PET imaging in CNS tumors
Glioma and meningioma

Japanese Scandinavian Radiological Society Symposium
and Nordic Japan Imaging Informatics Symposium 2026
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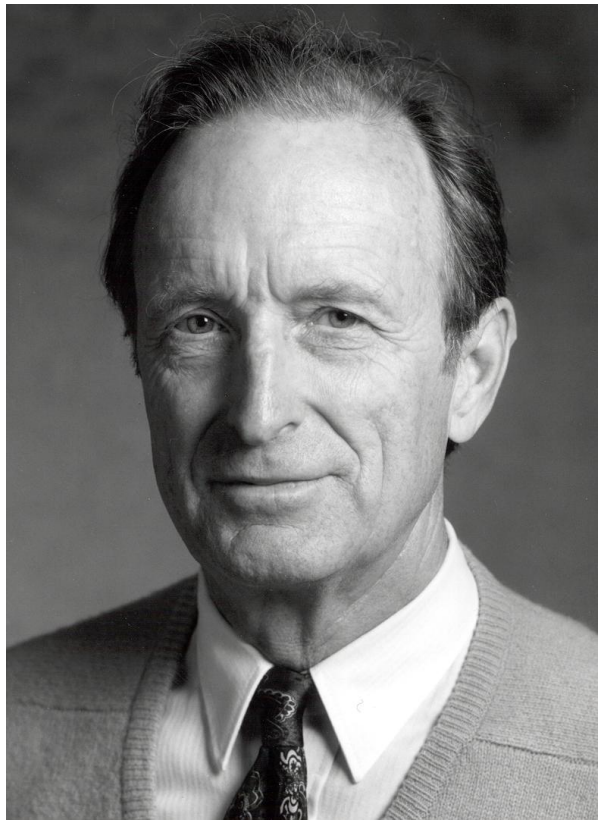
Thank you, Japan



N. A. Lassen
(1926 -1997)

1990年（平成2年）4月5日　木曜日

痴ほう症のナゾに迫る

／ポジトロンＣＴ使い脳の断層撮影

ポジトロンCTで断層撮影し、脳の言語に関する機能を解明しようという研究センター（上村和夫所長、秋田市千秋久保田町）で進められている。痴ほう性老人間脳の言語中枢がどのように働いているかを詳しく知ることによって、痴ほう症のようというのが狙い。脳の血流量（脳循環）から脳の働きを測定する技術は、んでいる。同脳研が開発して、脳卒中診断、死亡減少に大きな役割を果たしたポ脳のメカニズム解明に迫ろうとしている。この研究には、デンマークの若い医師協力」の形で進められており、その研究成果が期待される。

この研究を行っているのは、同脳研の菅野巌放射線医学研究部長らのグループ。菅部長らが開発したポジトロンCTは、従来のCT撮影方式と陽電子（ポジトロン）測定技術を組み合わせた断層撮影装置。かった本県で、このポジトロンCTが脳卒中診断に大きく貢献、全国的にも高い評価を得ている。

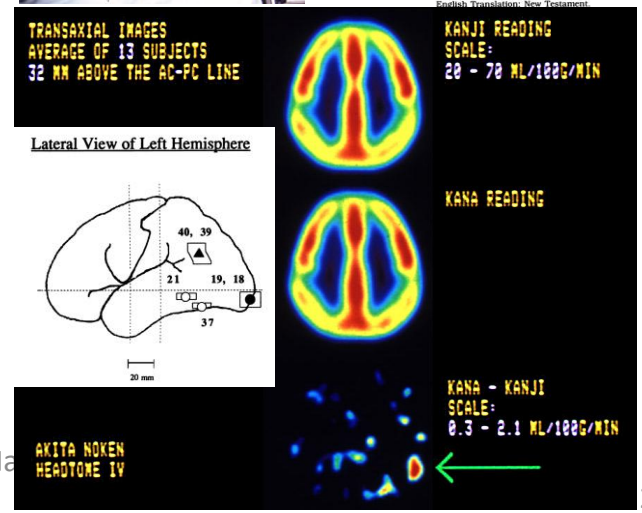
同グループの研究は、ポジトロンCTを脳卒中診断などだけでなく、脳のメカニズム解明に利用できないかというもの。現在取り

脳のメカニズム解明に利用されるポジトロンCT。中央がサムさん、左が菅野部長（県立脳血管研究センター）

先端

脳機

県脳



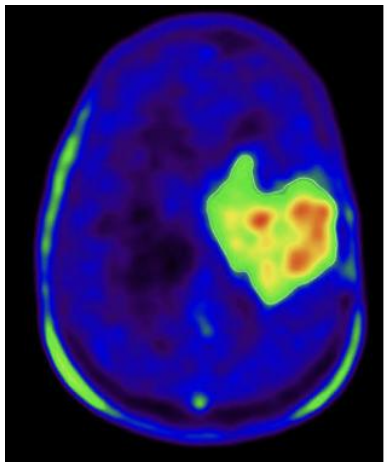
Law I, Kanno I, Fujita H, Lassen NA, Miura S, Uemura K. Left supramarginal/angular gyrus activation during reading of syllabograms in the Japanese language. J Neurolinguistics. 1991;6:243-251

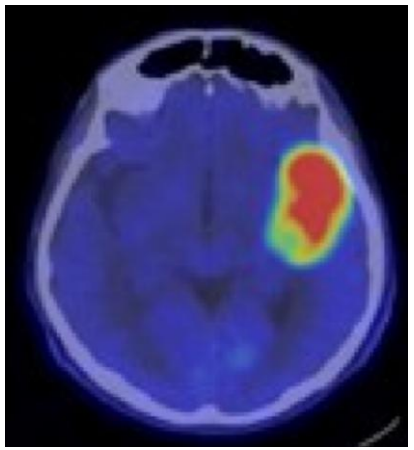
What PET in glioma?

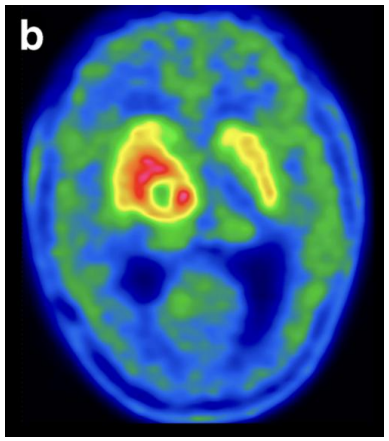
- The best choices are one of these 3 amino acids.

	[^{18}F]FET:	[^{11}C]MET	[^{18}F]FDOPA
Sensitivity to tumor in biopsy (%)	84 - 92	87	73
Main limitations		Short half-life	Uptake in striatum

- Added value vs MRI
  - Improved detection and delineation
  - Metabolic activity and volume







Why PET: to compensate for known limitations in MRI

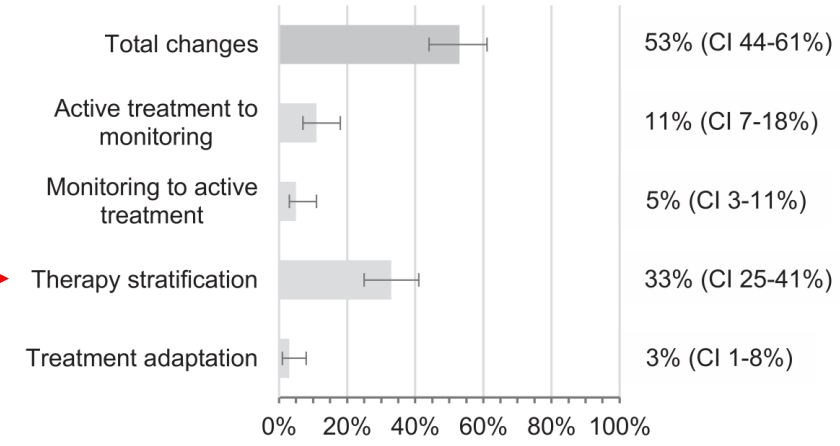
- Glioma:
  - MRI is the primary modality. Always MRI before PET
  - PET is the problem solving modality (< 5 % of MR for glioma patients)

- What are the limitations in MRI?
  - Artefacts => blind spots
  - Post treatment imaging multimorbidity => limits MRI specificity
  - Contrast enhancement based glioma assessment => limits sensitivity/specificity

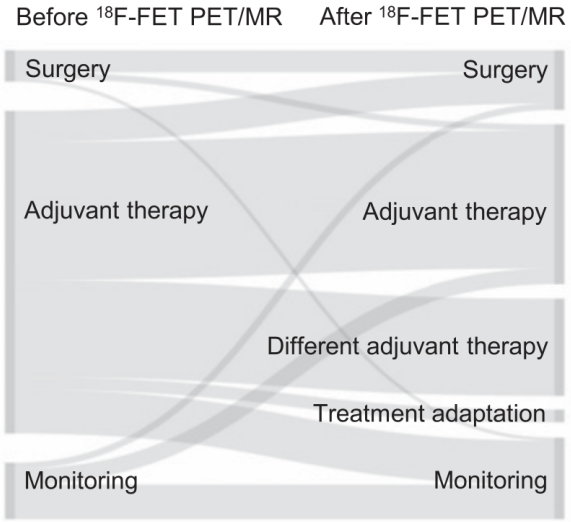
When PET: when it makes a clinical difference

- PET & MRI impacts follow-up clinical management in patients with **equivocal** MRI
  - 50 % in adult
  - 33 % in paediatric

A



B



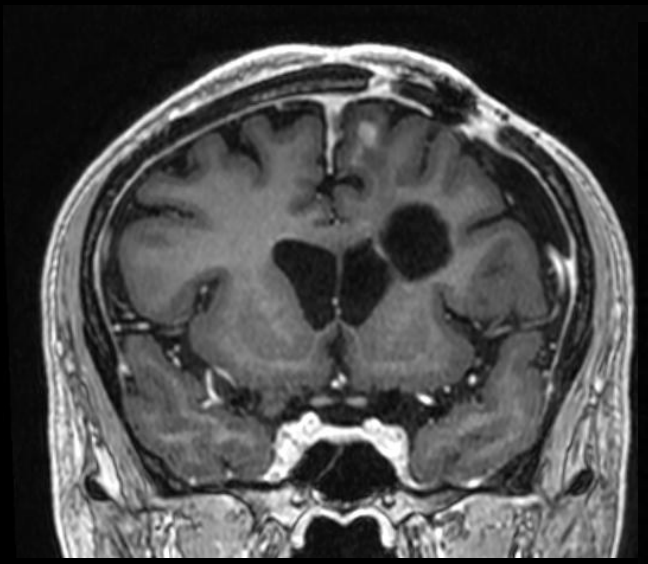
[^{18}F]FET: overall high diagnostic accuracy

Parameter	Detection of progression
Total case number	105
Disease prevalence	80%
True-positive/true-negatives	78/20
False-positives/false-negatives	1/6
Sensitivity	93% (85%–97%)
Positive predictive value	99% (92%–100%)
Specificity	95% (76%–100%)
Negative predictive value	77% (61%–88%)
Accuracy	93% (87%–97%)

Brendle C, et al. J Nucl Med. 2021
Yamane T, et al.Eur J Nucl Med Mol Imaging. 2010;37:685-690.
Marner L, et alNeuro Oncol. 2021;23:2107-2116

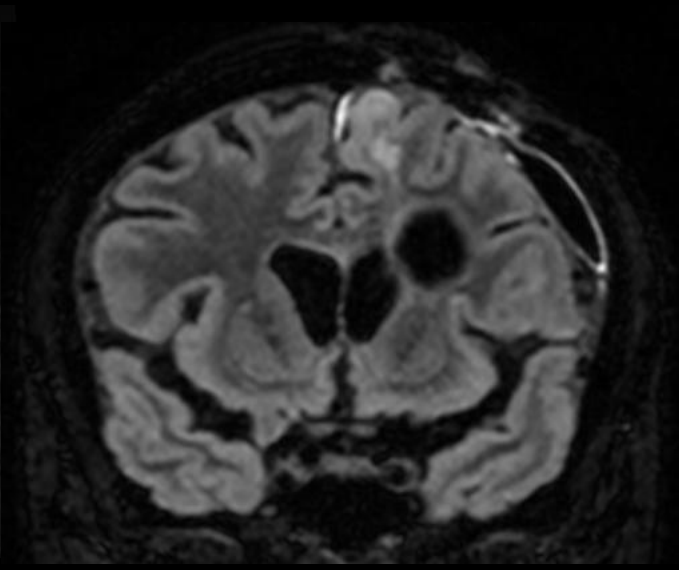
Contrast enhancement based glioma assessment

MRI T1c



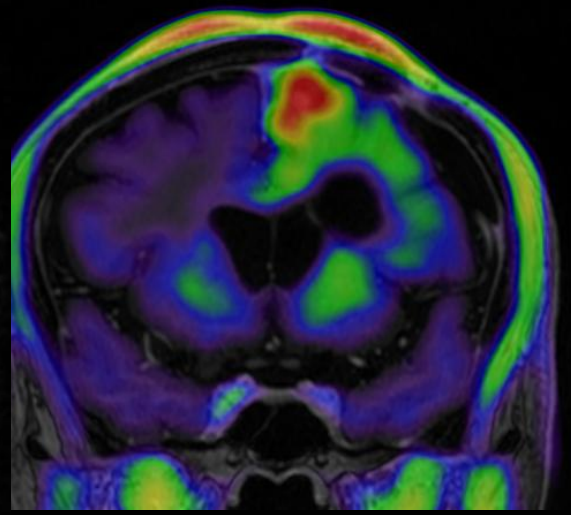
VOL_{CE}: 1.5 mL

MRI FLAIR



Recurrent GBM IDHwt

MRI T1c & PET FET



VOL_{FET}: 13 mL

Recurrent GBM IDHwt
N= 86

Tumor volume with PET is x 2-3 than CE

50 – 100 % is missed

Total volume (mL)	Median mL (range)
FET vol	13.5 [0-111]
MRI CE vol	4.8 [0-49.5]

Fractional volume	Median (range)
MRI CE VOL in FET vol	32.5 [0-42.5] %
FET VOL in MRI CE vol	72.7 [0-100] %

Henriksen OM, Muhic A, Lundemann MJ et al. Added prognostic value of DCE blood volume imaging in patients with suspected recurrent or residual glioblastoma-A hybrid [18F]FET PET/MRI study. Neurooncol Adv. 2024;6

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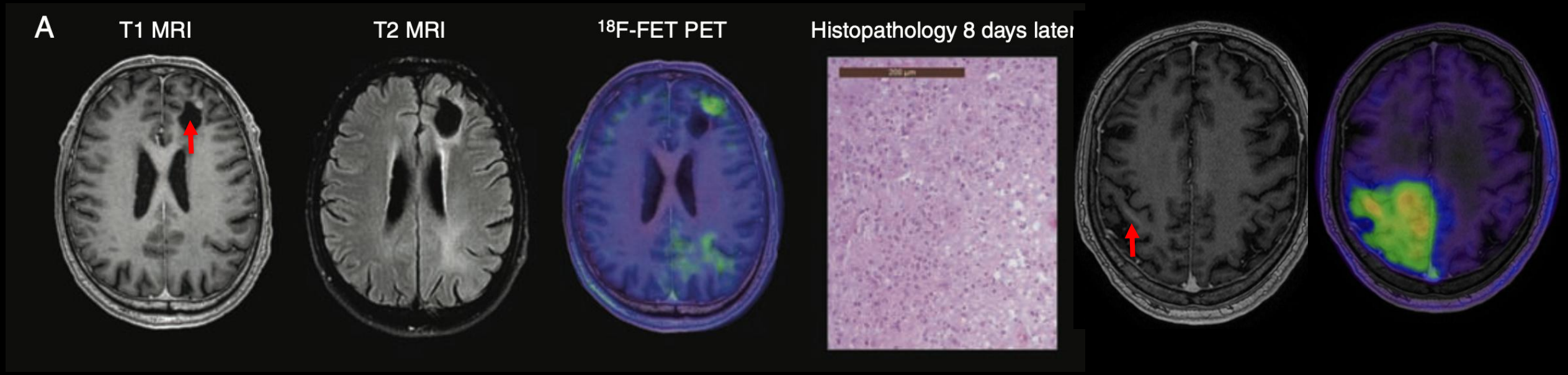
PET/MRI [^{18}F]FET in Glioblastoma: Recurrence or late treatment effects?

- Literature: mix of glioma grades, type, treatment, management stage

- N =146 GBM/168, 20 min static [^{18}F]FET > 6 mo after RT,
- 16 Treatment damage/152 recurrences (11%)
- ROC: Best parameter is Tmax/B > 2.0
- Sensitivity: 99 %, Specificity: 95 %, Diagnostic accuracy: 99%

PET may measure non-measurable CE lesions (< 10 mm)

- 34 GBM with new non-measurable lesions confirm recurrence, Median 7 mm (4-9 mm)
- 90 % are above PET threshold
- Identifying active infiltration outside CE MRI

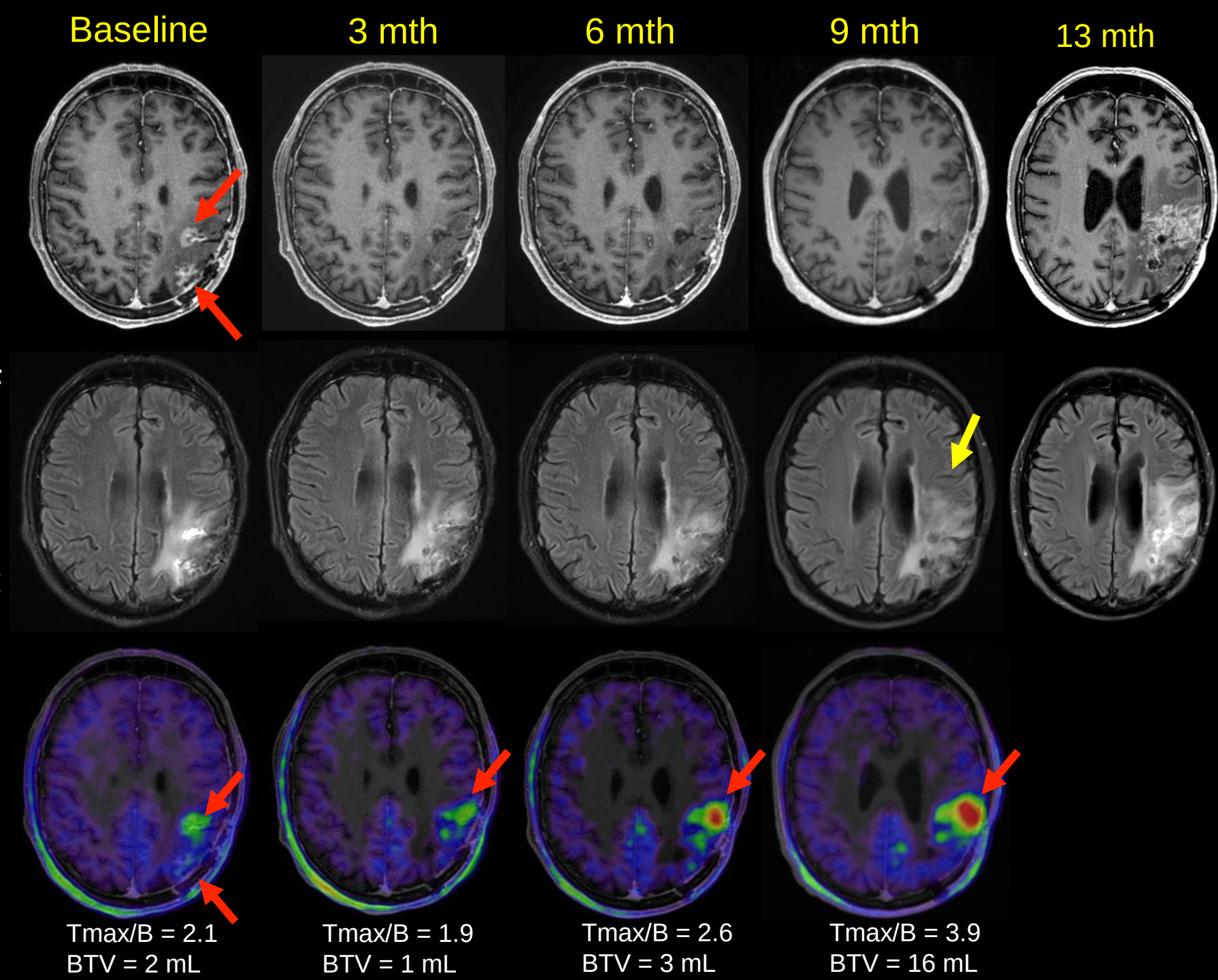


Glioblastoma 11 months after adjuvant TMZ, MRI with a 6 mm non-measurable solitary contrast enhancement at the anterior part of the surgical cavity, with nodular configuration on [^{18}F]FET PET with BTV of 0.5 mL.

GBM IDH wt

Pseudoresponse

- MRI: CE =disrupted BBB
- Bevacizumab-> anti-VEGF vascular normalization and decreased BBB permeability independent of an anti-tumor effect
- Neo-vascularisation rebound on anti-angiogentic discontinuation



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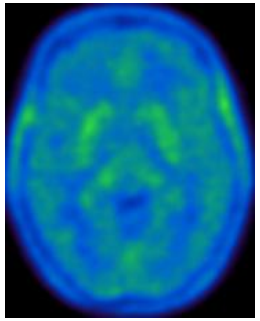
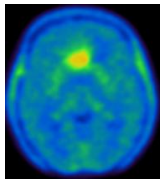
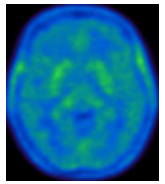
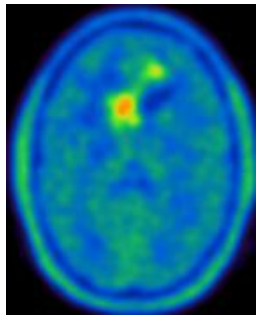
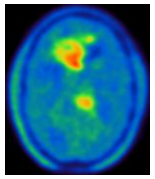
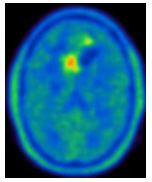
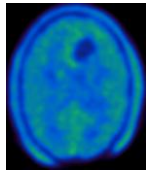
PET-based response assessment criteria for diffuse gliomas is quantitative (PET RANO 1.0)

No measurable / non-measurable PET-positive disease

Baseline PET	Follow-up PET
	 **PET-PD**
	 **PET-SD**
TBR_{max} < 1.6 or **TBR_{max} > 1.6 and PET-positive volume < 0.5 ml**	

Measurable PET-positive disease

Baseline PET	Follow-up PET
	 **PET-PD**
	 **PET-SD**
TBR_{max} > 1.6 and PET-positive volume ≥ 0.5 ml	**PET-PR**
	 **PET-CR**

Max 3 target lesions

progression of at least one target lesion

Increase of
- TBR_{max} ≥ 30% or
- TBR_{mean} ≥ 10% or
- PET Vol ≥ 40% or
- any new measurable lesion

Decrease of
- TBR_{max} ≥ 30% or
- TBR_{mean} ≥ 10% or
- PET Vol ≥ 40%

no PET-PD definition fulfilled

complete disappearance

NL, Galldiks N, Ellingson BM et al. RANO criteria for response assessment of brain metastases based on amino acid PET imaging. Nat Med. 2025

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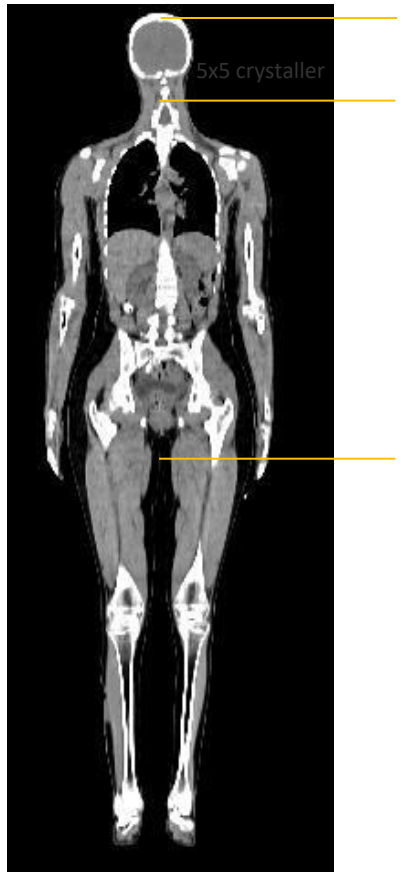
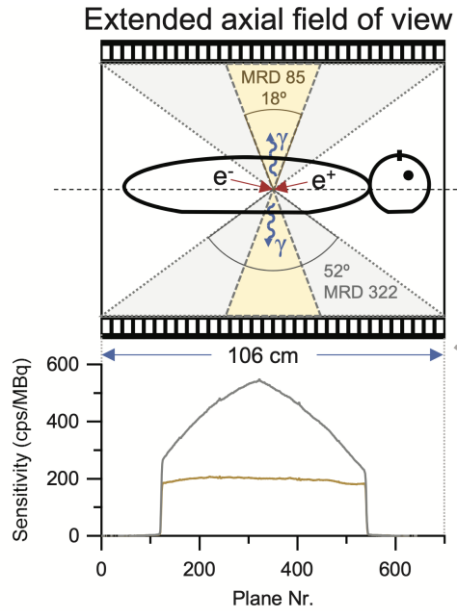
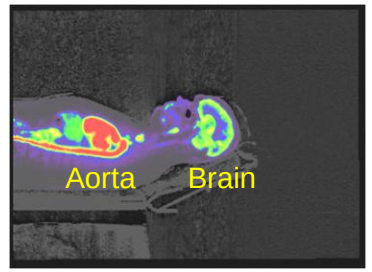
The Long Axial Field of View PET/CT

- Siemens PET/CT Quadra – x 4 detector rings
- Sensitivity x 10 => best technical quality
- Patients:
  - Children: Neurooncology, epilepsy
    - short scan/anaesthesia, low dose
  - Spinal cord tumors
  - Steno-occlusive disease



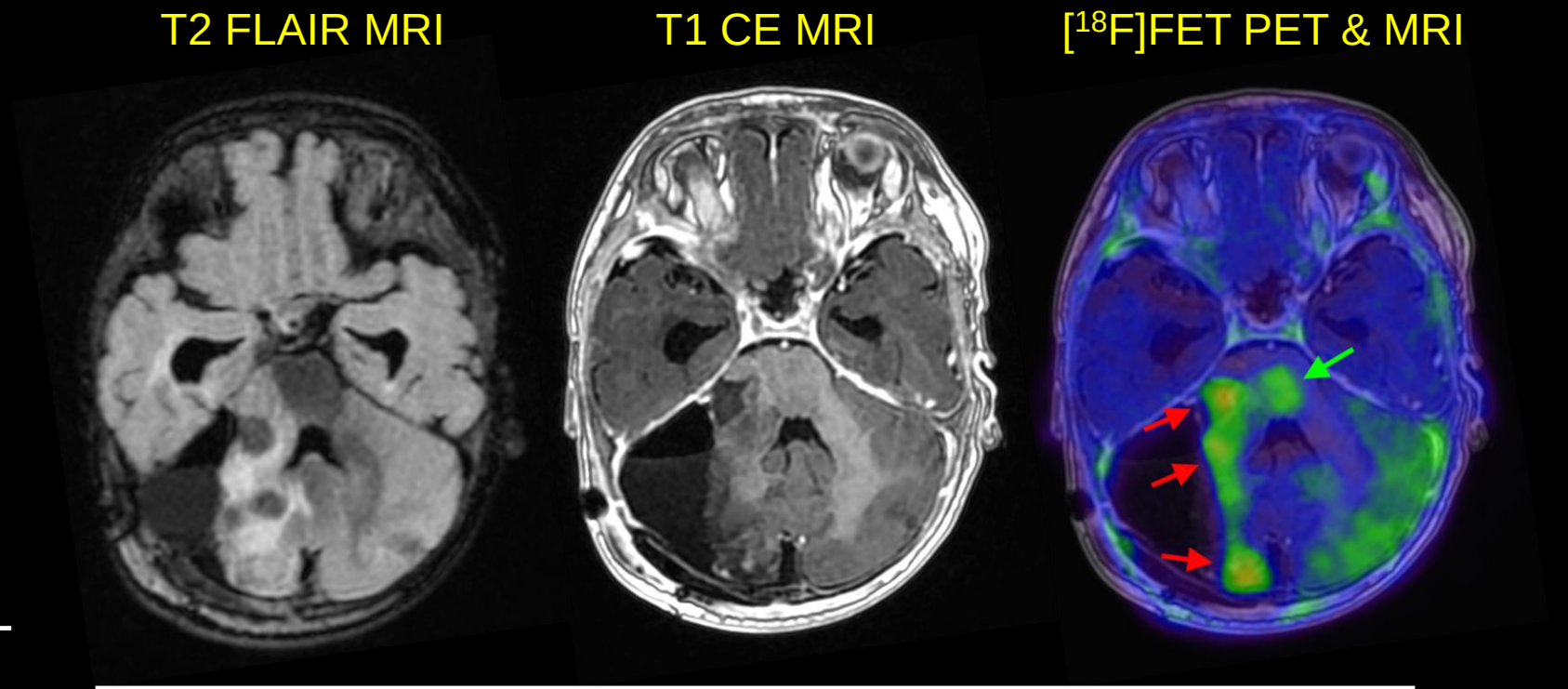
Large acceptance angle with

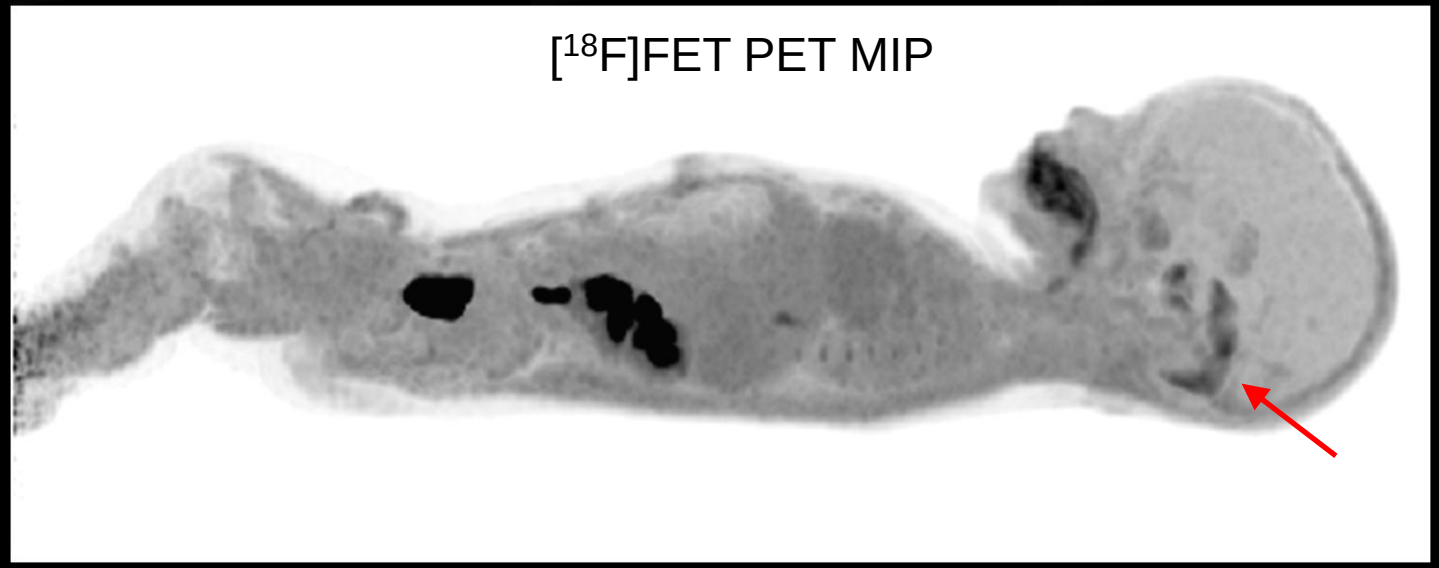




Reducing length of anesthesia

- 11 mo M
- Medulloblastoma
- non-enhancing metabolically active remnants
- LAFOV PET/CT [^{18}F]FET in 5 min GA vs 1-1 1/2 h in PET/MRI
- Screening for drop mets the spine (none)
- [^{18}F]FET has no trapping





Marner L, Lundemann M, Sehested A et al. Diagnostic Accuracy and Clinical Impact of [18F]FET PET in Childhood CNS tumors. Neuro Oncol. 2021

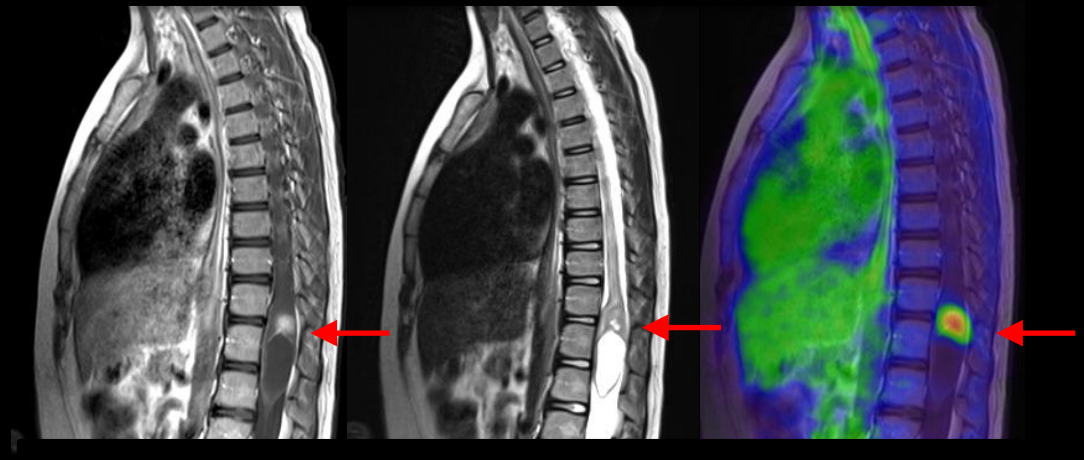
MRI Blind Spots

12 Y F Resection for Ganglioglioma grade 1 in medullary conus

Surgical stabilization -> obscuring tumor and spinal cord

MRI 5 y postop not evaluable because of metal artefacts

Pre surgical
High focal uptake
TBRmax ~ 6

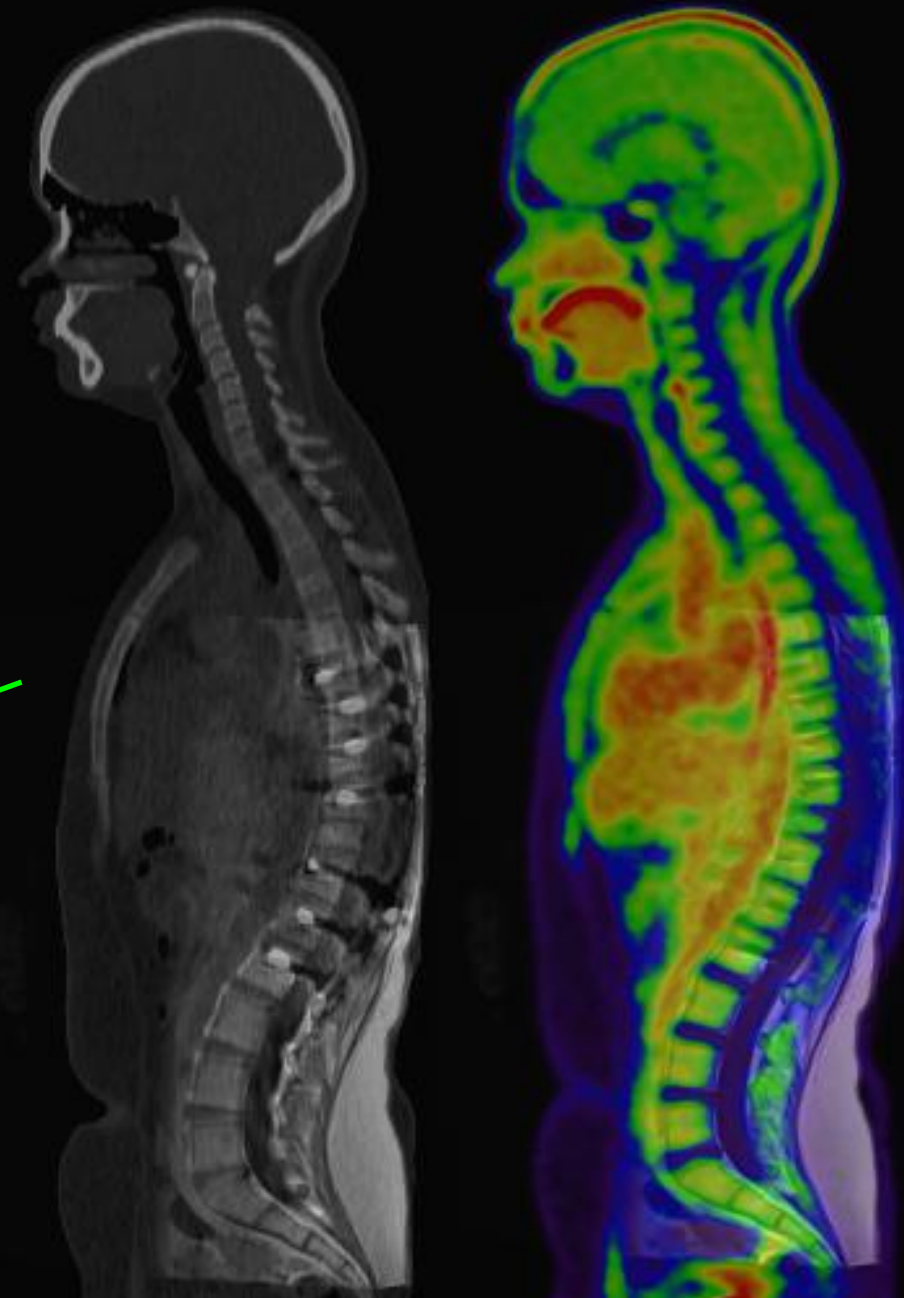


T1 MRI

LAFOV [^{18}F]FET PET/CT 30-35 min pi

CT & MRI

[^{18}F]FET PET & MRI



[^{18}F]FET PET/CT:
Pre op: Metabolic phenotype
Post op: Recurrence detection/delinenation

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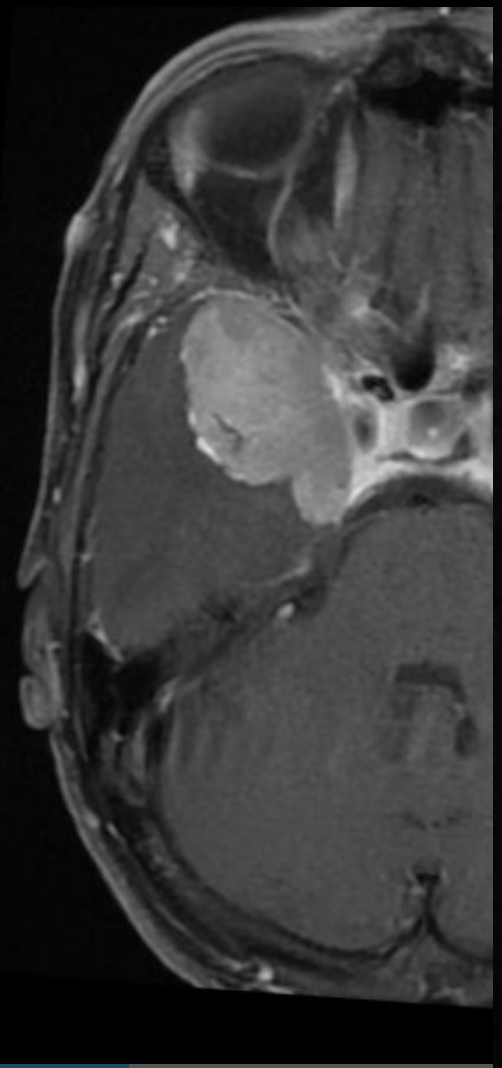
Meningiomas – overexpress SSRT
Indications for Ga-68 DOTAx:
When it becomes difficult for MRI and have a treatment consequence

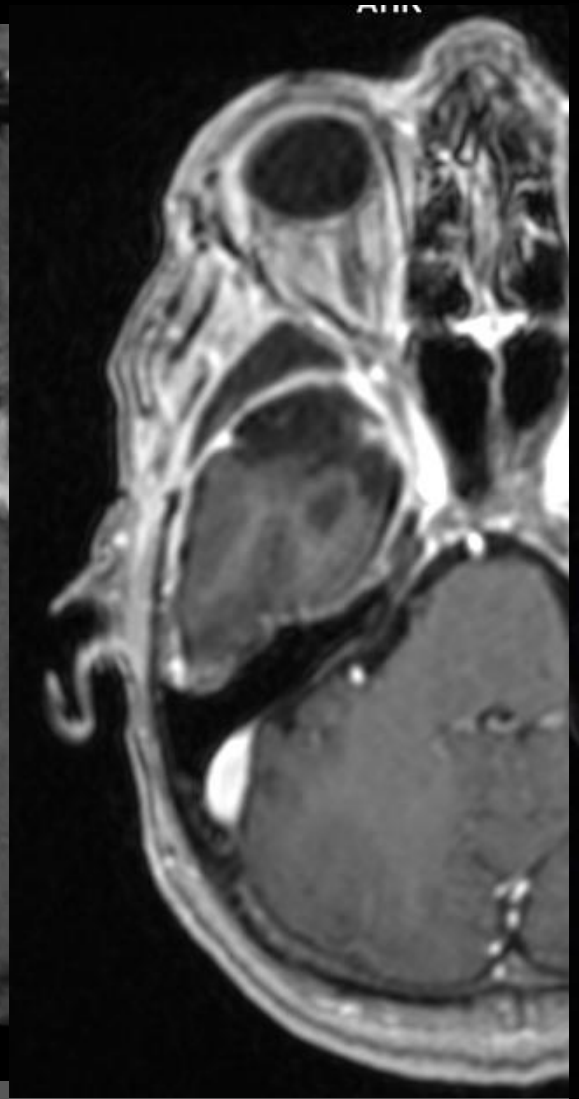
- Differential diagnosis:
  - Meningioma mimicking lesion ?
  - Tumors of optic pathways
- **Definition of tumor extent/burden**
  - Preoperative planning/Treatment selection (Surgery/Non-surgery)
  - Target definition in radiation planning
  - Recurrence/Treatment damage?
- Receptor-targeted radiopeptide therapy (Lu177-, Y90-DOTAx)

Radiotherapy planning - Meningioma Grade II

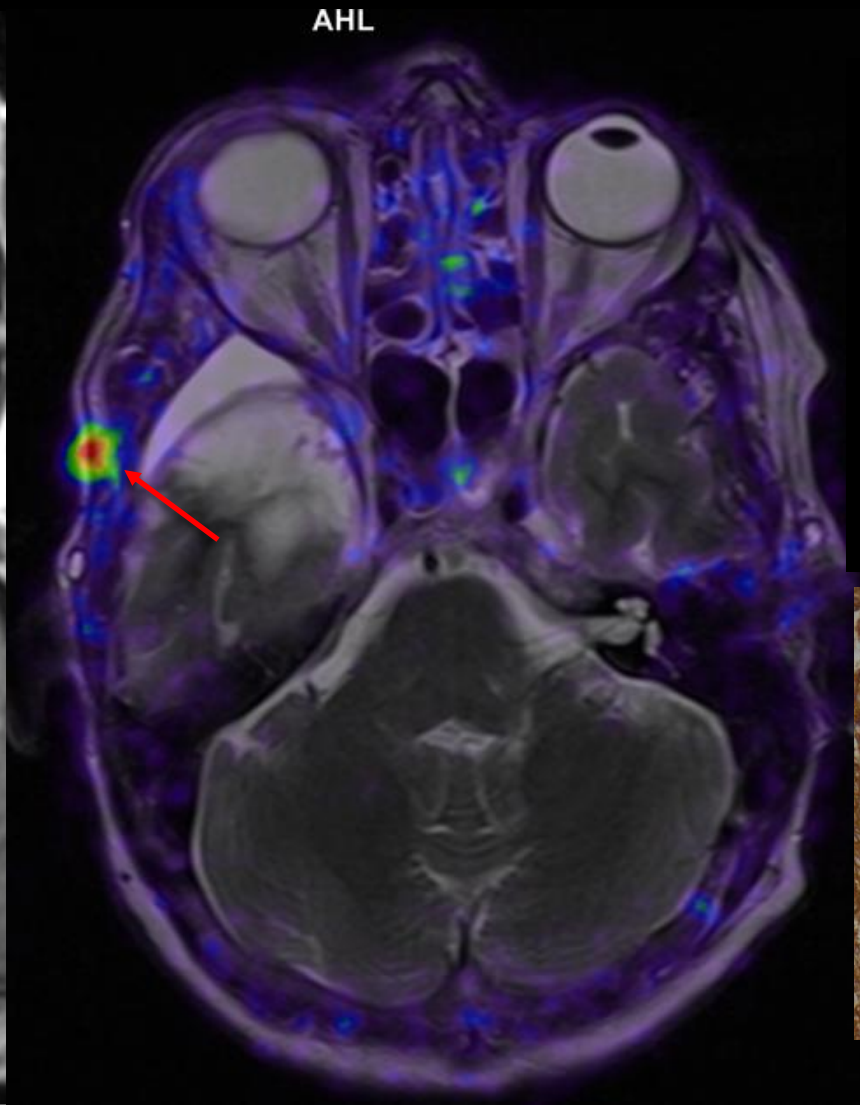
Pre OP MRI T1c



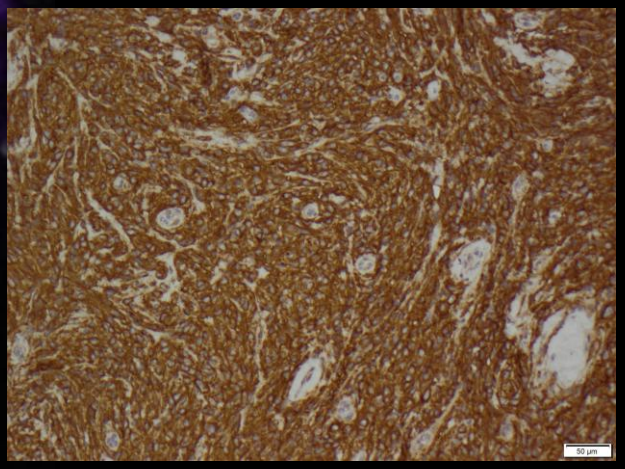
Post OP MRI T1c



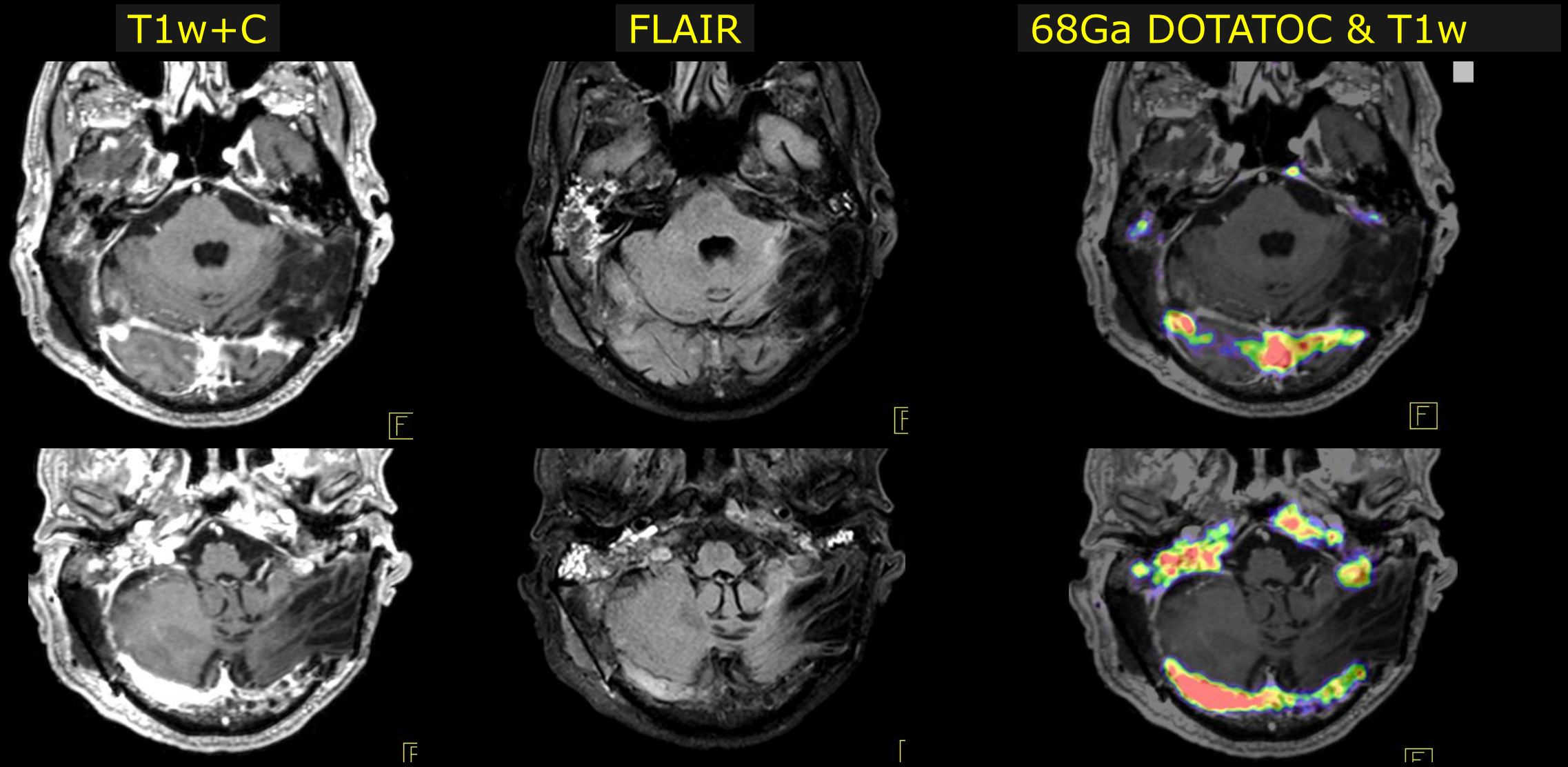
DOTATOC & MRI T2



CT



Meningioma Grade II - Radiotherapy planning



Law I, Højgaard L. Brain tumors: other primary brain tumors, metastases and radiation injury. In: von Schulthess GK, editor. Clinical molecular anatomic imaging - PET/CT, PET/MR and SPECT/CT. Wolters Kluwer Health; 2015. p. 169-179.

Meningioma invasion of vascular system

Anatomical Reference

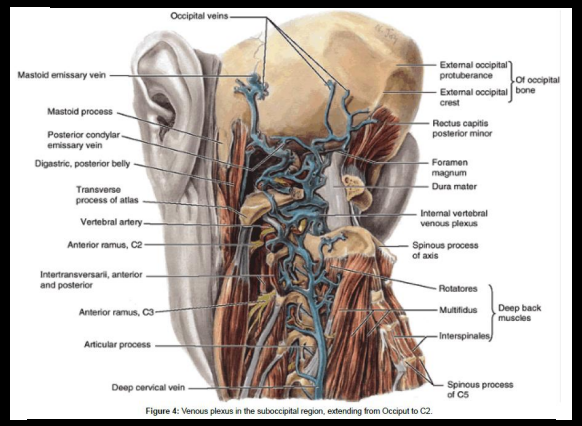
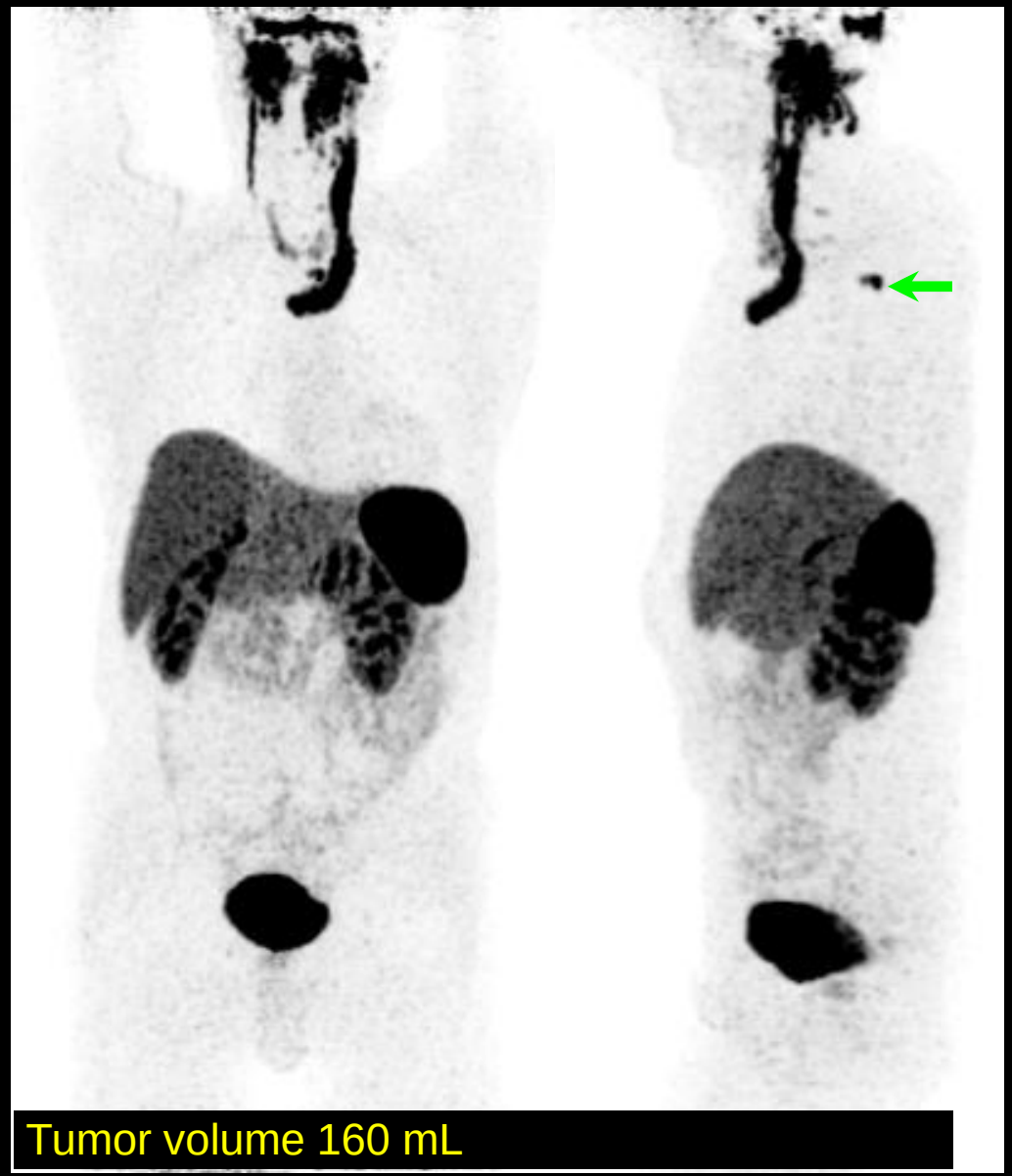


Figure 4: Venous plexus in the suboccipital region, extending from Occiput to C2.

Suboccipital venous plexus

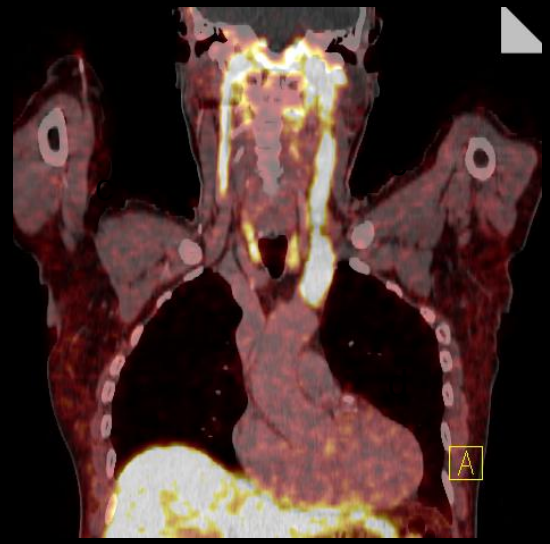
DOTATOC MIP Anterior

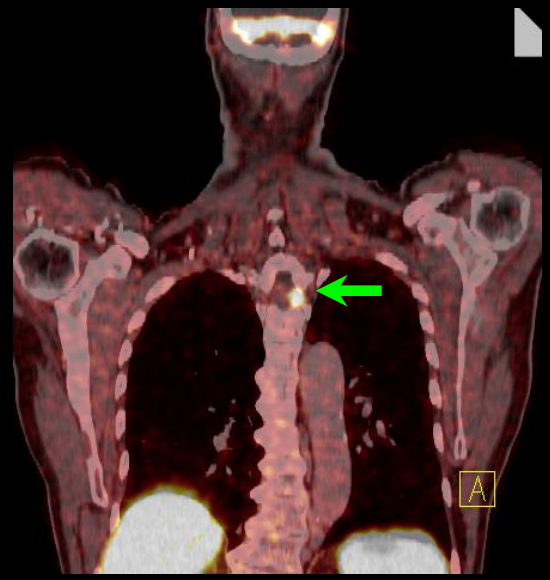
DOTATOC MIP Lateral



Tumor volume 160 mL

DOTATOC PET/CT Coronal





Is Gross Total Resection on MRI Gross Total?

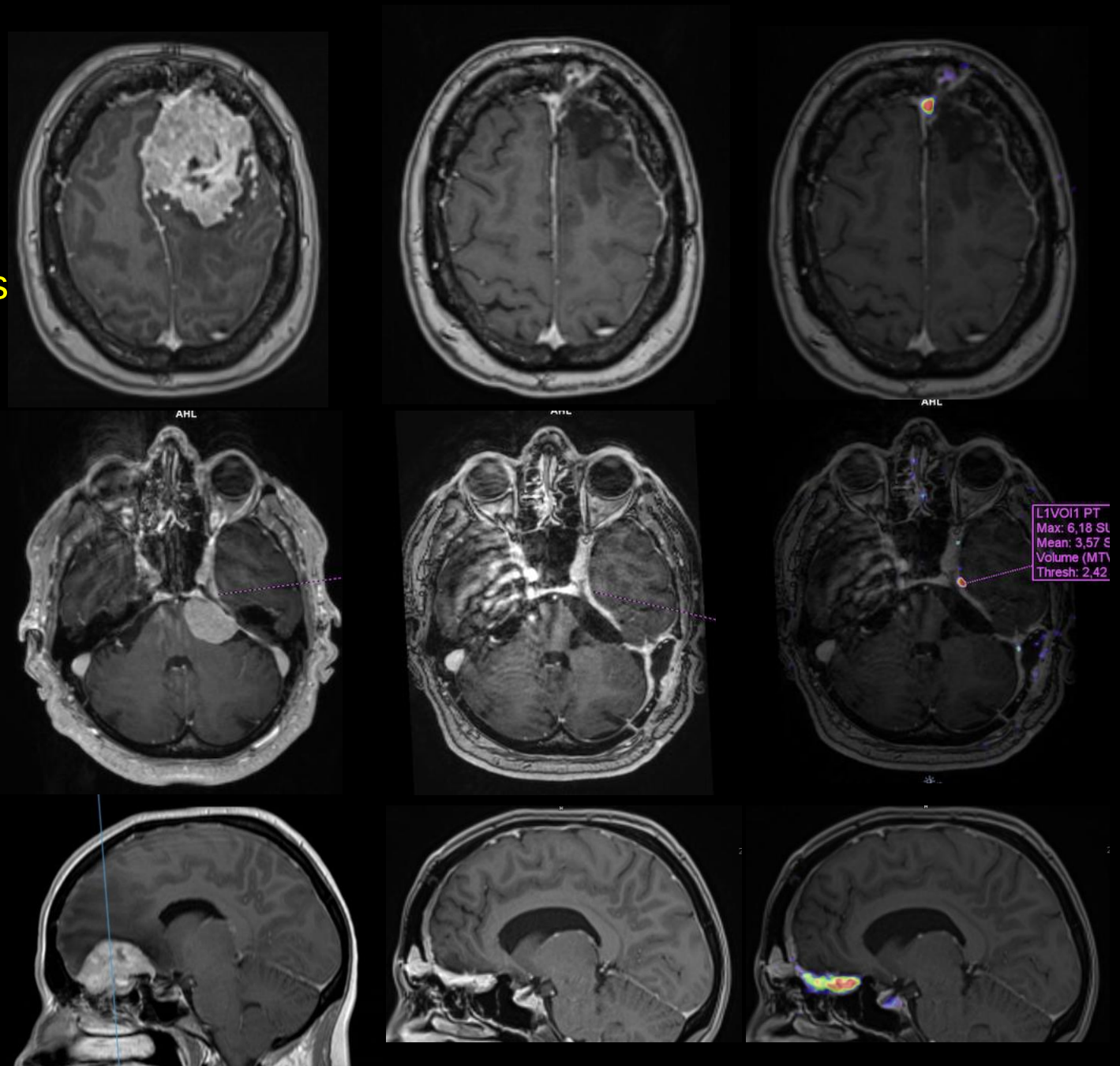
- N=37
- GTR MR 3 mo post primary resection + PET [^{68}Ga]Ga-DOTATOC
- 62 % has PET avid lesions
- Median PET volume: 0.2 cm^3 (range 0.1-6.3 cm^3), 74 % < 1 mL
- Sensitivity: 90 %, specificity: 92%, diagnostic accuracy 90%

Typical Remnant locations in MRI GTR

Meningioma Grade II
Parasagittal: medial for craniotomy on sinus

Meningioma Grade I
Cerebellopontine angle: apex

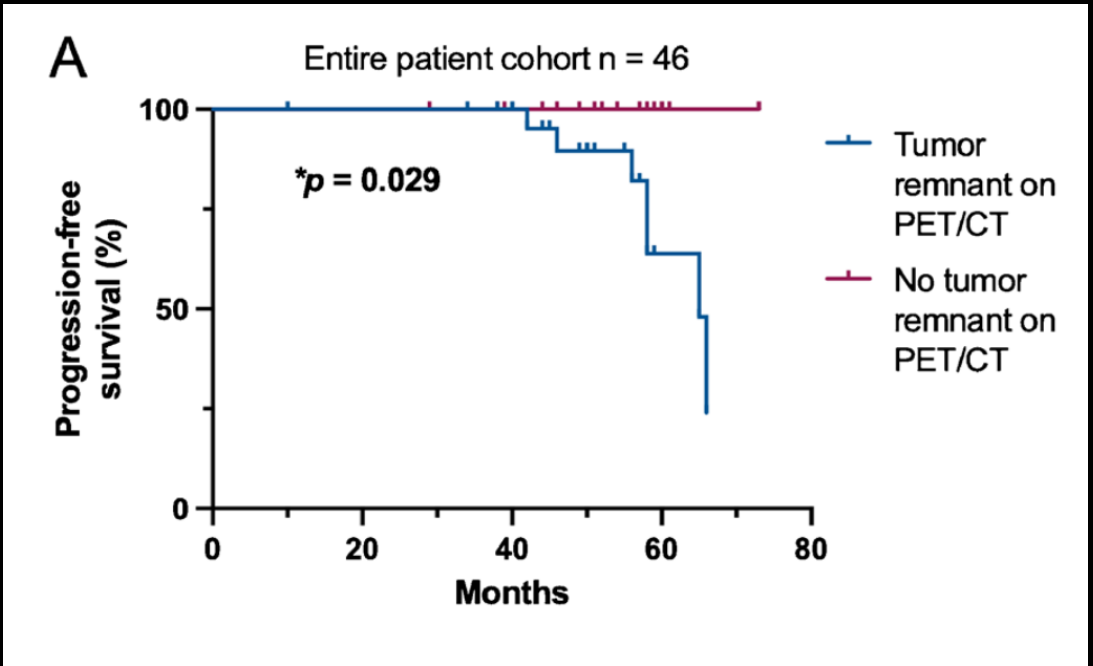
Meningioma Grade II
Olfactory: ethmoid/inferior border

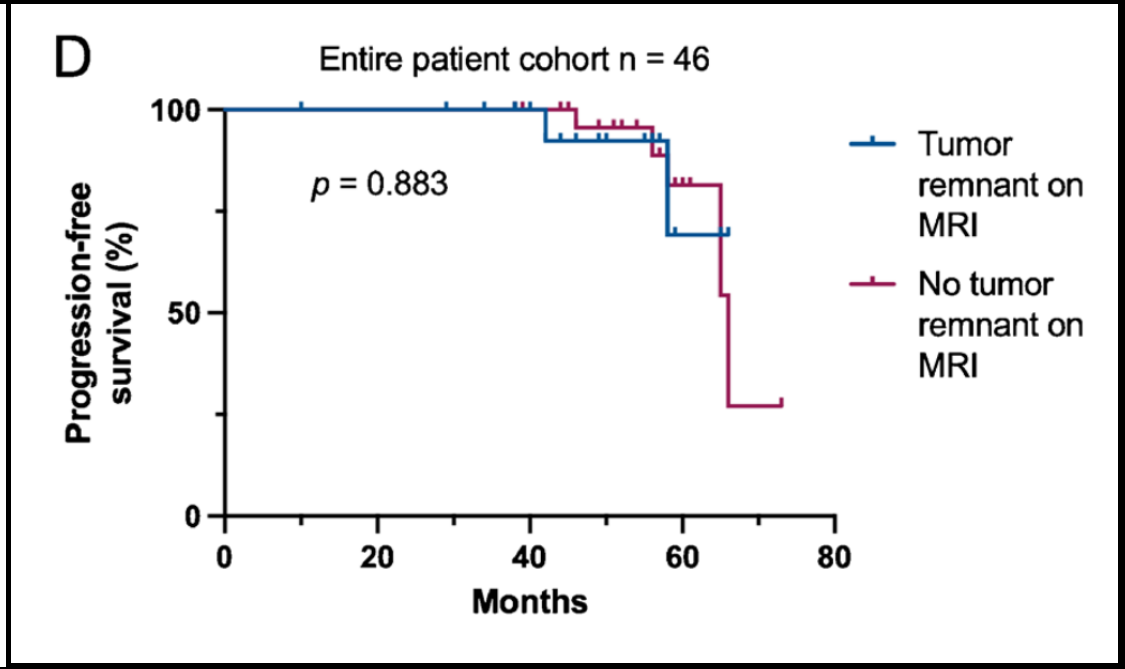


Postoperative [^{68}Ga]Ga-DOTA-TATE PET/CT imaging is prognostic for progression-free survival in meningioma WHO grade 1

Nico Teske[1,2] · Annamaria Biczok[1,2] · Stefanie Quach[1,2] · Franziska J. Dekorsy[2,3] · Robert Forbrig[4] · Raphael Bodensohn[5] · Maximilian Niyazi[2,5,6] · Joerg-Christian Tonn[1,2] · Nathalie L. Albert[2,3] · Christian Schichor[1,2] · Moritz Ueberschaer[1,2]

- Positive PET was associated with an increased risk for progression (p = 0.015) and a lower progression-free survival (*p = 0.029), whereas MRI was not
- All with negative PET findings remained recurrence-free
- Perspective: Early [^{68}Ga]Ga-DOTATOC => Personalised follow-up





Teske N, Biczok A, Quach S et al. Postoperative [^{68}Ga]Ga-DOTA-TATE PET/CT imaging is prognostic for progression-free survival in meningioma WHO grade 1. Eur J Nucl Med Mol Imaging. 2023;51:206-217.

^{177}Lu-DOTATATE for recurrent Meningioma: a randomized phase II study (LUMEN-1)

EORTC 2334

- Study coordinator: Nathalie L. Albert, Germany
- Study co-coordinator: Matthias Preusser, Austria

Study design LUMEN-1

Recurrent meningioma
WHO grade 1, 2, 3
No local therapy indicated
No prior systemic therapy
Measurable disease
Radiologically documented progression (>25% in last 2 y)
SSTR-positive (confirmed by PET)

R
2:1

^{177}Lu-DOTATATE
(7.4 GBq i.v. every 4 weeks, 4 cycles)

Local standard of care (LOC)

- **136** patients
- **35** sites
- **10** countries

Thanks to the organisers