpretation more difficult compared to adults
 - Limited soft-tissue contrast on low dose CT: hampers localisation
 - More movement artefacts, physiologic uptake in normal tissue
 - Concomitant infectious disease
- One-stop shop where possible/indicated
 - 1 sedation
 - Better localisation
 - Cave: radiation dose
 - ALARA, dedicated pediatric protocols, PET-MR?, good indication
- Lymphoma; soft tissue sarcoma