^{18}F-FET and ^{68}Ga-Dotatate-PET/CT in the management of brain tumors

Donatienne Van Weehaeghe, MD, PhD

UZ GENT

^{18}F-FET-PET/CT

- Uptake mechanism
- Indications
- Analysis
- Pitfalls

^{18}F-FET-PET/CT

- **Uptake mechanism**
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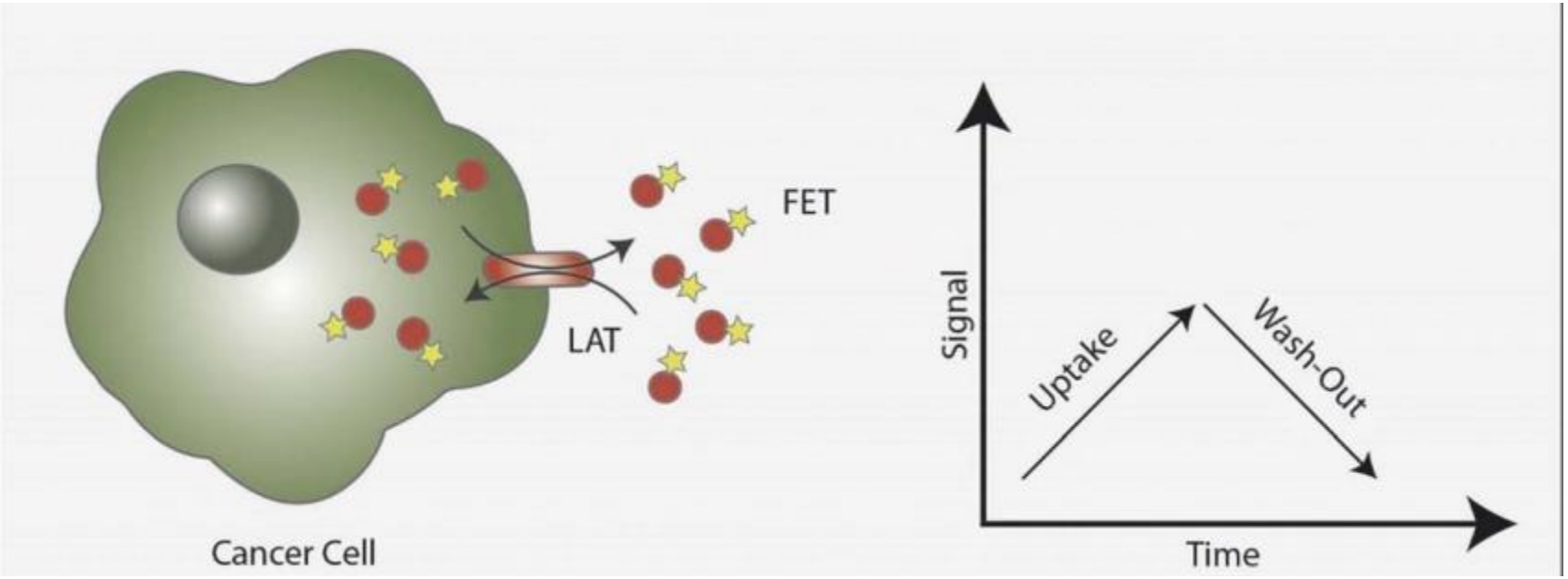
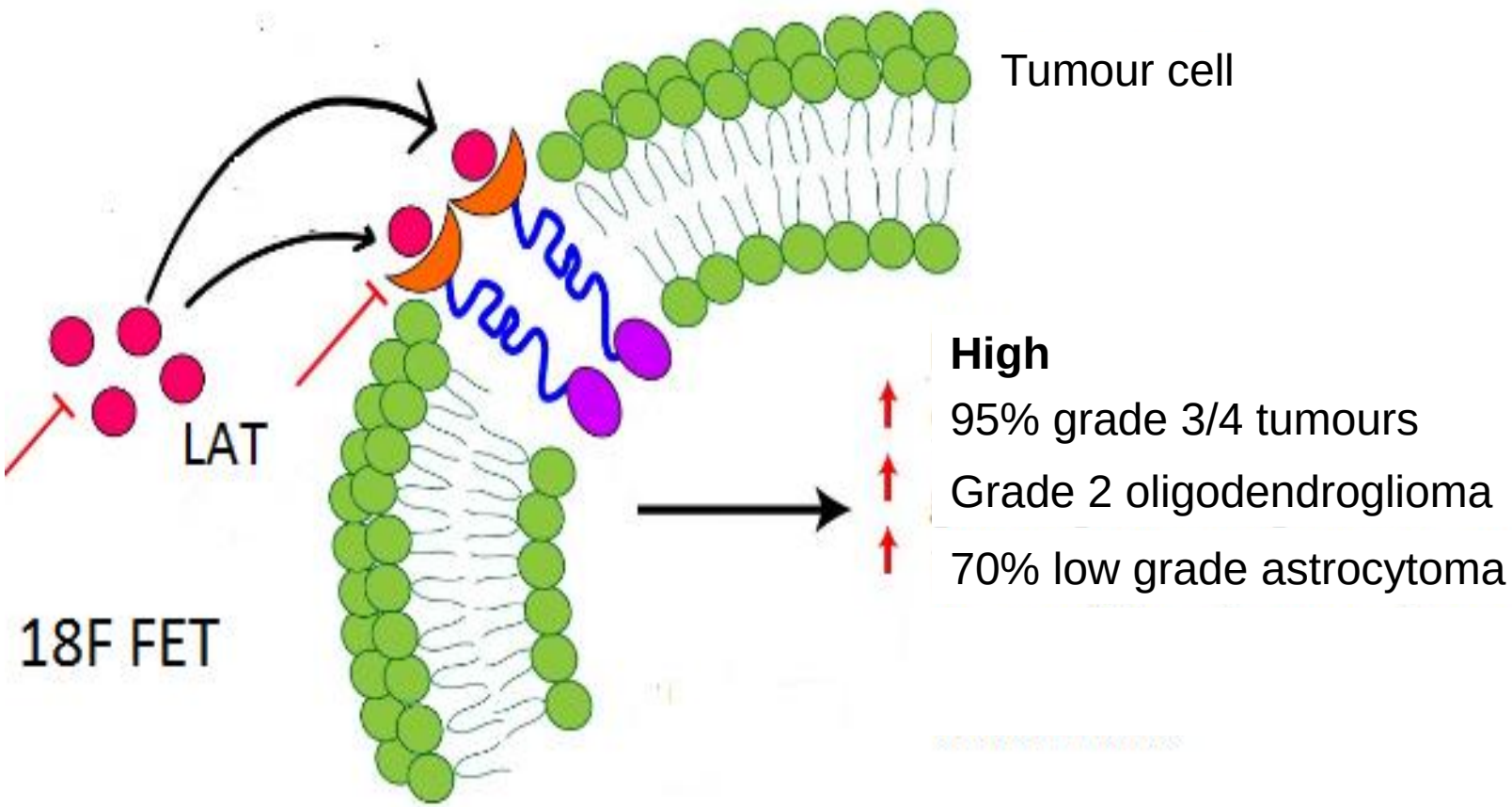
- Pitfalls

Uptake mechanism



Akhoundova et al. Zurich open repository and archive 2020.

Uptake mechanism



Courtesy of UMC Utrecht.

^{18}F-FET-PET/CT

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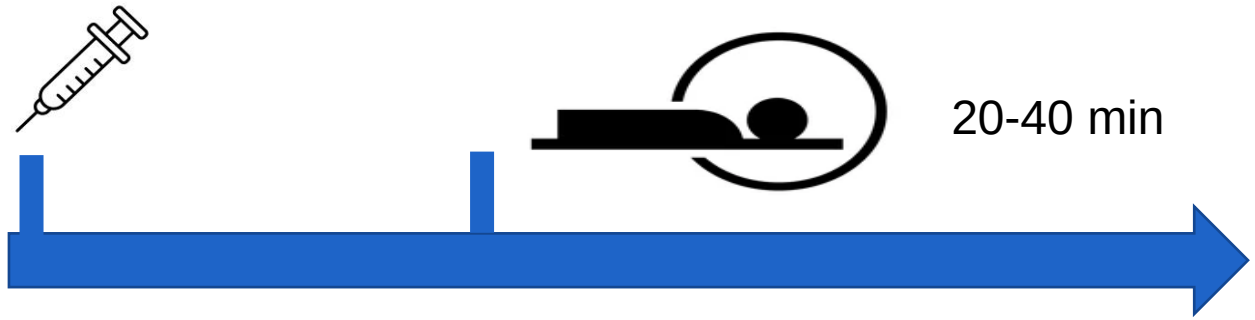
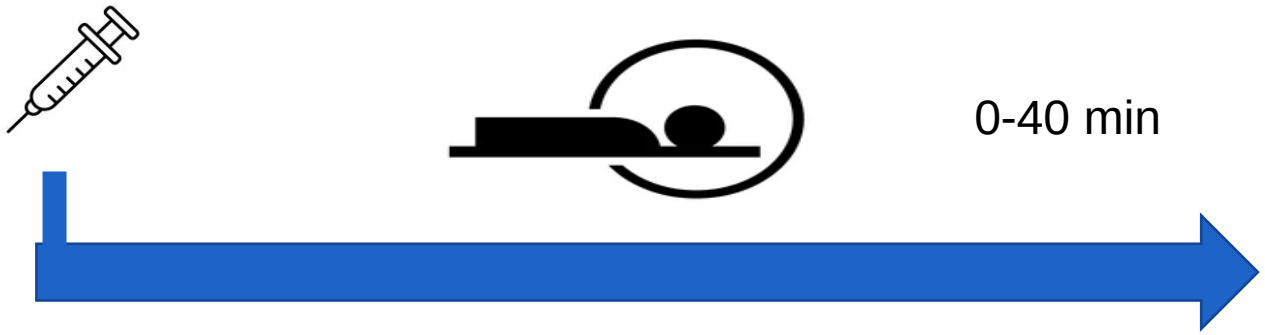
Indications

Dose: 185 - 200 MBq



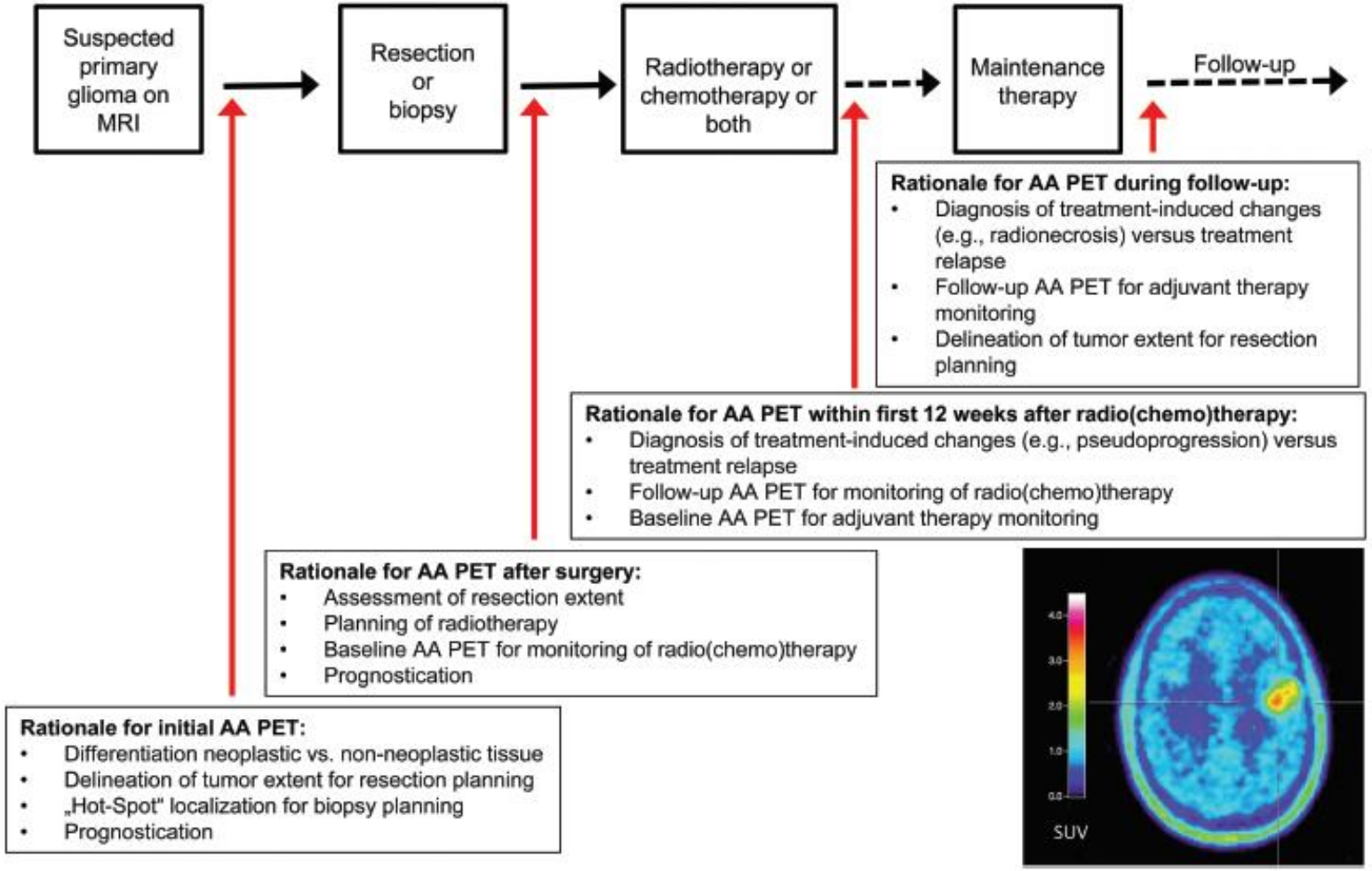


When?

Dynamic scan to determine grade

Galldiks et al. EJNMMI 2014.

Indications



Albert et al. RANO. NeuroOncol 2016.

Indications

Suspected primary glioma on MRI

Radiotherapy or chemotherapy or both

Maintenance therapy

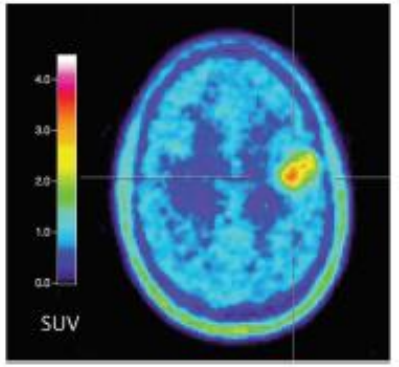
Follow-up

Rationale for AA PET during follow-up:
- Diagnosis of treatment-induced changes (e.g., radionecrosis) versus treatment relapse
- Follow-up AA PET for adjuvant therapy monitoring
- Delineation of tumor extent for resection planning

Rationale for AA PET within first 12 weeks after radio(chemo)therapy:
- Diagnosis of treatment-induced changes (e.g., pseudoprogression) versus treatment relapse
- Follow-up AA PET for monitoring of radio(chemo)therapy
- Baseline AA PET for adjuvant therapy monitoring

rgery:
xtent

oring of radio(chemo)therapy



Rationale for initial AA PET:
- Differentiation neoplastic vs. non-neoplastic tissue
- Delineation of tumor extent for resection planning
- „Hot-Spot" localization for biopsy planning
- Prognostication

Albert et al. RANO. NeuroOncol 2016.

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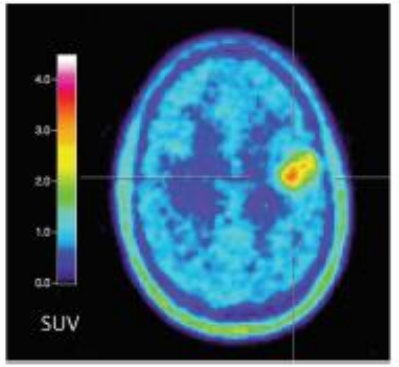
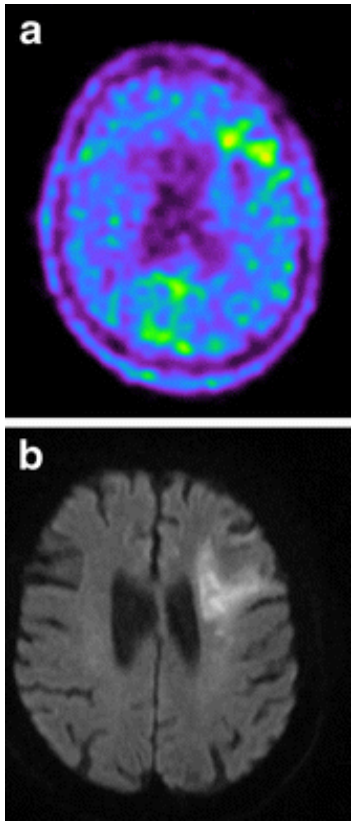


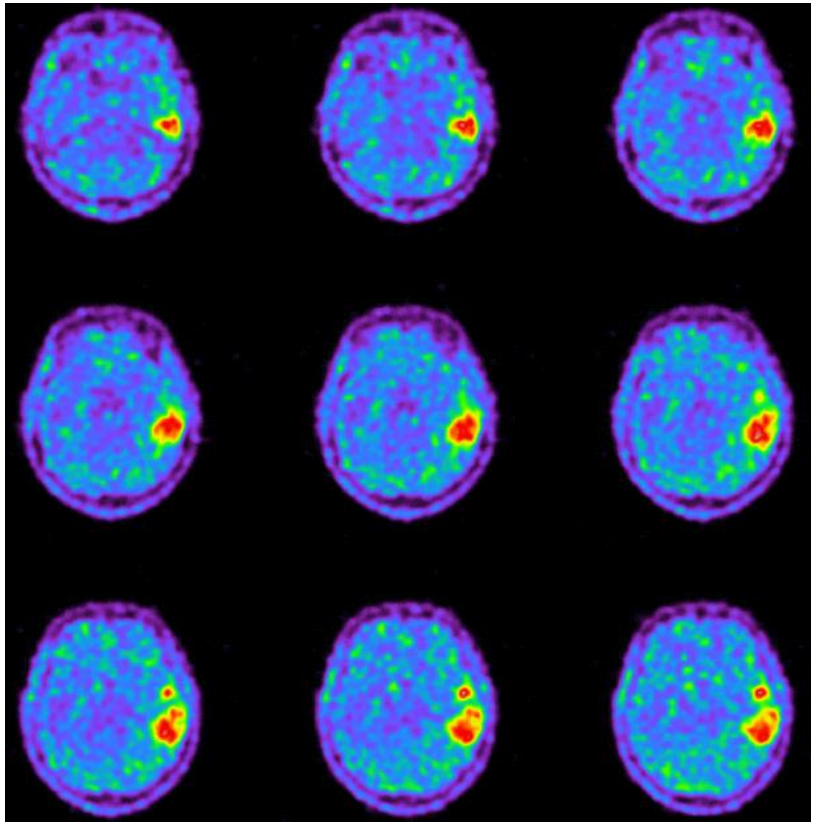
Albert et al. RANO. NeuroOncol 2016.

Indications

Ischaemia with haemorrhagic transformation

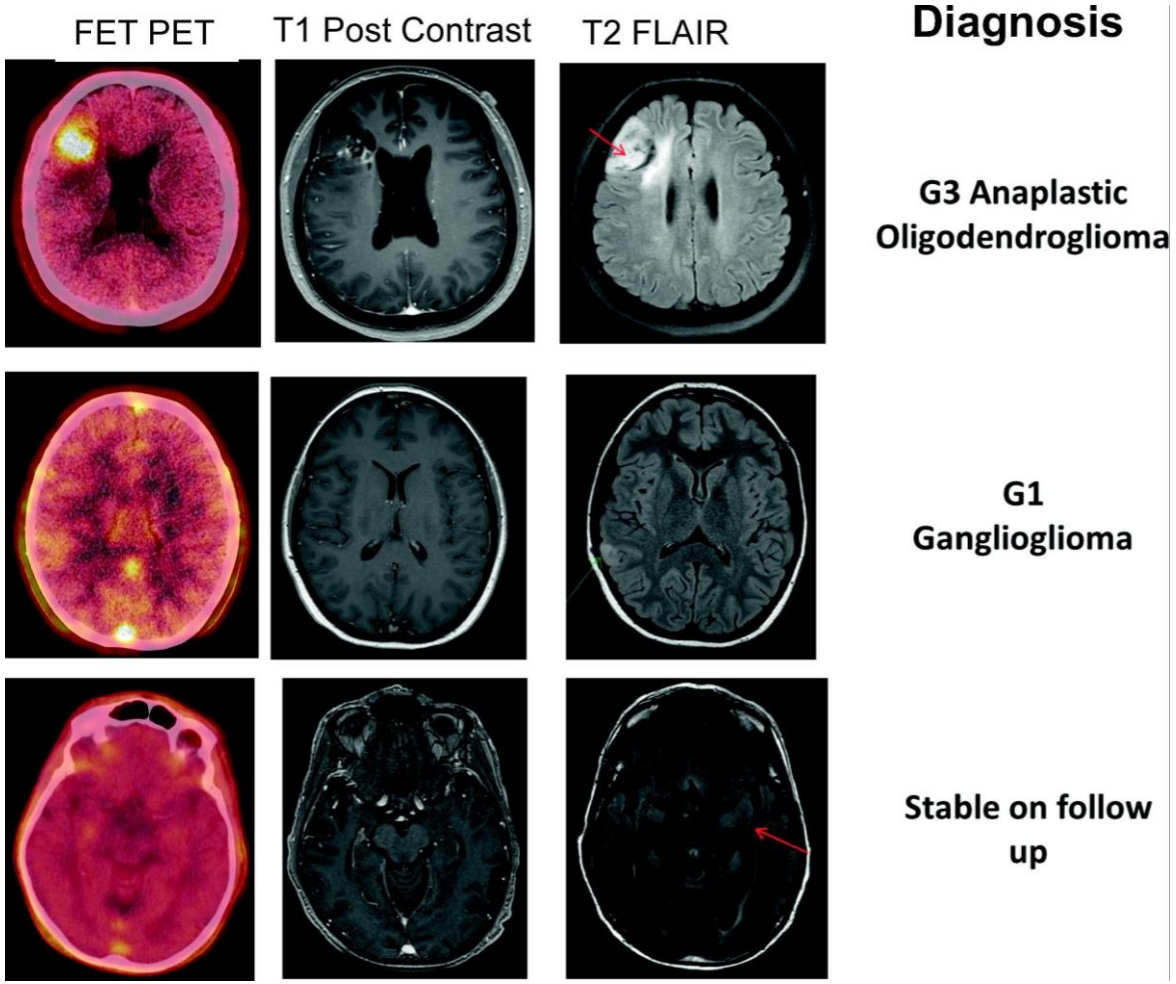


Glioblastoma



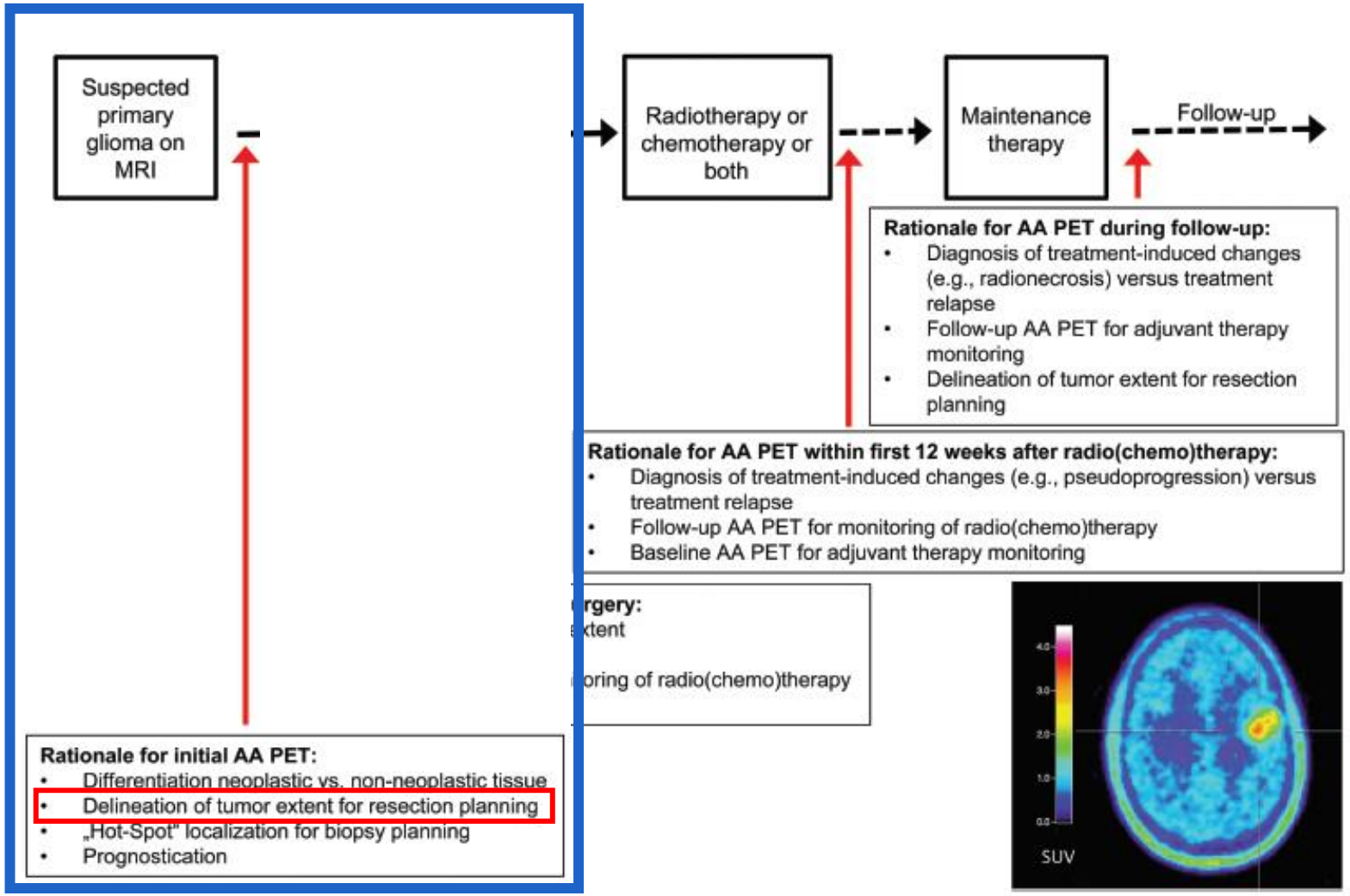
Pichler et al. EJNMMI 2010.

Indications



Chan et al. Journal of clinical neuroscience 2018.

Indications



Albert et al. RANO. NeuroOncol 2016.

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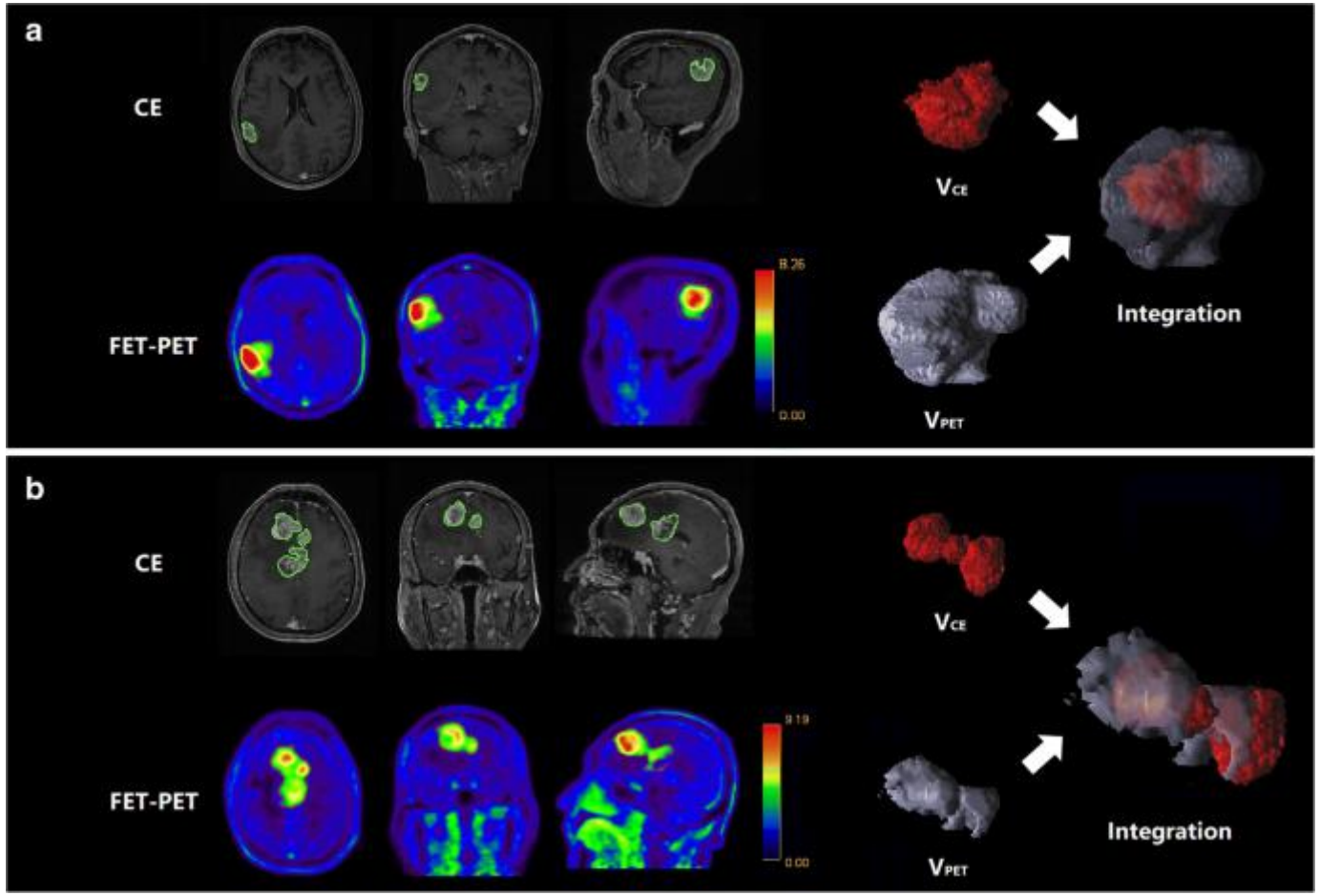
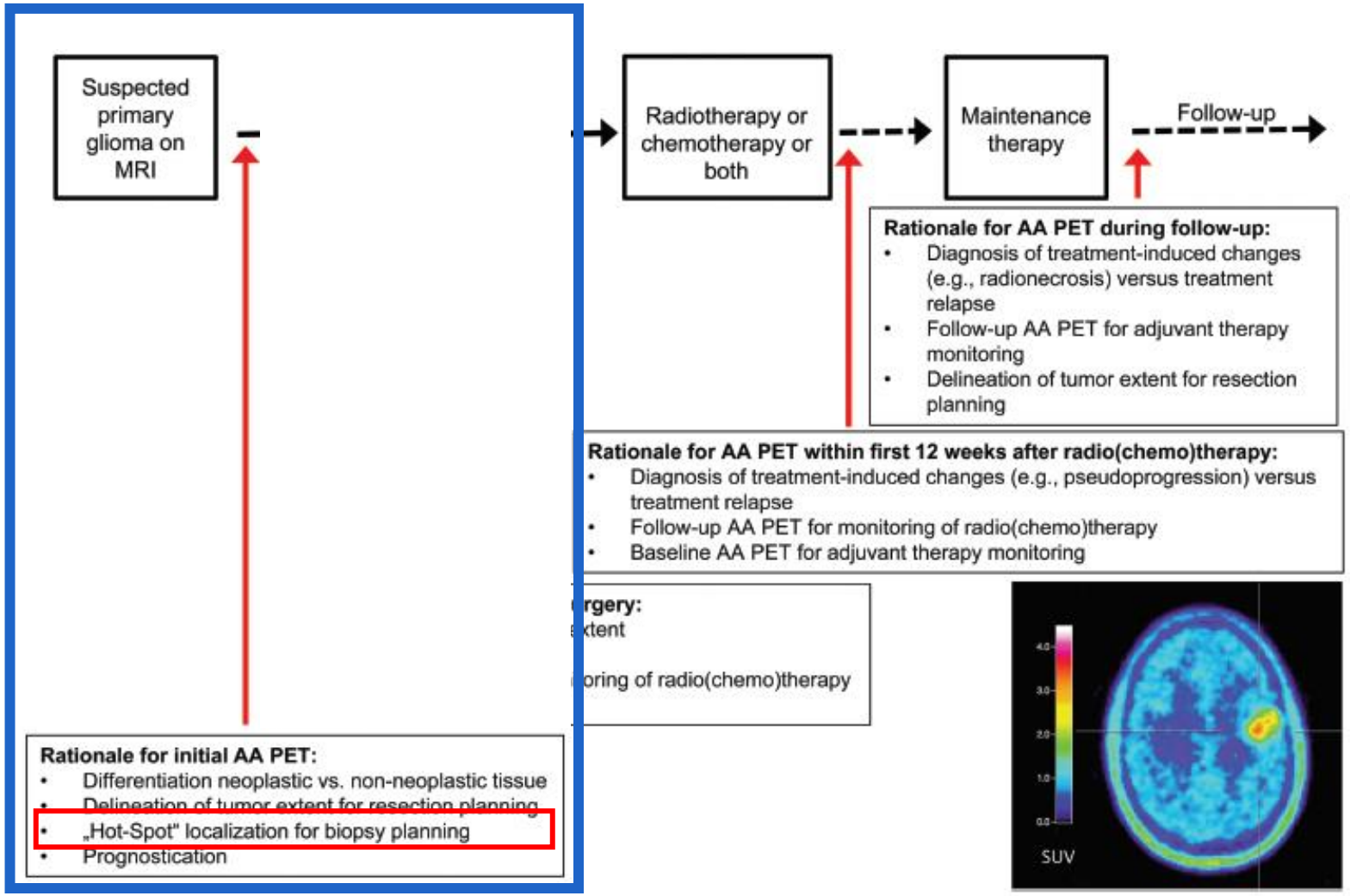


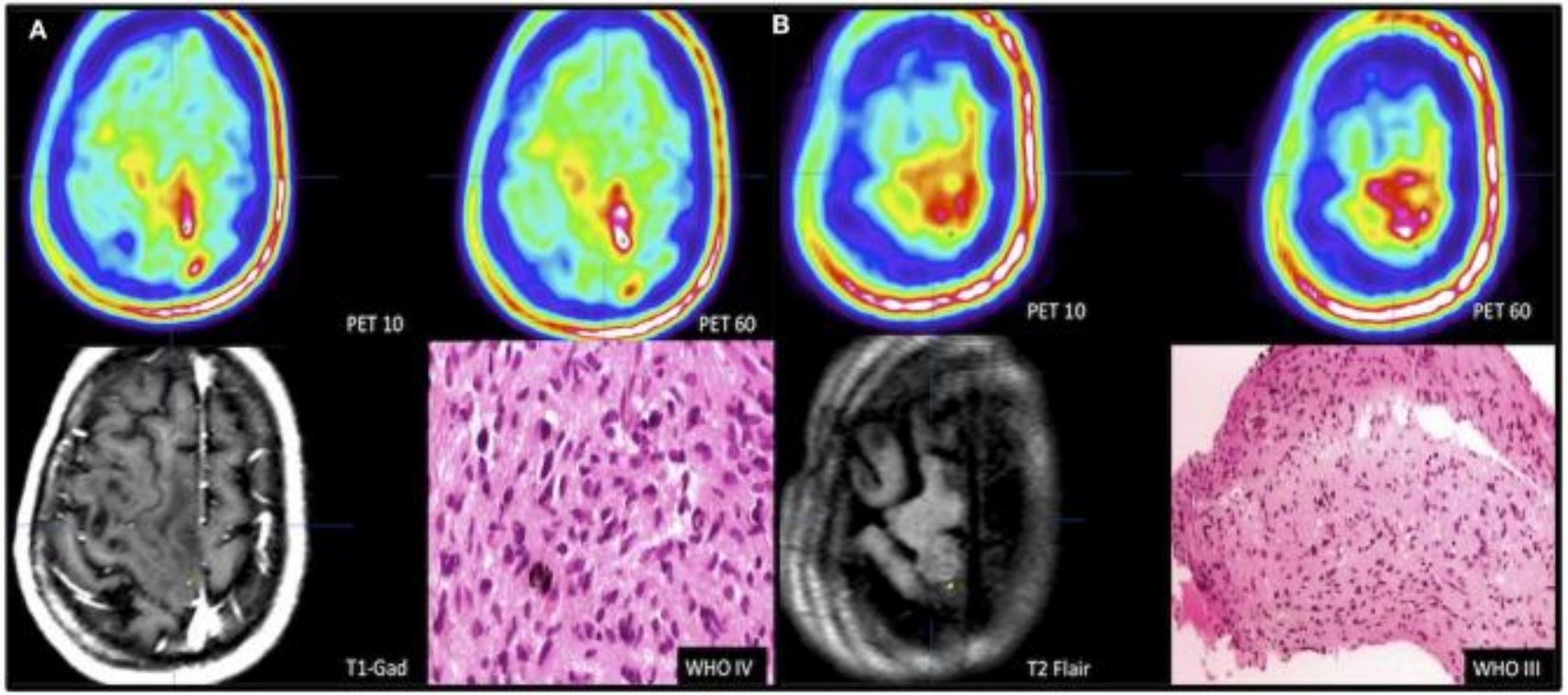
Song et al. EJNMMI 2020.

Indications



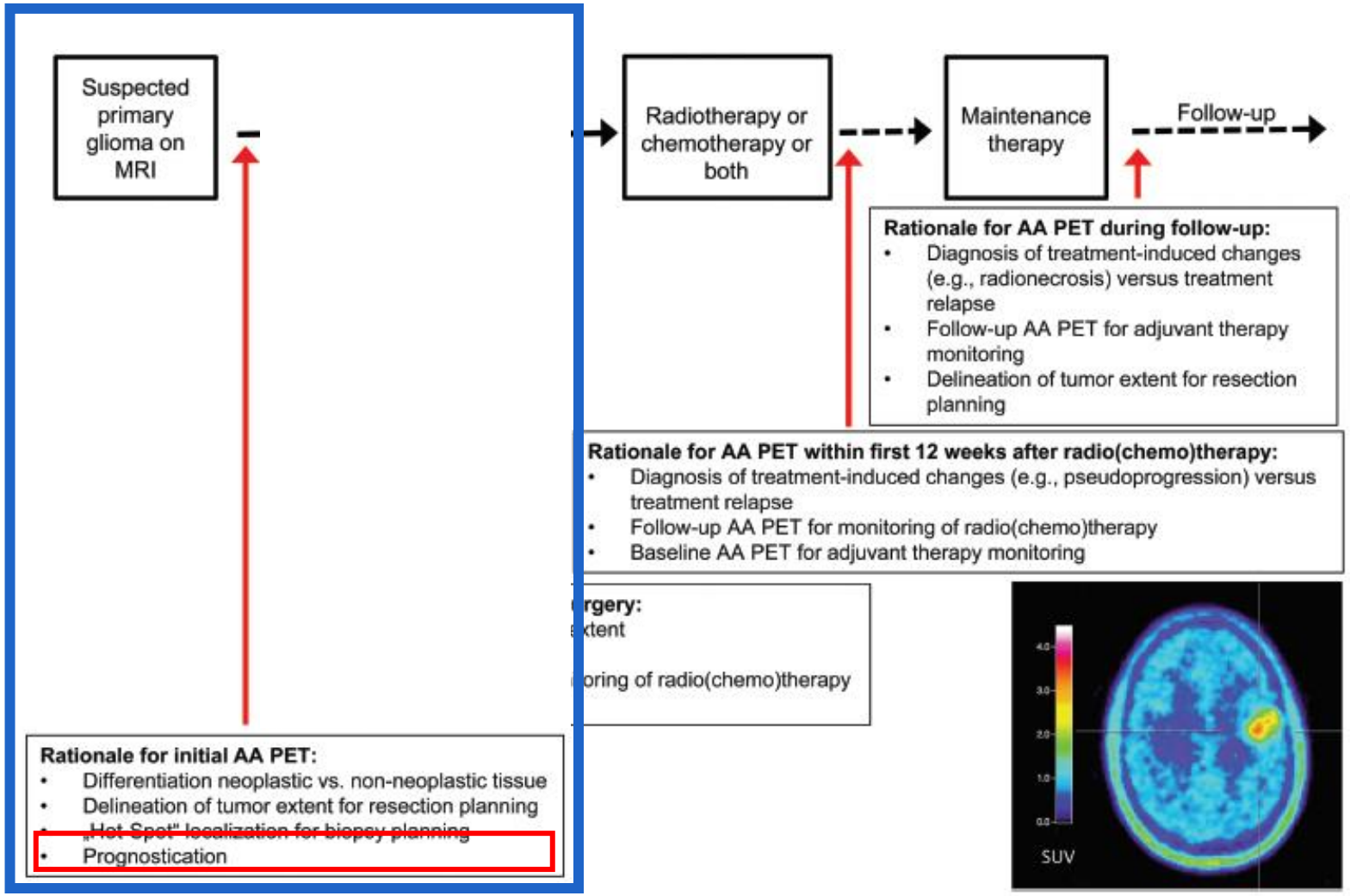
Albert et al. RANO. NeuroOncol 2016.

Indications



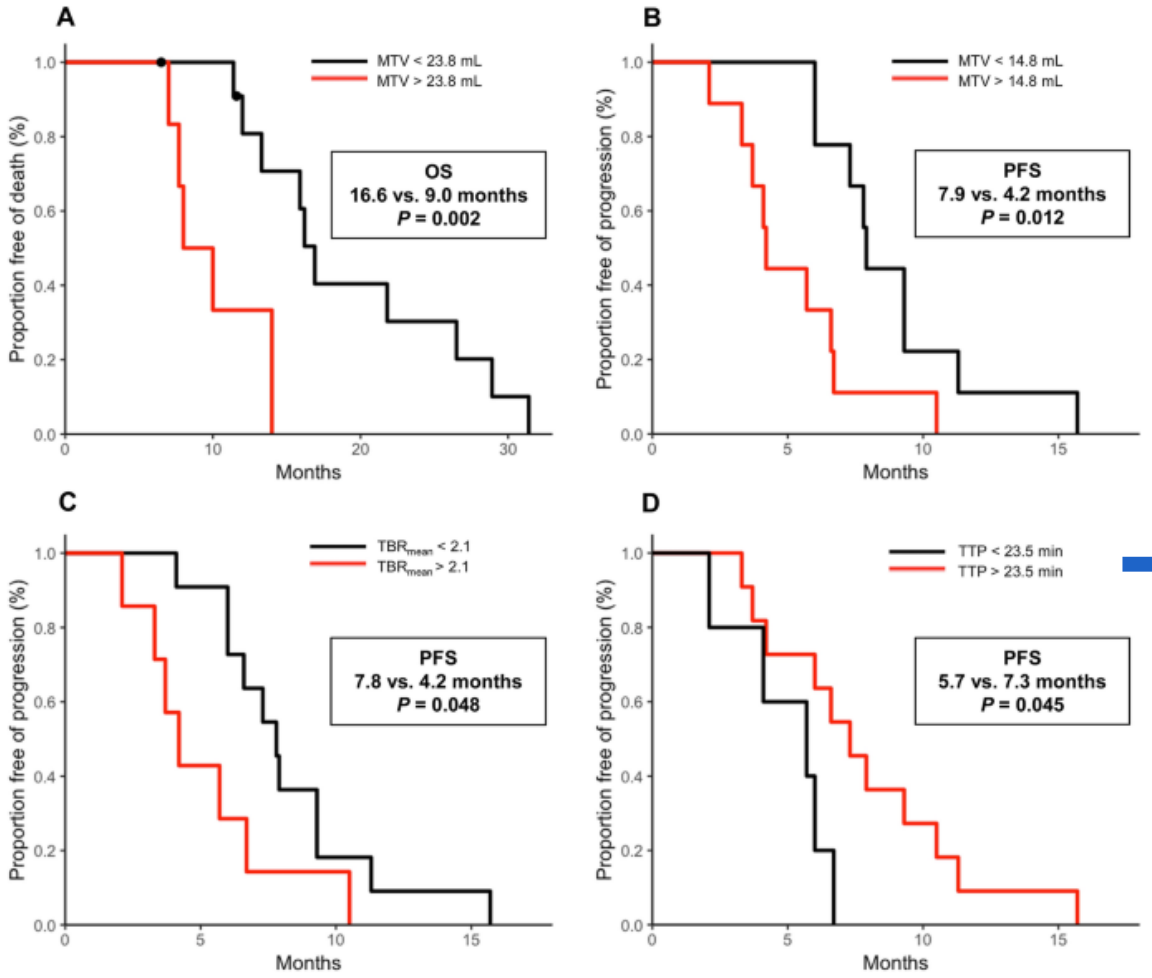
Furtak et al. Front Neurol 2021.

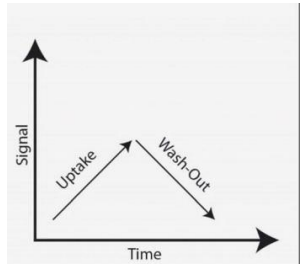
Indications



Albert et al. RANO. NeuroOncol 2016.

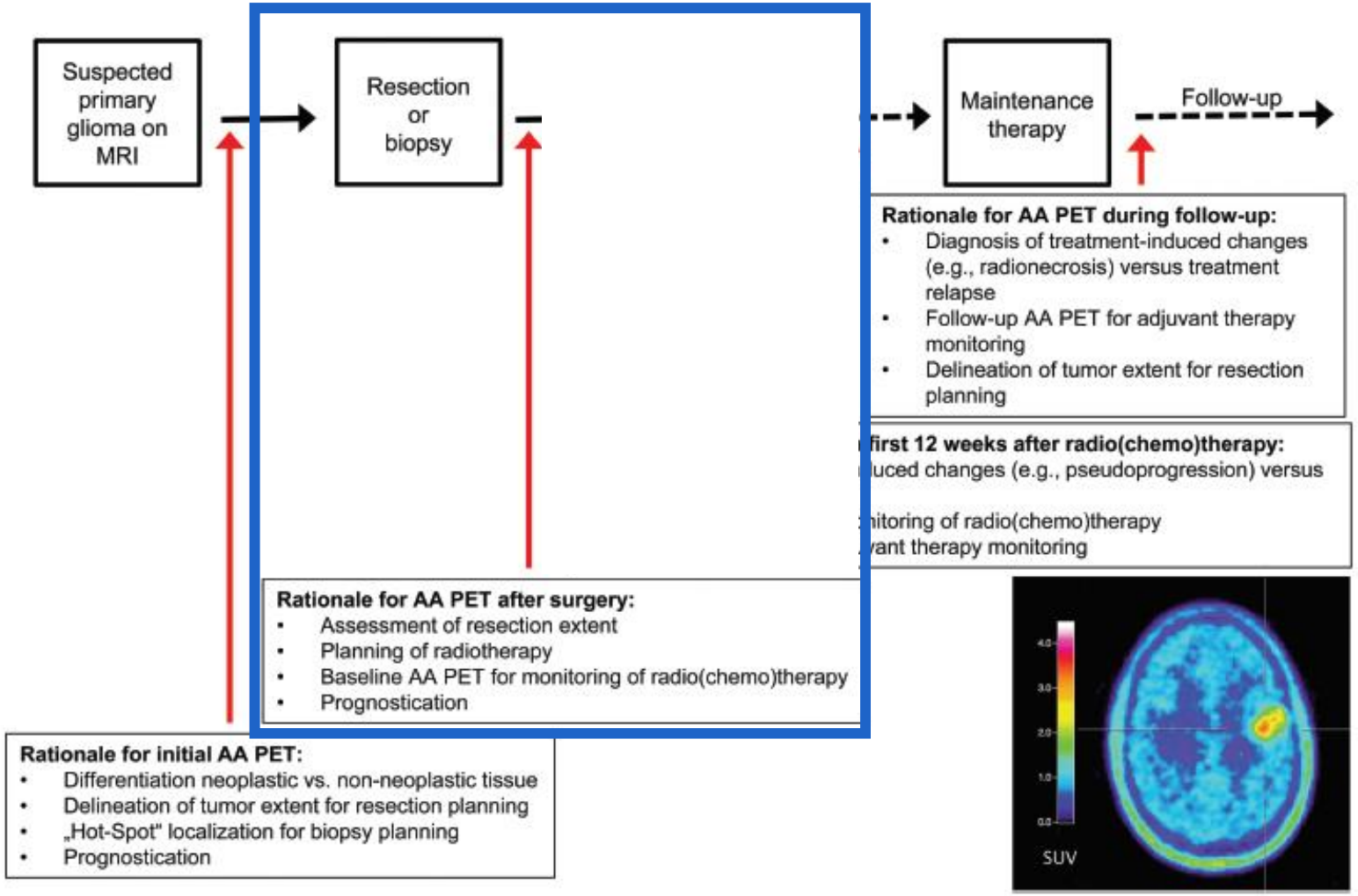
Indications





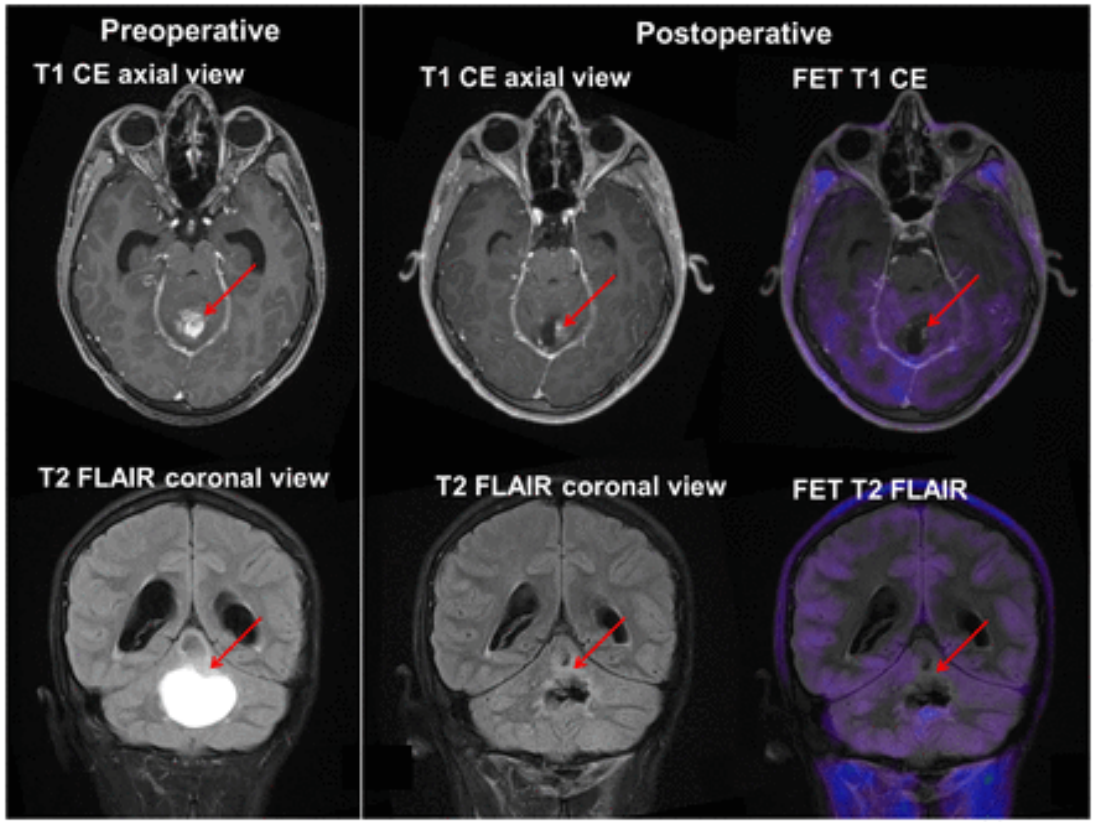
Rosen et al. Scientific reports 2021.

Indications



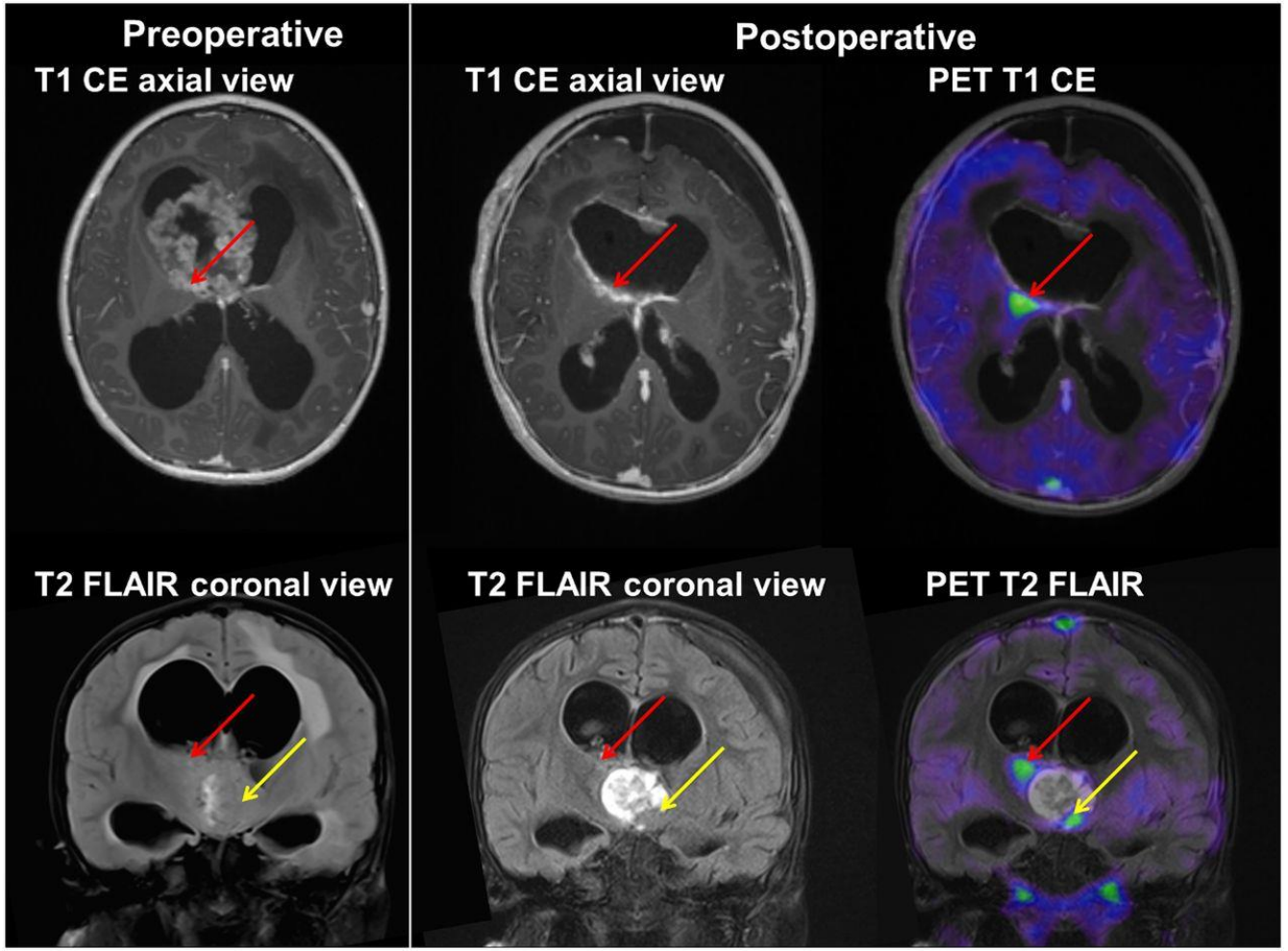
Albert et al. RANO. NeuroOncol 2016.

Indications



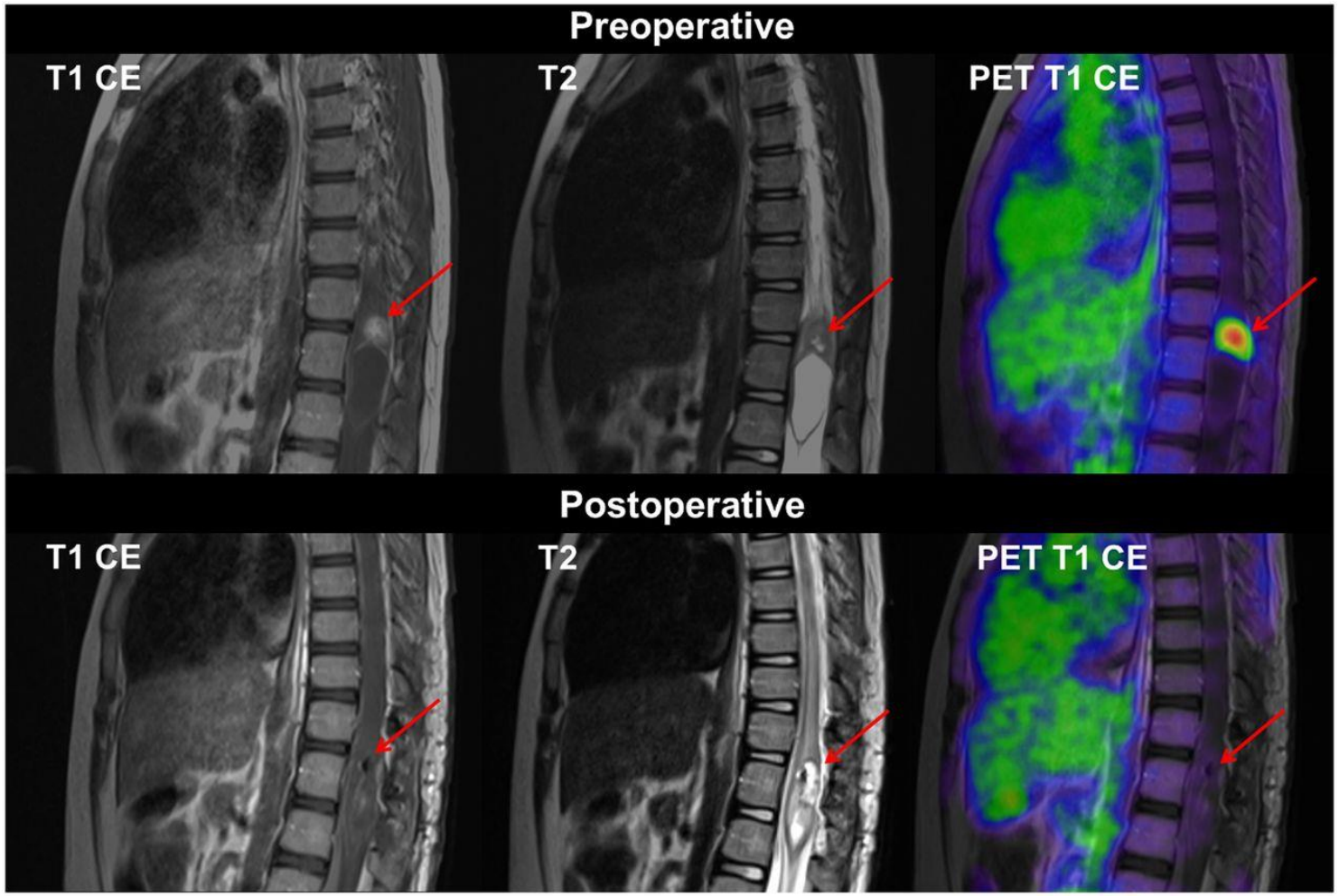
Marner et al. JNM 2019.

Indications



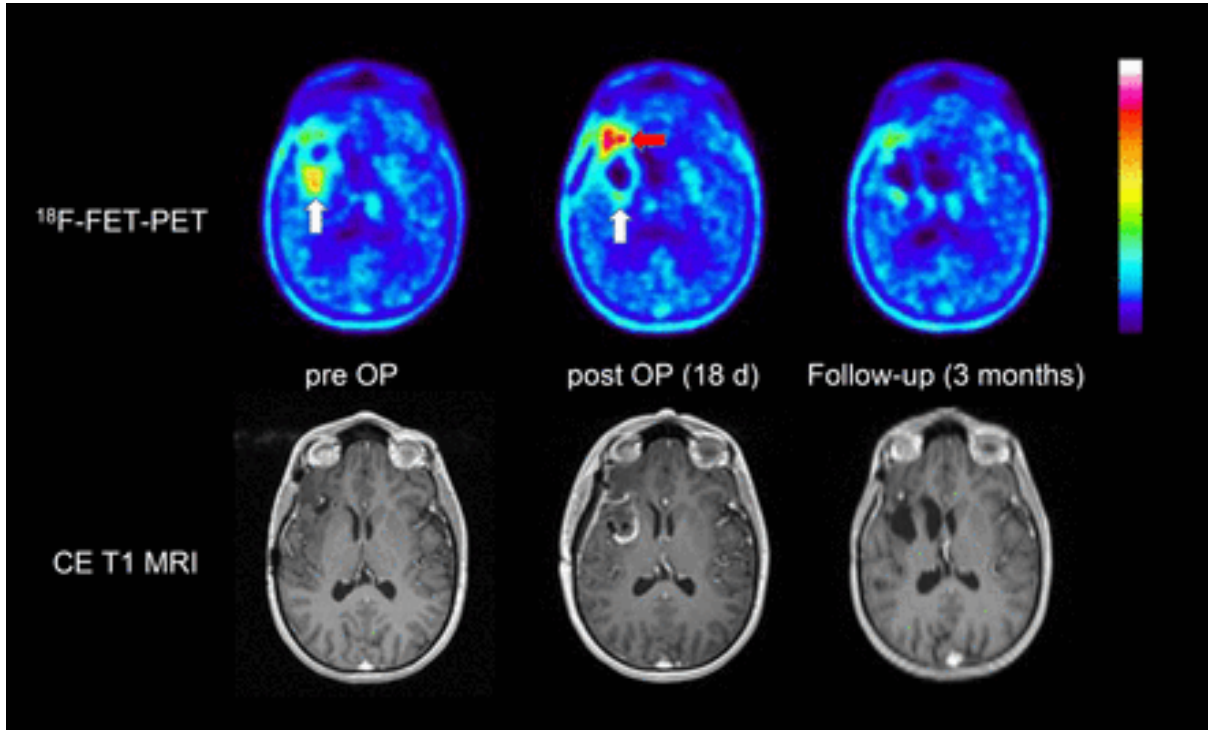
Marner et al. JNM 2019.

Indications



Marner et al. JNM 2019.

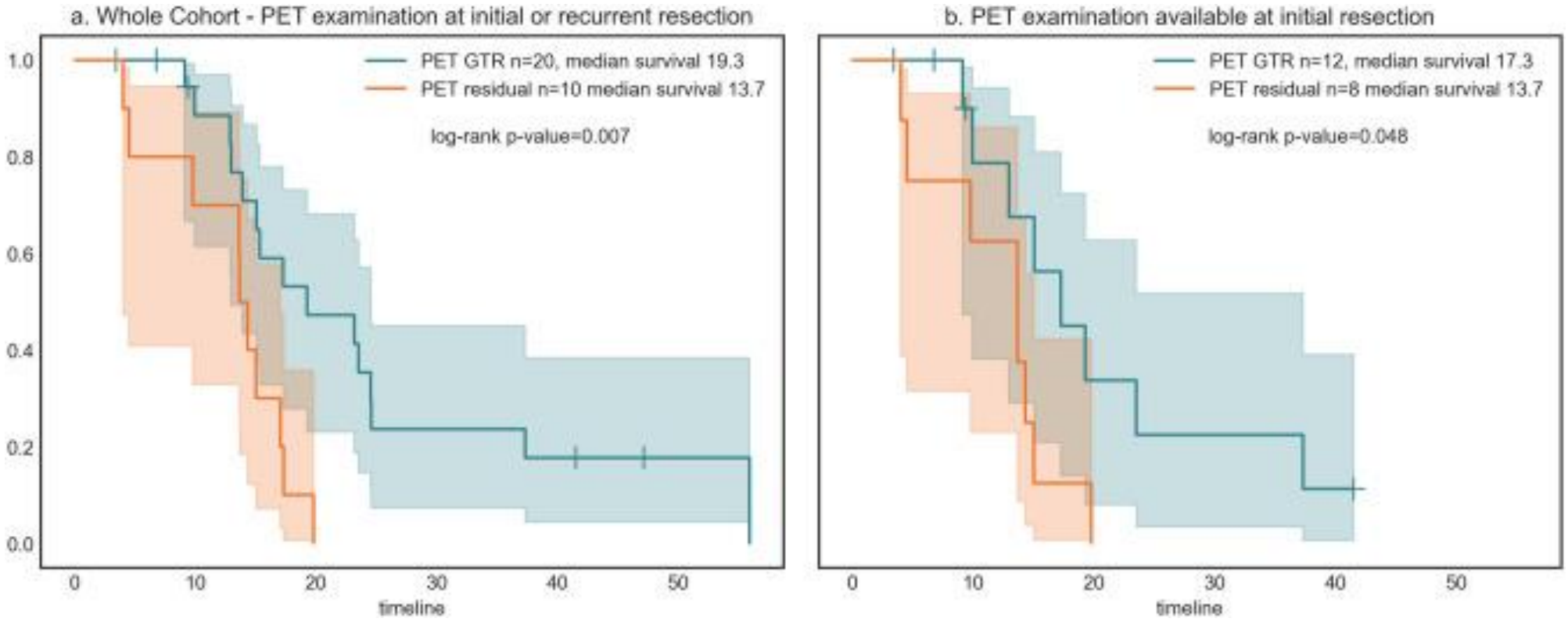
Indications



Cave flare phenomen

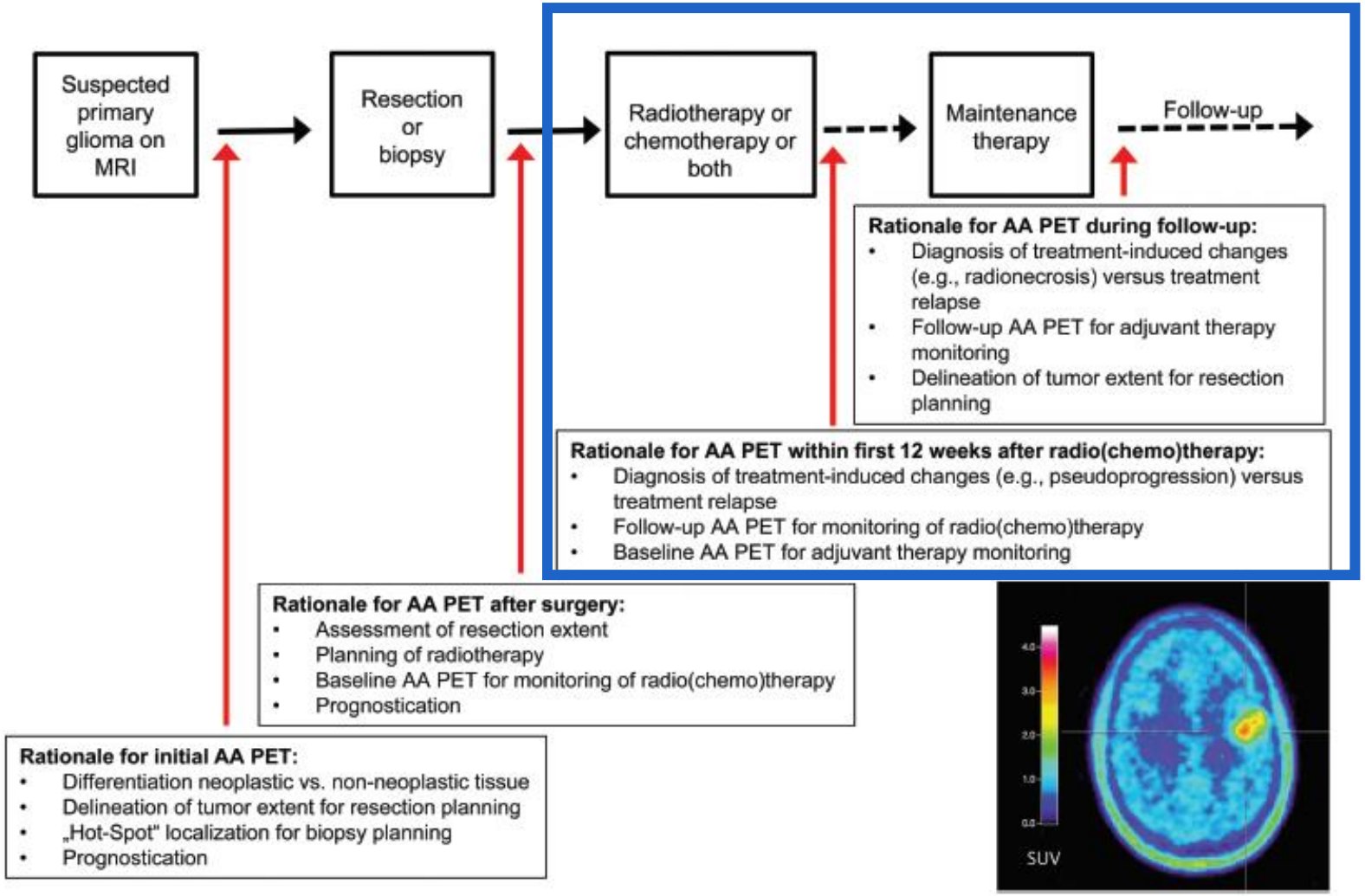
Filss et al. JNM 2020.

Indications



Ort et al. J Neurooncol 2021.

Indications



Albert et al. RANO. NeuroOncol 2016.

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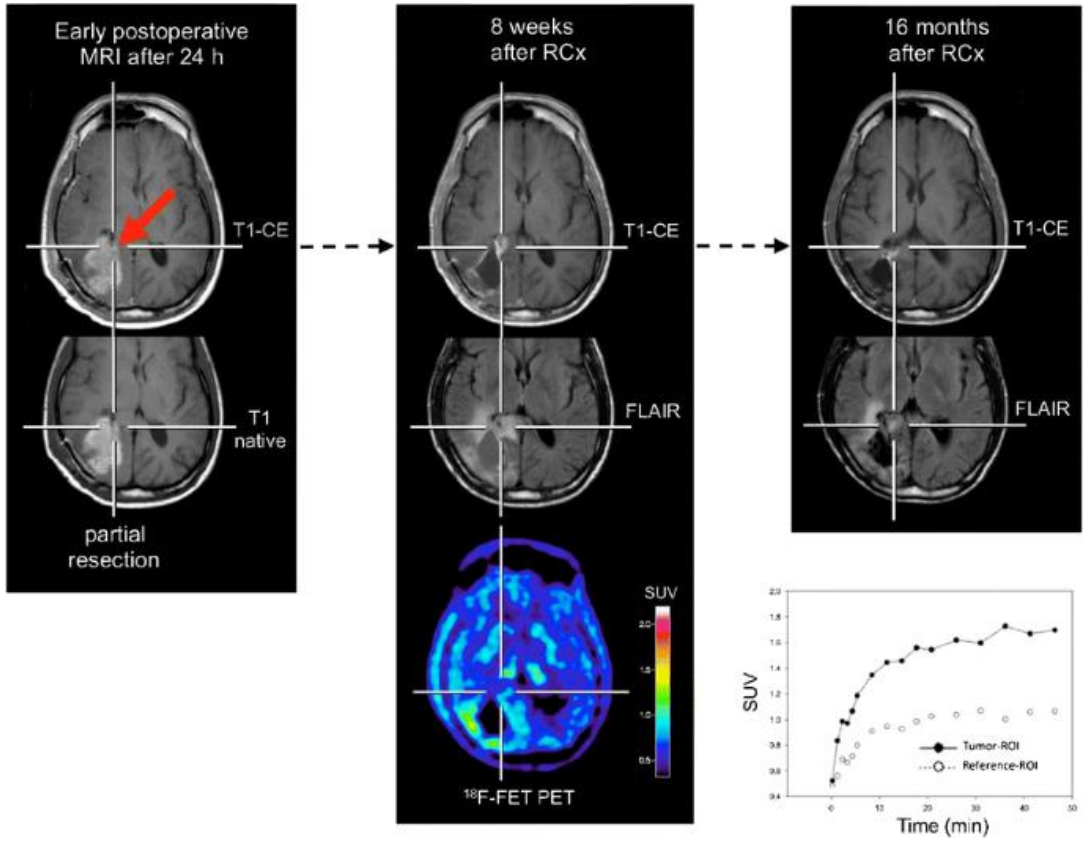
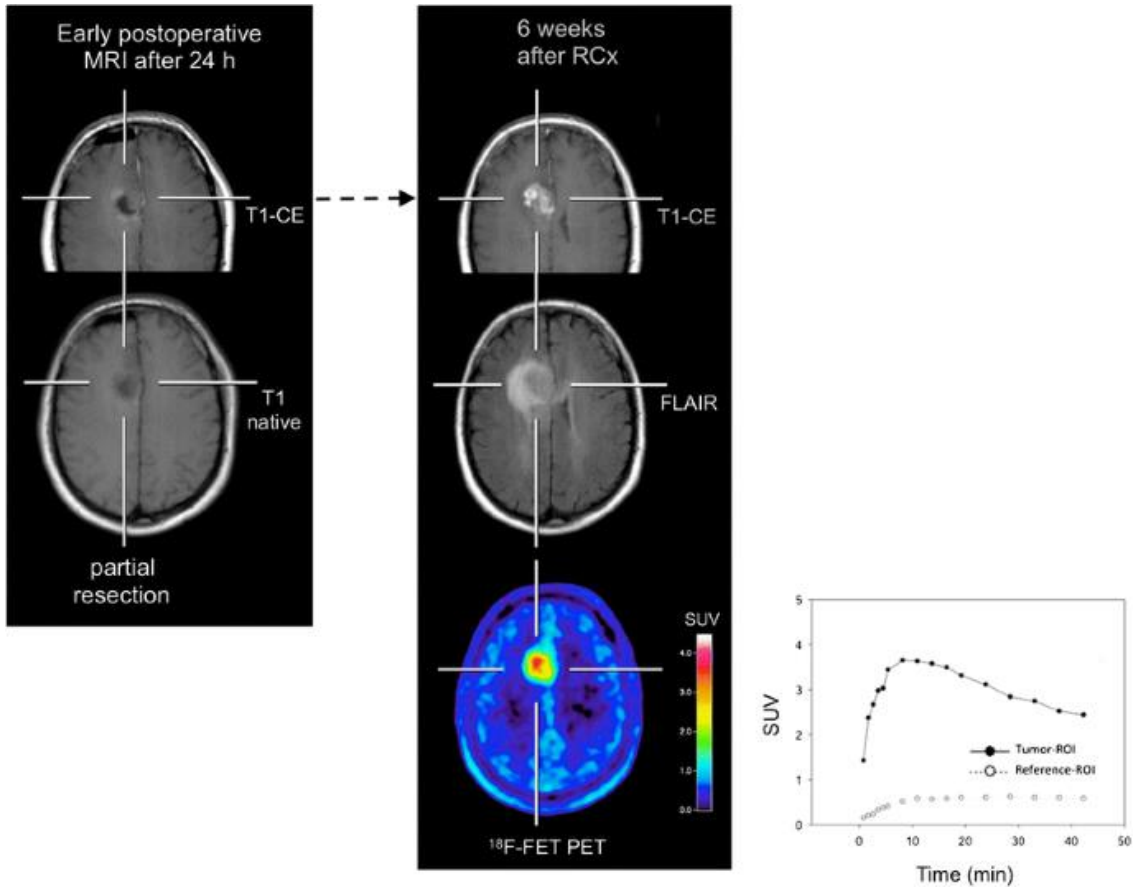


Galldiks et al. EJNMMI 2014.

Indications



Galldiks et al. EJNMMI 2014.

^{18}F-FET-PET/CT

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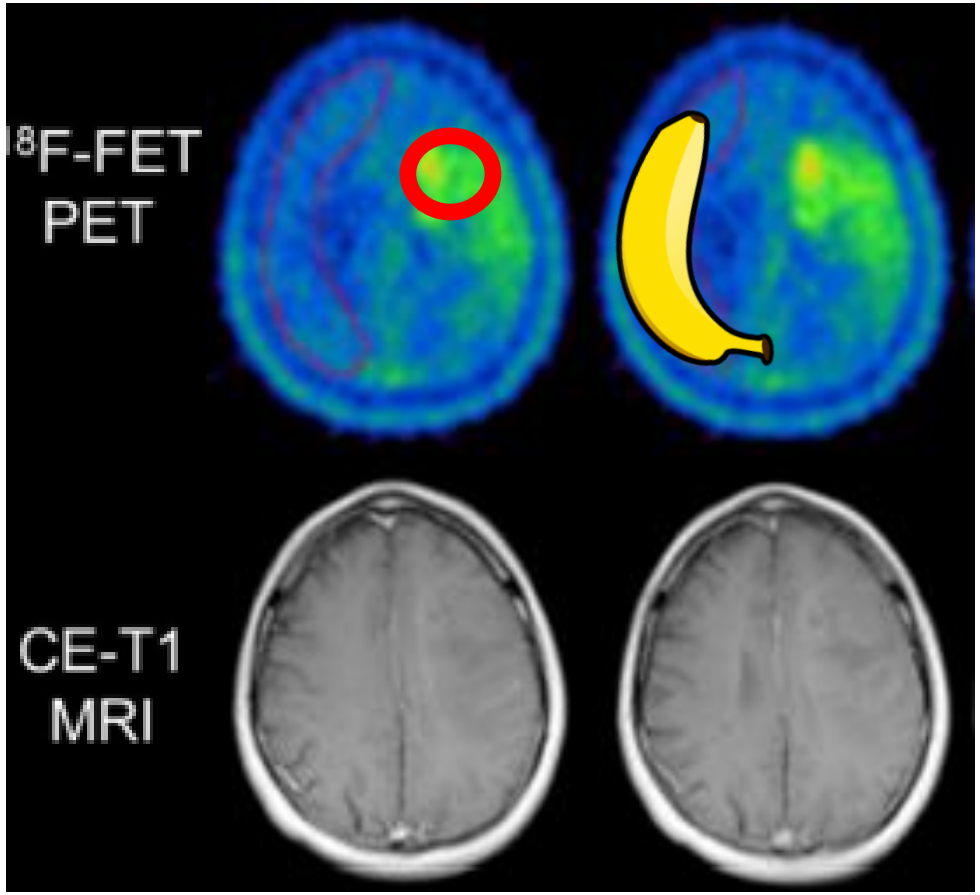
- Indications
- **Analysis**
- Pitfalls

Analysis



Metabolic index

SUV_{max} / Bg_{mean}

OR

SUV_{mean} / Bg_{mean}

Law et al. EJNMMI 2019.

Analysis

Table 1 Commonly used thresholds for amino acid PET, validated histologically or clinically, according to the clinical question

Clinical question	Tracer	Method		Threshold	Reference
Differentiation between neoplastic and non-neoplastic tissue	FET	TBRmax		2.5	[45]
		TBRmean		1.9	
	MET	TBRmax		1.3–1.5	[33, 46]
	FDOPA	–		n.a.	
Tumour grading (grade I/II versus III/IV glioma)	FET	TBRmean		1.9–2.0	[45, 47, 48]
		TBRmax		2.5–2.7	
		TTP		<35 min	
		TAC pattern (I, II, III)		Pattern II, III	
Tumour extent	FET	TBR		1.6	[32]
	MET	TBR		1.3	[49]
	FDOPA	TBR		2.0	[50]
Tumour recurrence	FET	TBRmean (circular ROI diameter 1.6 cm)		2.0	[51]
		TTP		<45 min	
	MET	TBRmax		1.6	[52]
	FDOPA	TSRmax		2.1	[53]
		TSRmean		1.8	
Malignant transformation of grade I/II glioma	FET	TBRmax		>33% increase	[54]
		TBRmean		>13% increase	
		TTP change in ROI >1.6 brain		6 min decrease	
Differentiation between *early* pseudoprogression and true progression	FET	TBRmax		2.3	[55]
Differentiation between *late* pseudoprogression and true progression	FET	TBRmax		1.9	[56]
		TBRmean		1.9	
Identification of responders in treatment response evaluation	FET	Radiochemotherapy (7–10 days)	TBRmax	>20% decrease	[57–59]
			TBRmean	>5% decrease	
		Bevacizumab/irinotecan (4–12 weeks)	BTV	>45% decrease	
	MET	Temozolomide	TBRmax	Stable or decreasing	[60]
	FDOPA	Bevacizumab (2 weeks)	BTV	>35% decrease <18 mL	[29]

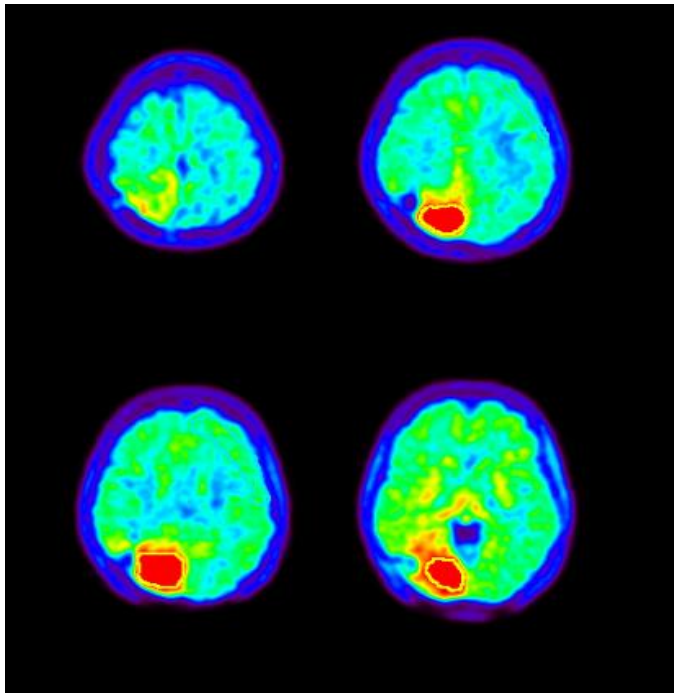
TBR tumour to background ratio, *TTP* time to peak, *TAC* time–activity curve, *TSR* tumour to striatum ratio, *ROI* region of interest

Law et al. EJNMMI 2019.

General cut-off

SUV_{max} / Bg_{mean}= 1.6 - 1.8

Analysis

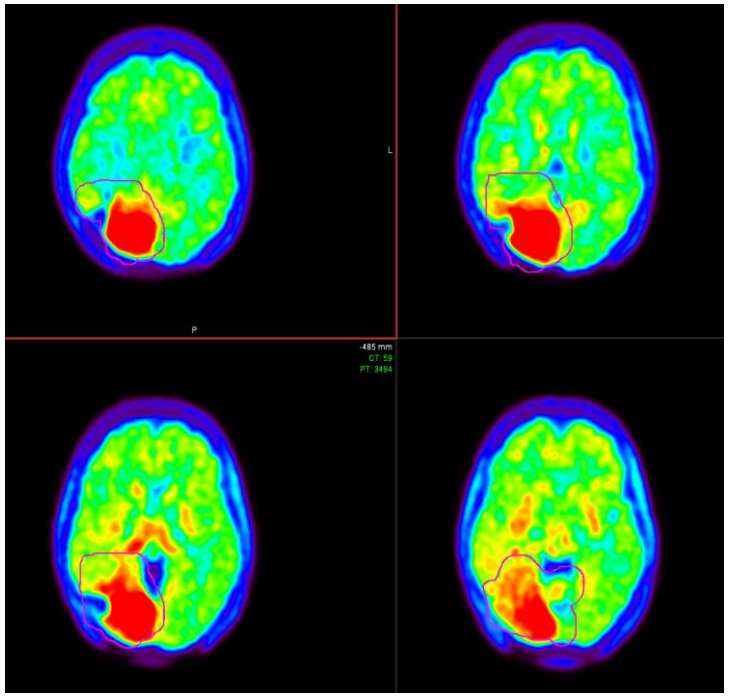


Dynamic analysis

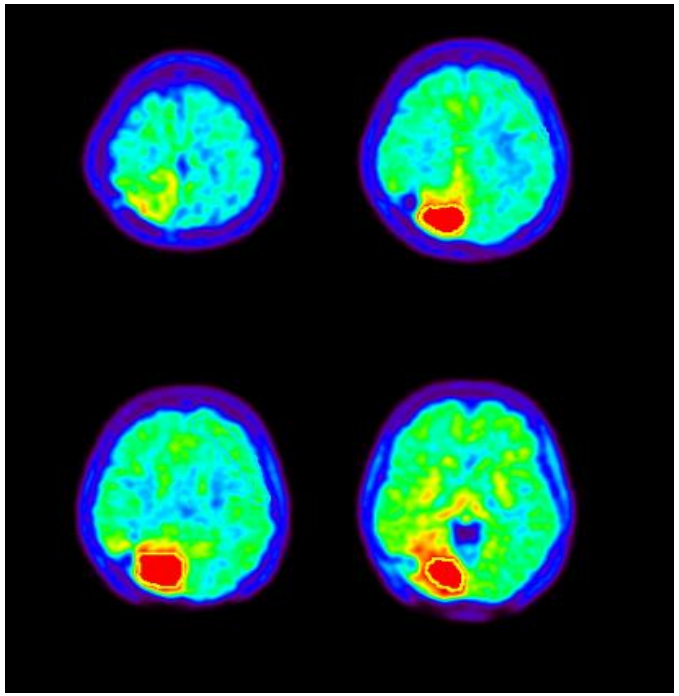
Isocontour on SUV_{max} with volume 1-2 ml

OR

VOI with fixed diameter 1.6 cm on SUV_{max}



Analysis



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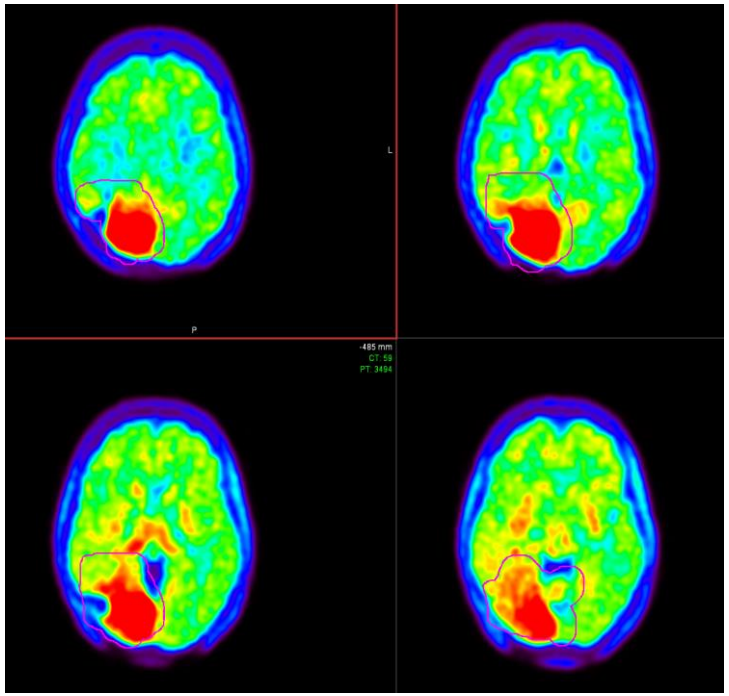

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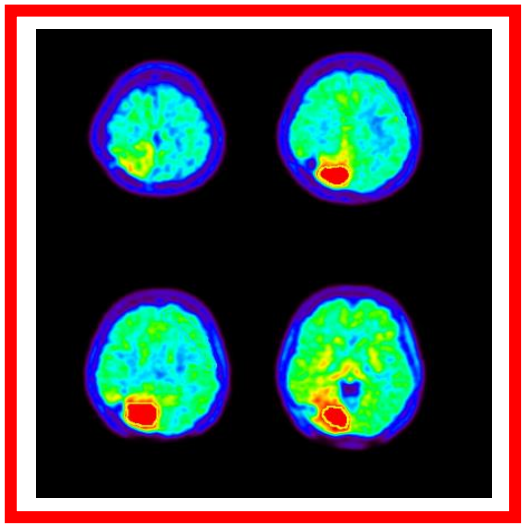

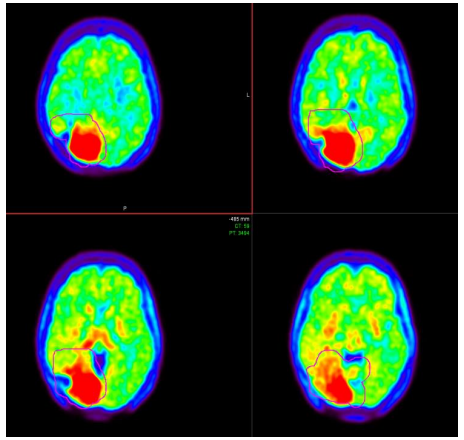

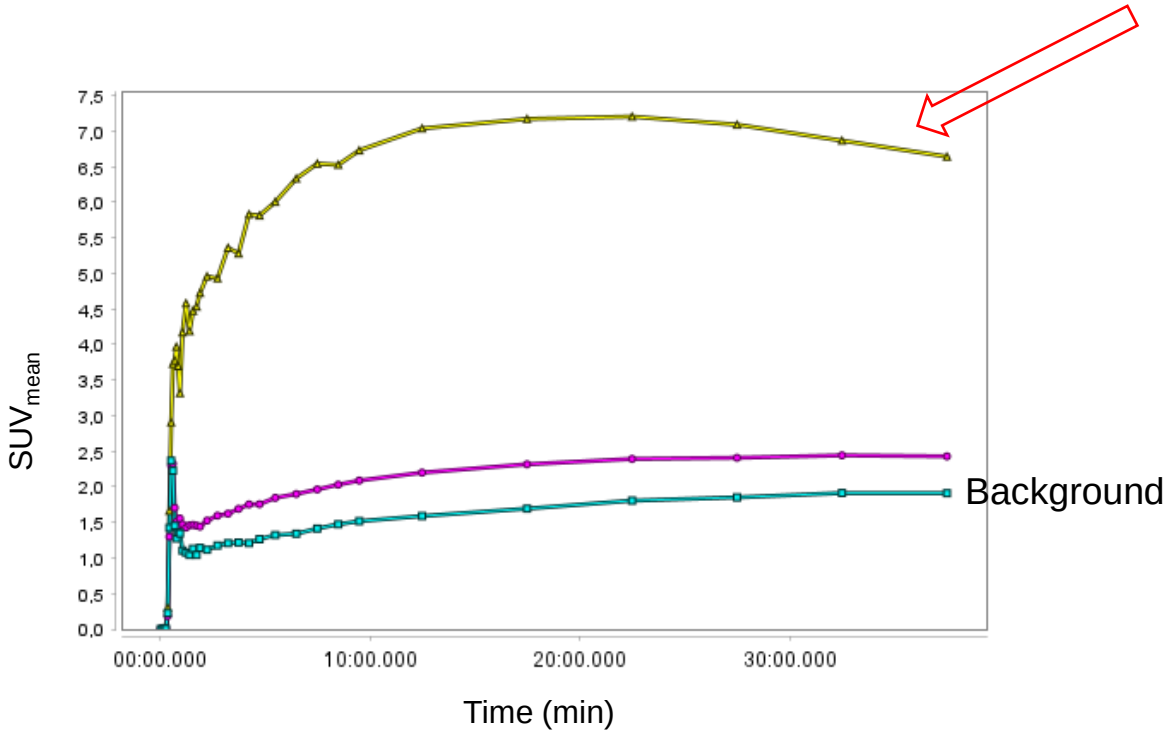
7,5
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2,5
2,0
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1,0
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0,0
SUV$_{mean}$
00:00.000
10:00.000
20:00.000
30:00.000
Time (min)
Background

^{18}F-FET-PET/CT

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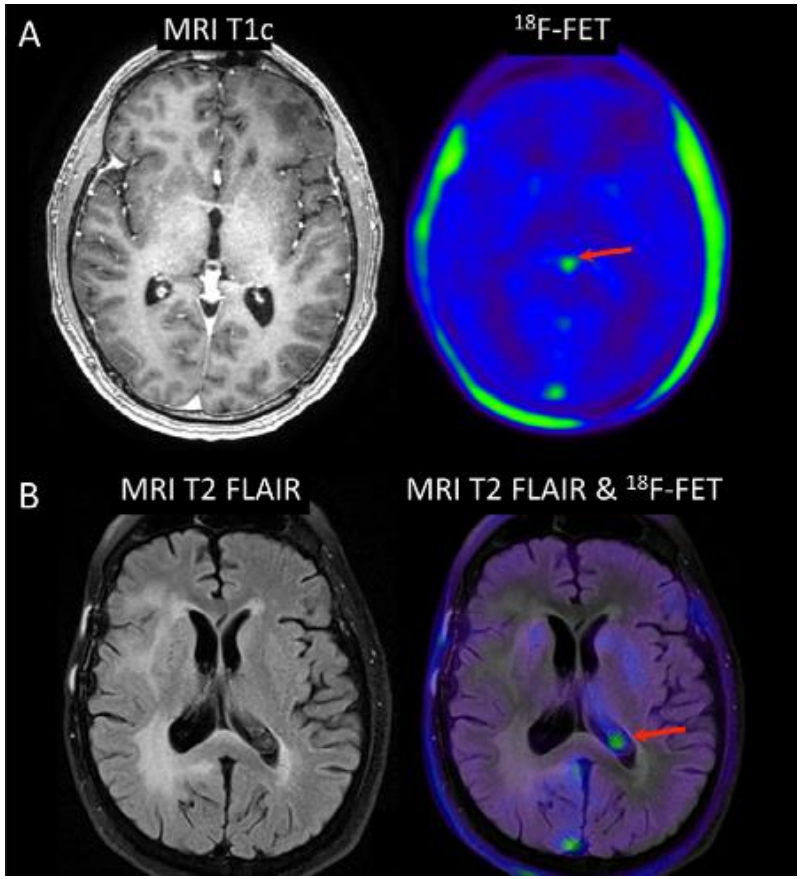
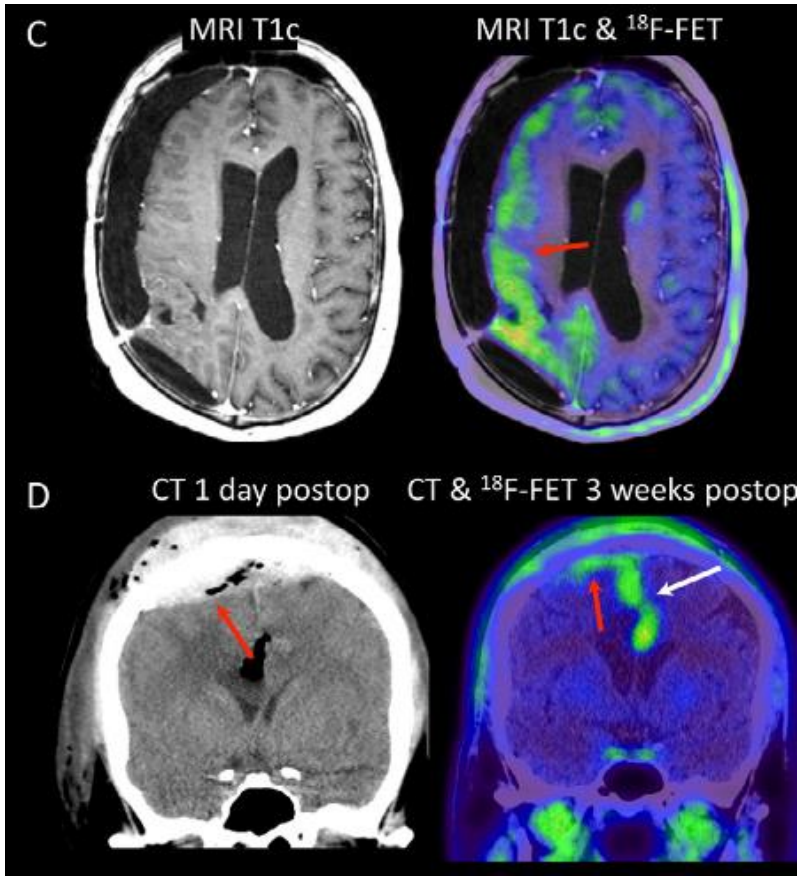
Pitfalls: pineal body, choroid plexus



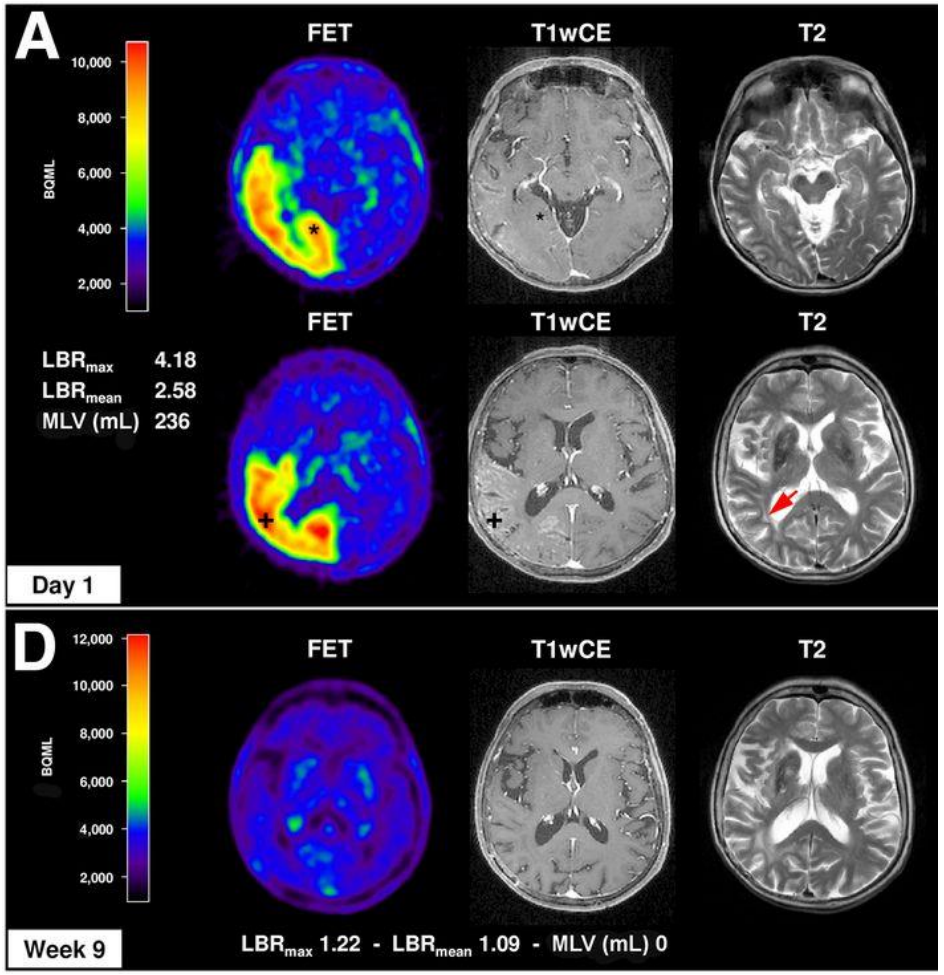
Cecchin et al. Seminars in nuclear medicine 2021.

Pitfalls: pressure



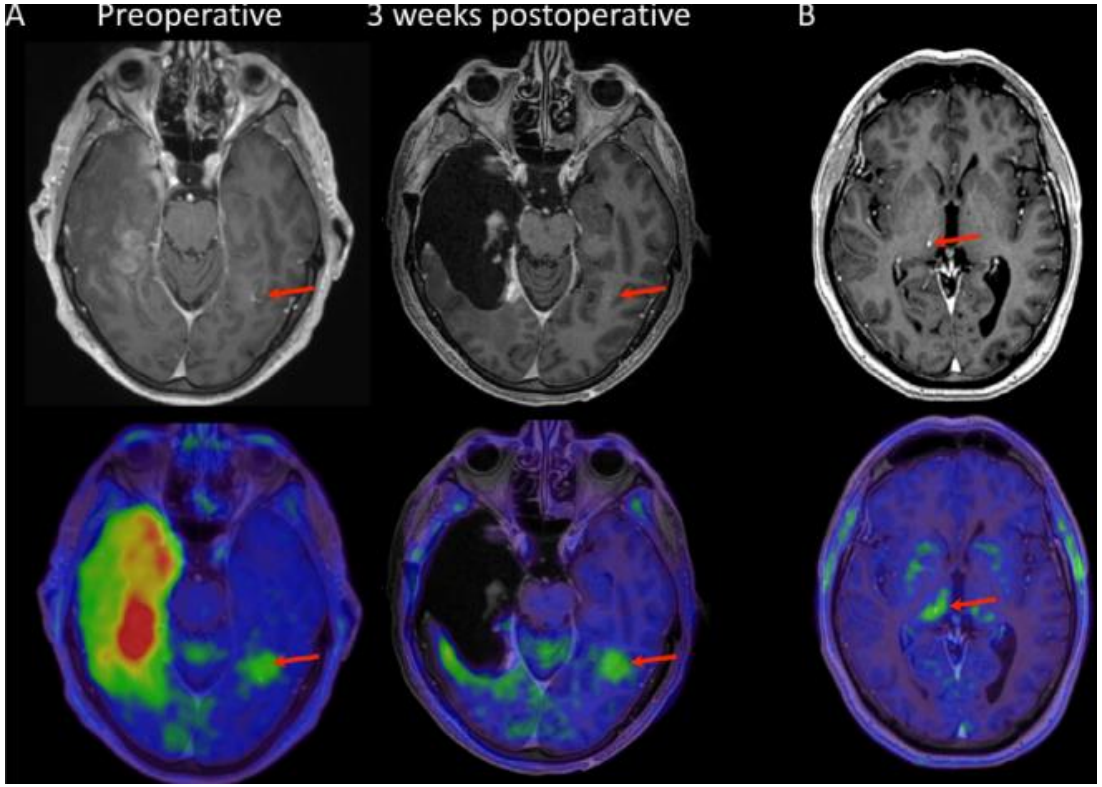
Cecchin et al. Seminars in nuclear medicine 2021.

Pitfalls: recent epilepsy



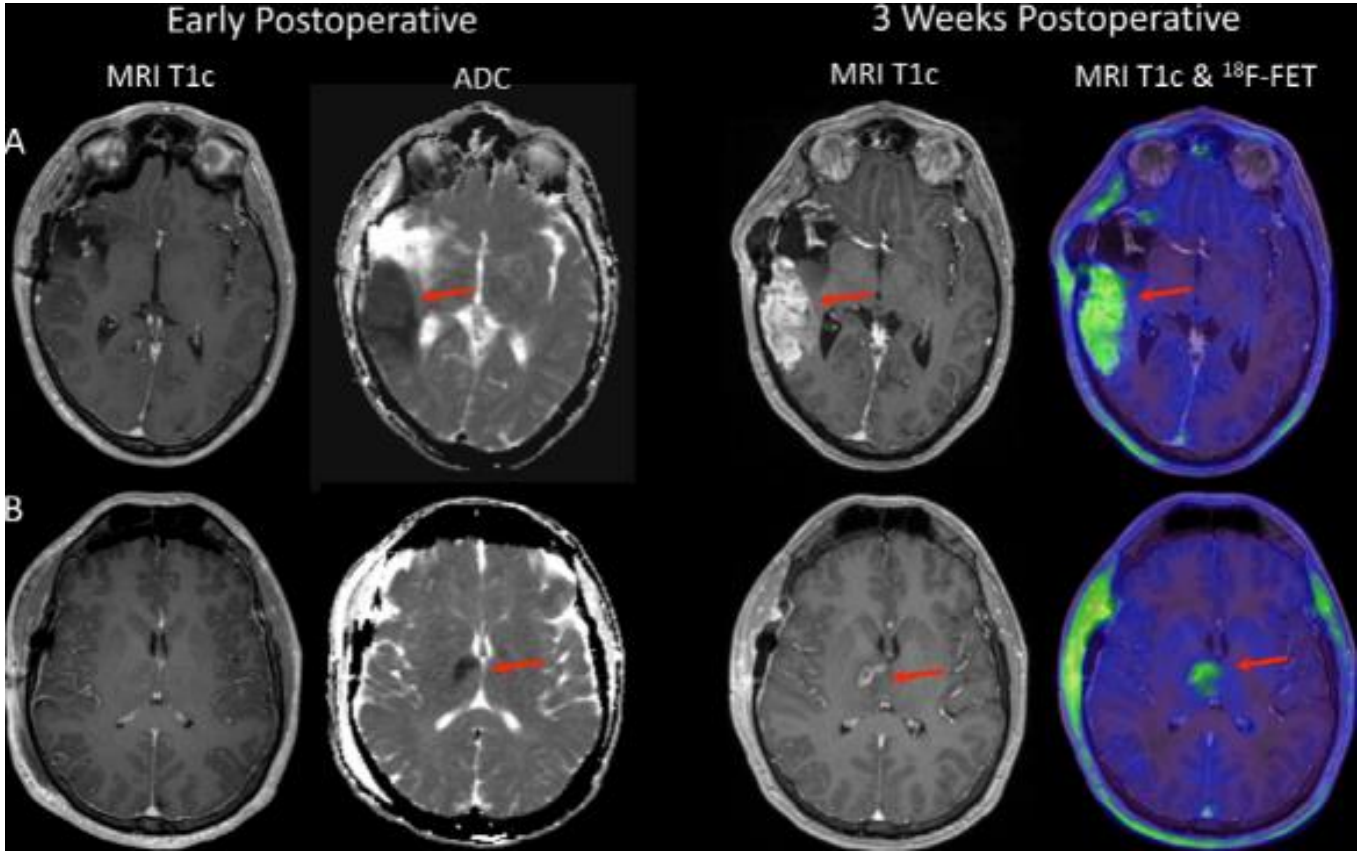
Hutterer et al. JNM 2017.

Pitfalls: developmentar venous anomaly



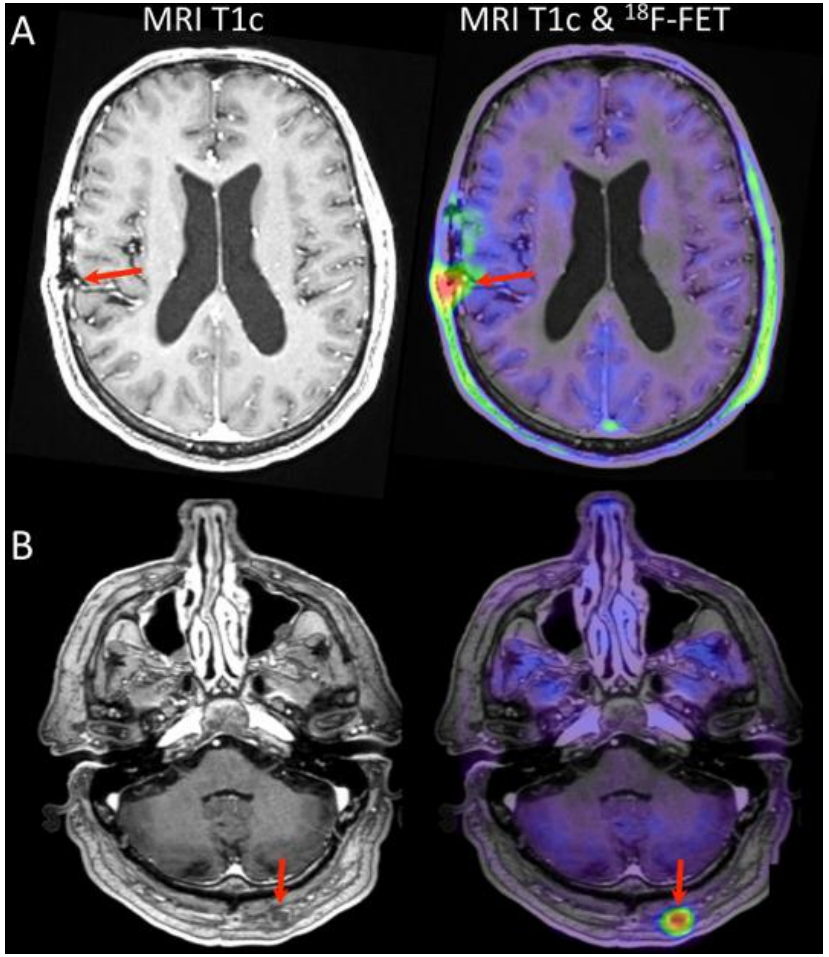
Cecchin et al. Seminars in nuclear medicine 2021.

Pitfalls: perioperative infarct



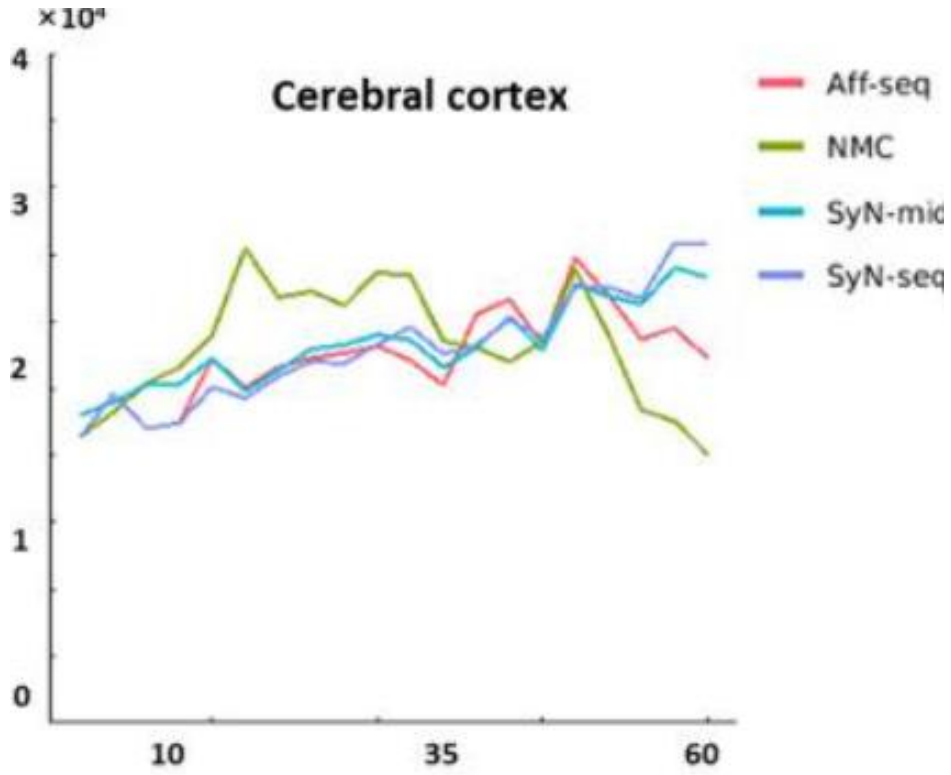
Cecchin et al. Seminars in nuclear medicine 2021.

Pitfalls: abcess



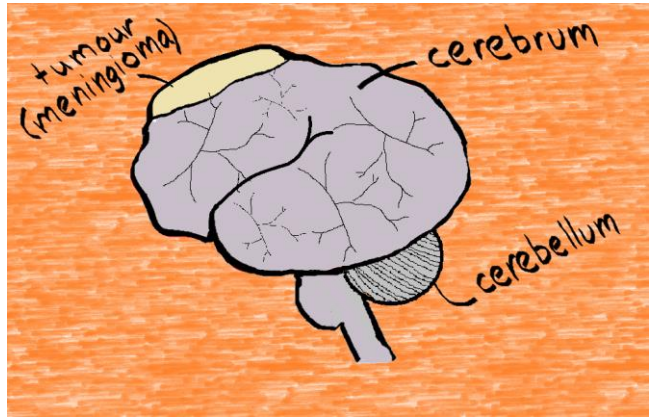
Cecchin et al. Seminars in nuclear medicine 2021.

Pitfalls: TAC movement



Sun et al. EJNMMI Phys 2022.

^{68}Ga-Dotatate-PET/CT



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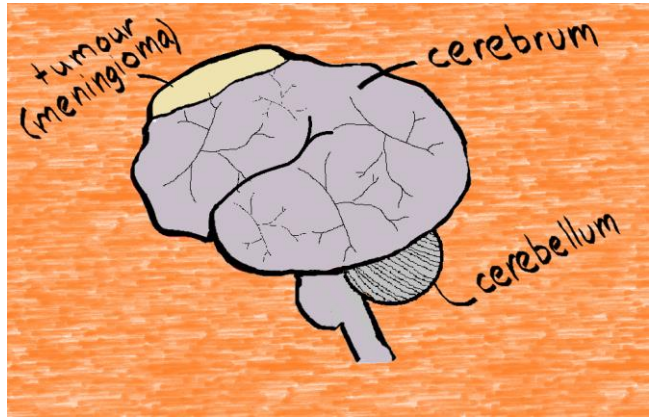

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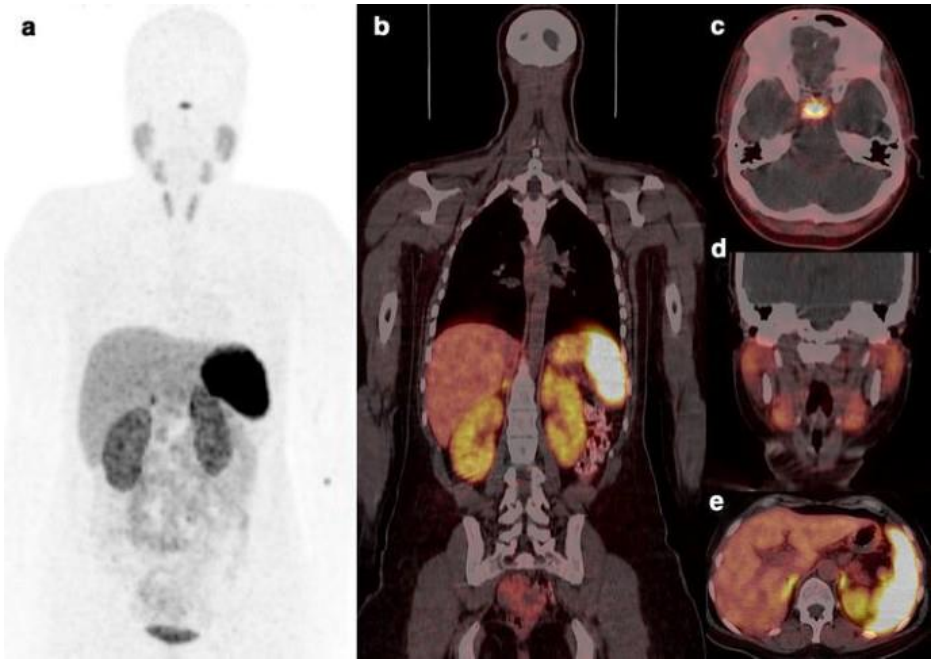
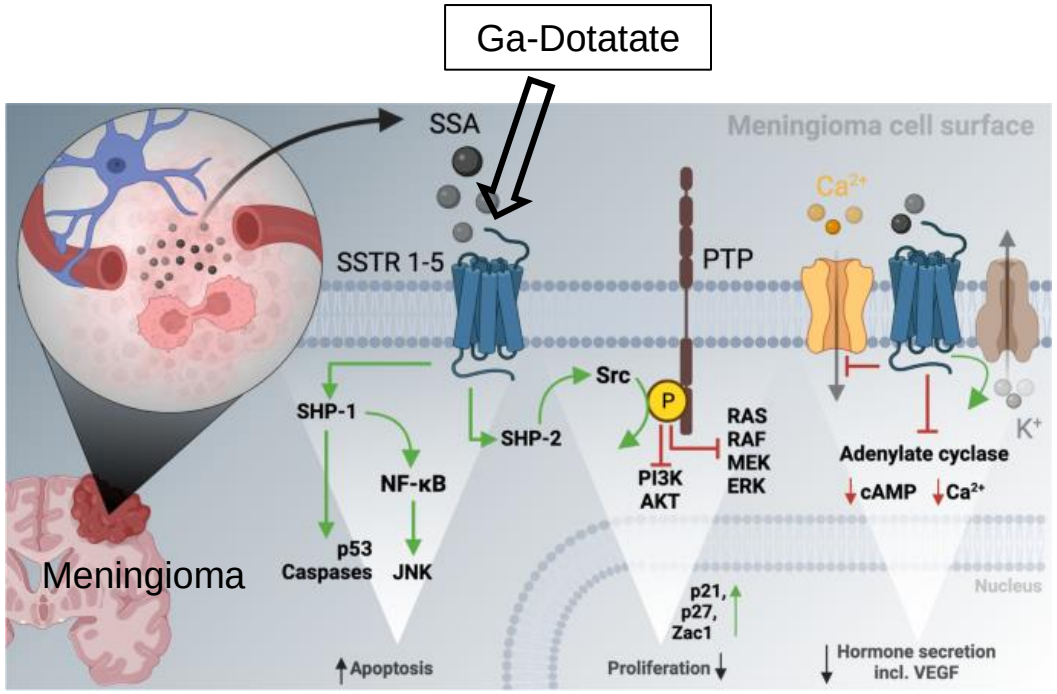
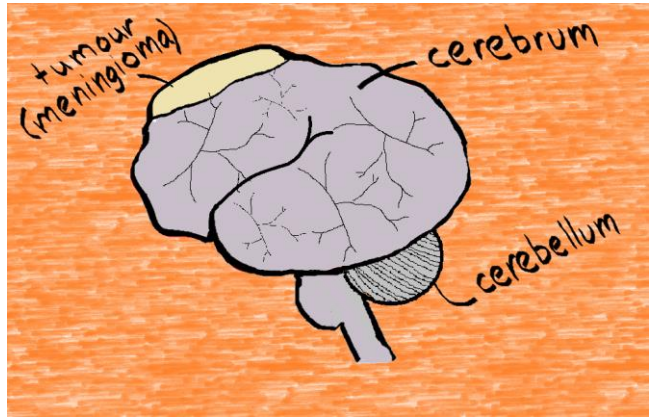
Uptake mechanism





Kuyumcu et al. Annals of nuclear medicine 2013. Jensen et al. Neurosurgical review 2022.

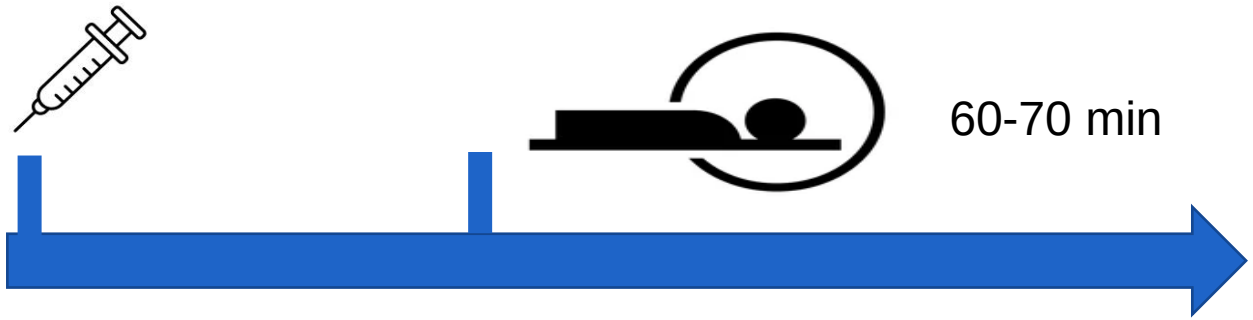
^{68}Ga-Dotatate-PET/CT



- Uptake mechanism
- **Indications**
- Analysis
- Pitfalls

Indications

Dose: 100 - 200 MBq



Virgolini et al. EJNMMI 2010.

Indications

Clinical Indication	PET Ligands for Somatostatin Receptors	Amino Acid PET Tracers	Other PET Tracers
Detection of meningioma tissue/ differential diagnosis	^{68}Ga-DOTATOC and ^{68}Ga-DOTATATE PET may add valuable diagnostic information[24,53]	na	na
Meningioma grading	^{68}Ga-DOTATATE binding correlates with tumor growth rate in WHO grades I and II meningiomas[35]	^{11}C-MET correlates with proliferative activity,[54] but data on grading are controversial.[34,55] Static and dynamic ^{18}F-FET PET may provide additional information for meningioma grading[32]	^{11}C-choline seems to be helpful for meningioma grading.[41] ^{11}C-acetate seems not to be helpful[18]
Delineation of tumor extent for resection planning	^{68}Ga-DOTATATE PET delineates the meningioma extent better than standard MRI[23,61]	na	na
Delineation of tumor extent for radiation treatment planning	^{68}Ga-DOTATOC PET delivers additional information on tumor extent for radiotherapy target definition[56,57,64,65]	^{11}C-MET PET significantly influences GTV delineation in meningiomas[31,59]	na
Treatment monitoring	na	^{11}C-MET PET allows an earlier evaluation of treatment effects than standard imaging.[66,67] Boronated amino acid PET probes may help to evaluate treatment effects[38]	na
Diagnosis of tumor progression/differentiation of tumor progression from posttreatment changes	^{68}Ga-DOTATOC/^{68}Ga-DOTATATE PET is useful for differentiation between progression and posttreatment changes[23,24,52]	na	na

Galldiks et al. Neuro-oncology 2017.

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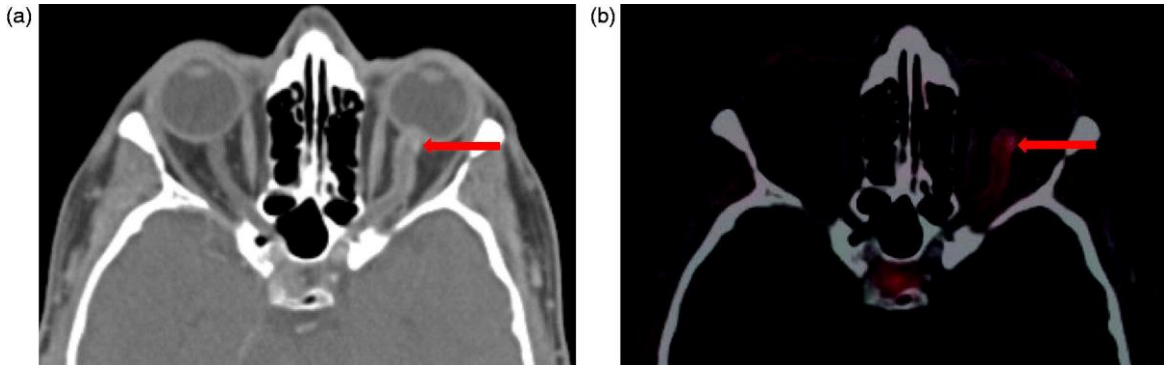
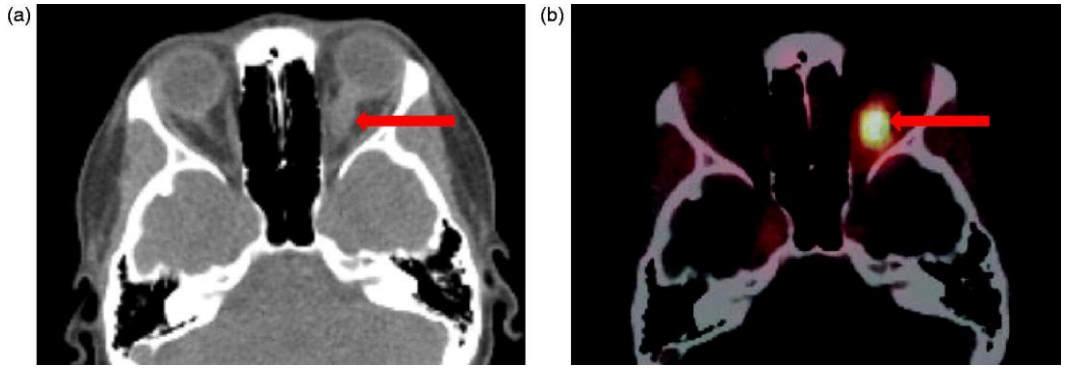
Galldiks et al. Neuro-oncology 2017.

Indications

Negative



Positive



Klingenstein et al. Orbit 2015.

Indications

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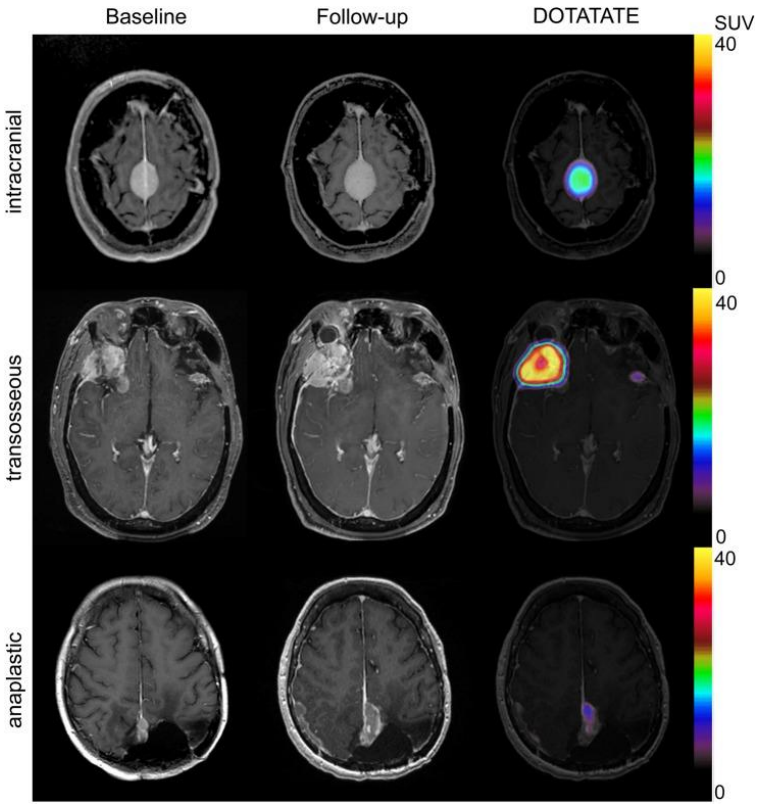
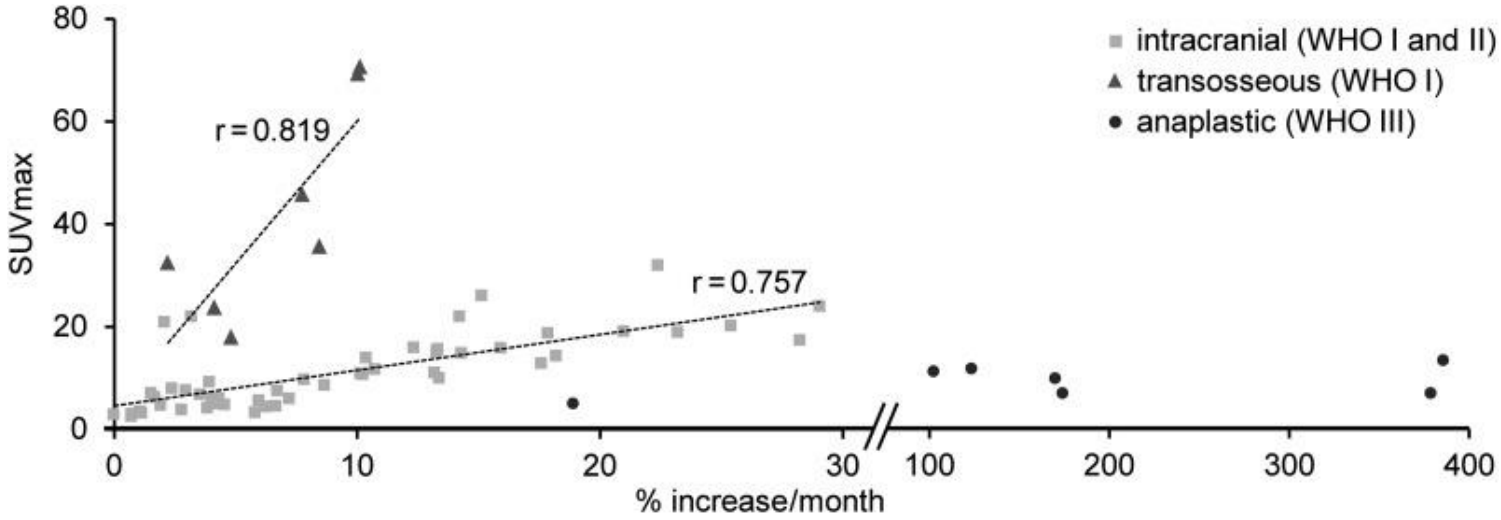
Galldiks et al. Neuro-oncology 2017.



Indications



Sommerauer et al. Neuro oncol 2016.

Indications

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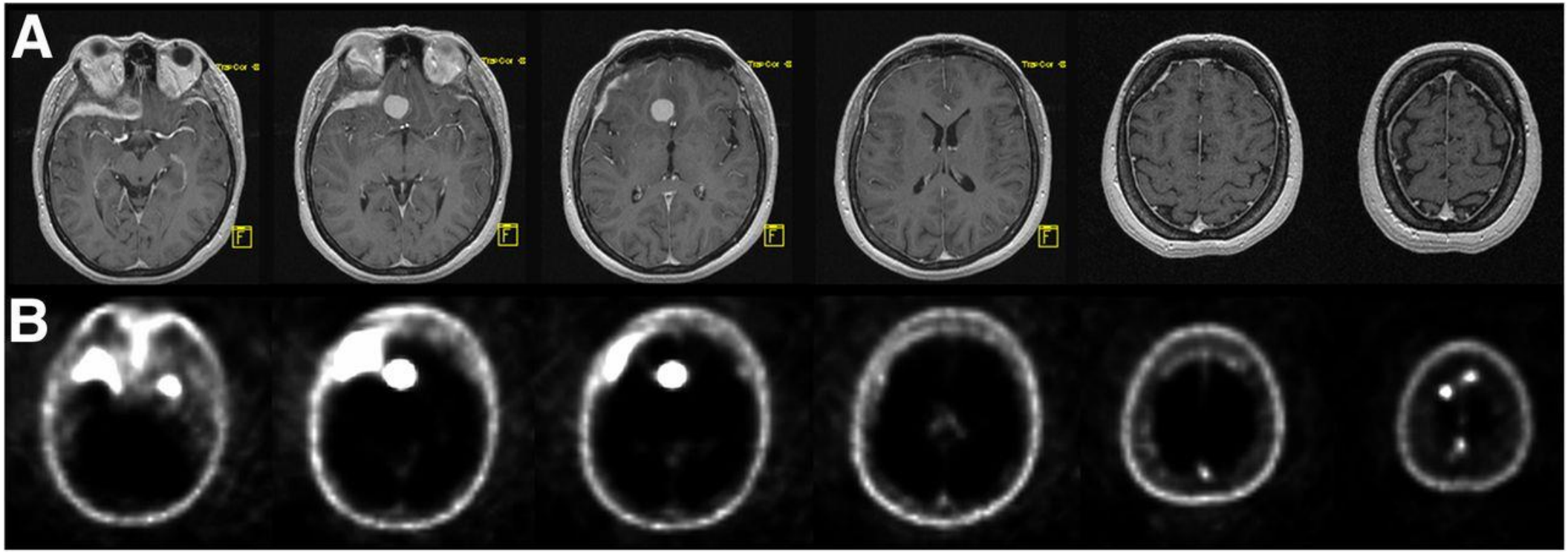
Galldiks et al. Neuro-oncology 2017.

Indications



Rachinger et al. JNM 2015.

Indications

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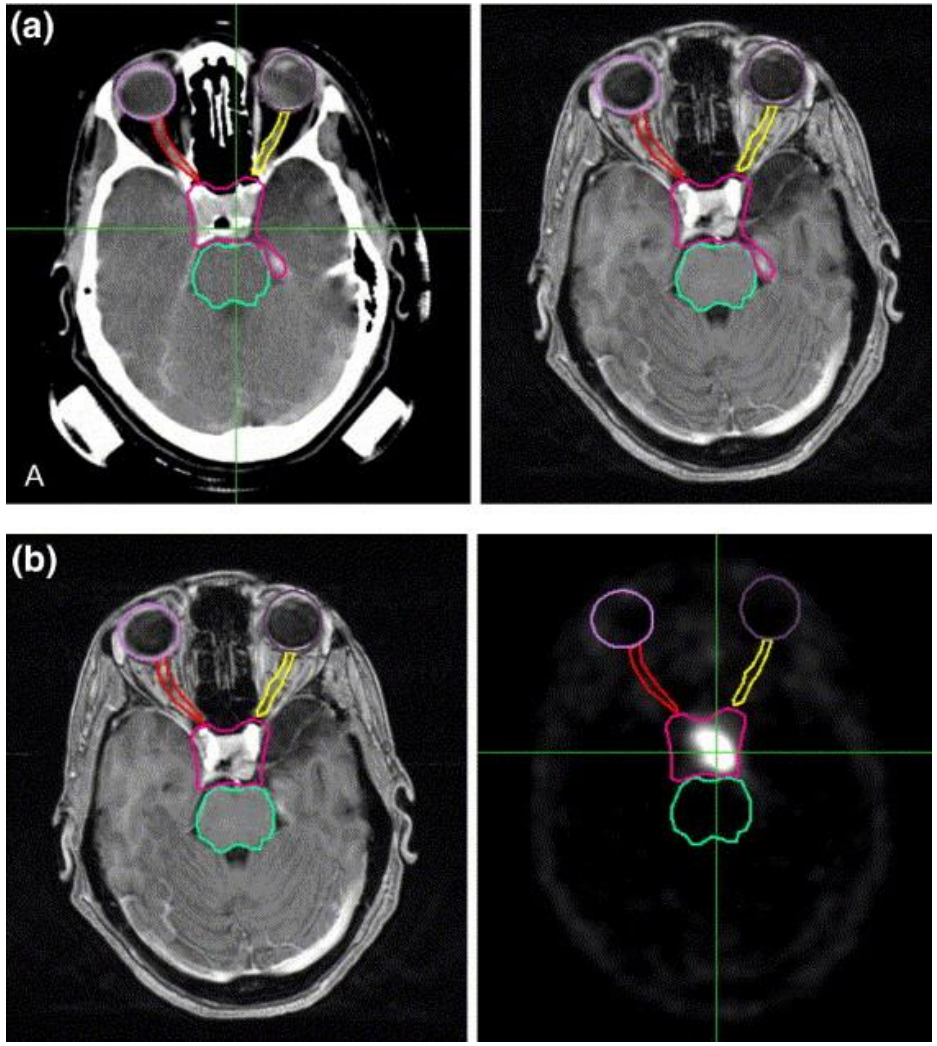
Galldiks et al. Neuro-oncology 2017.

Indications



Milker-Zabel et al. Internation journal of radiation oncology*biology*physics 2006.

Indications

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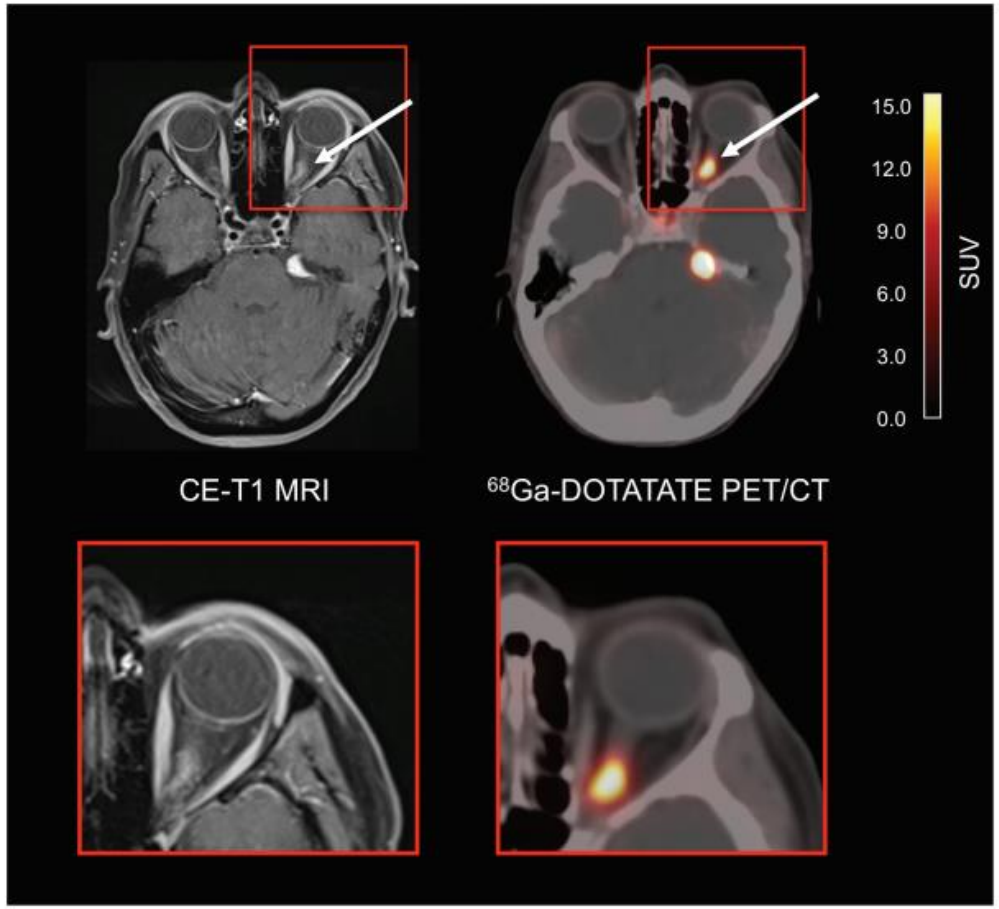
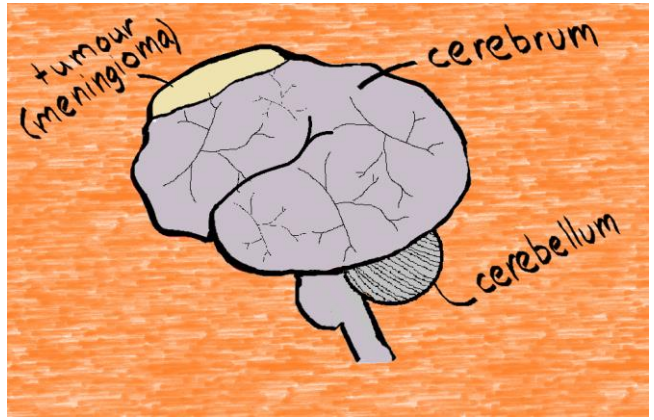
Galldiks et al. Neuro-oncology 2017.

Indications



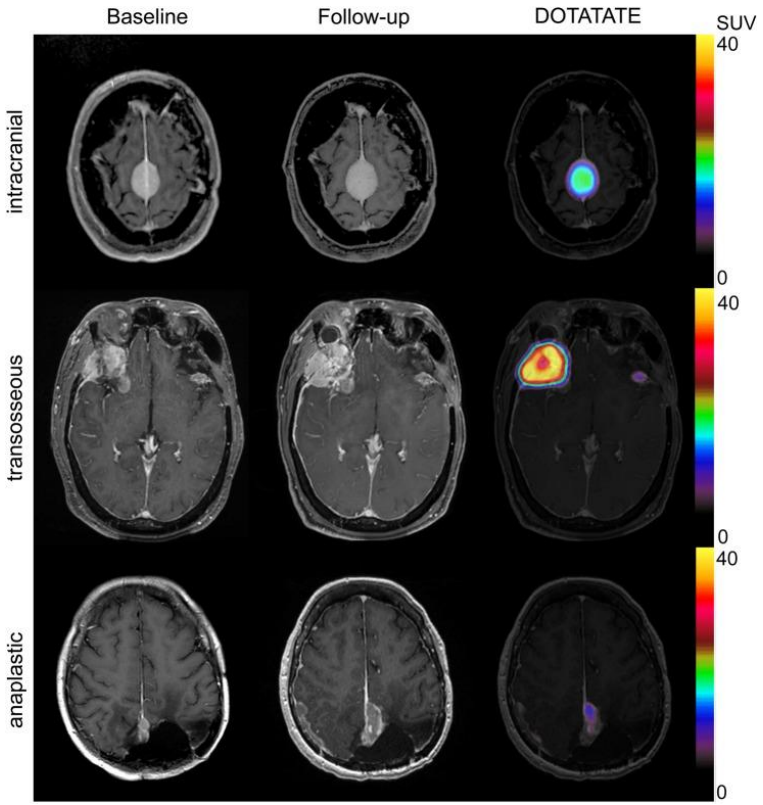
Galldiks et al. Neuro-oncology 2017.

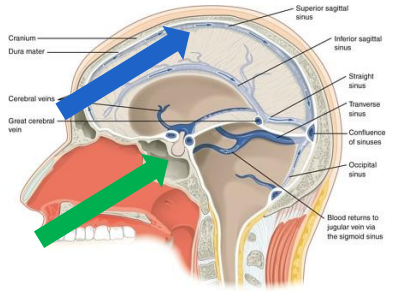
^{68}Ga-Dotatate-PET/CT



- Uptake mechanism
- Indications
- **Analysis**
- Pitfalls

Analysis

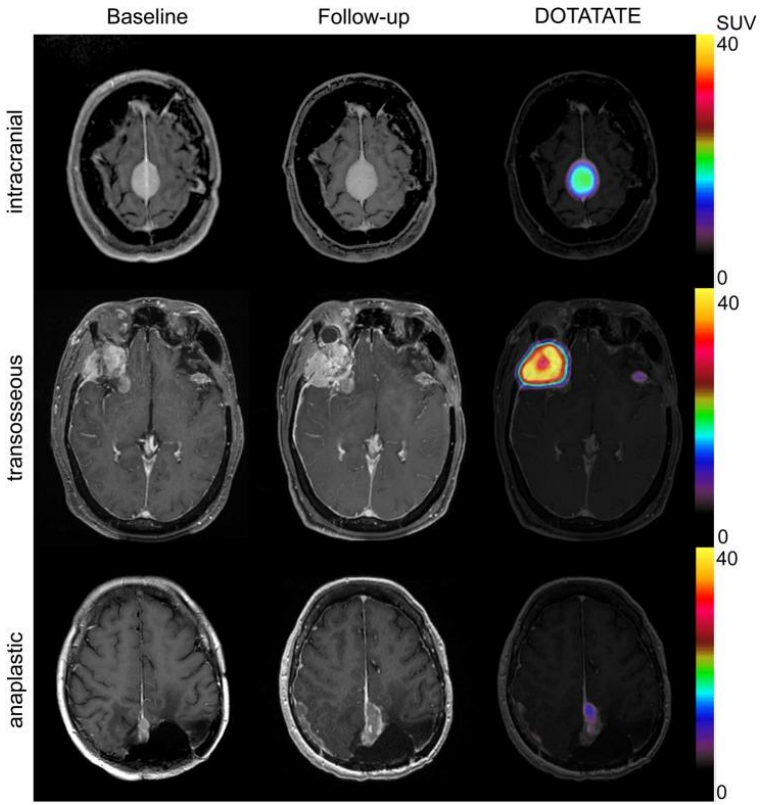


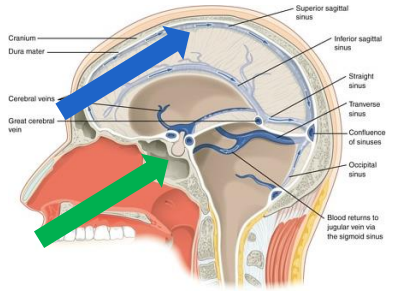


	> 2.3 SUVmax	> 0.3 SUVRpit	> 3 SUVRsss	> 62.6 SUVRnorm
Sensitivity	98.2% (94.8–99.5)	79.5% (72.7–85.0)	86.7% (80.8–91.1)	80.6% (73.9–85.9)
Specificity	56.1% (41.0–70.1)	87.8% (74.5–94.7)	80.5% (66.0–89.8)	70.7% (55.5–82.4)
PPV	90.1% (84.8–93.6)	96.4% (91.7–98.4)	94.7% (90.0–97.3)	91.7% (86.1–95.2)
NPV	88.5% (71.0–96.0)	51.4% (40.0–62.8)	60.0% (46.8–71.9)	47.5% (35.5–59.8)
Prevalence	80.2% (166/207)	80.2% (166/207)	80.2% (166/207)	80.2% (166/207)

Sommerauer et al. Neuro oncol 2016. Kim et al. Sci Rep 2022.

Analysis





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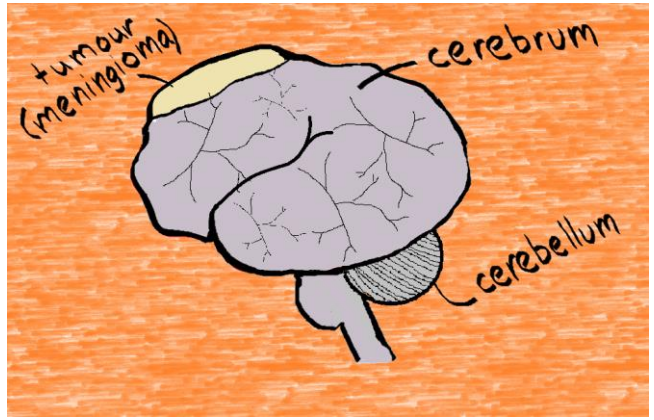

- Uptake mechanism
- Indications
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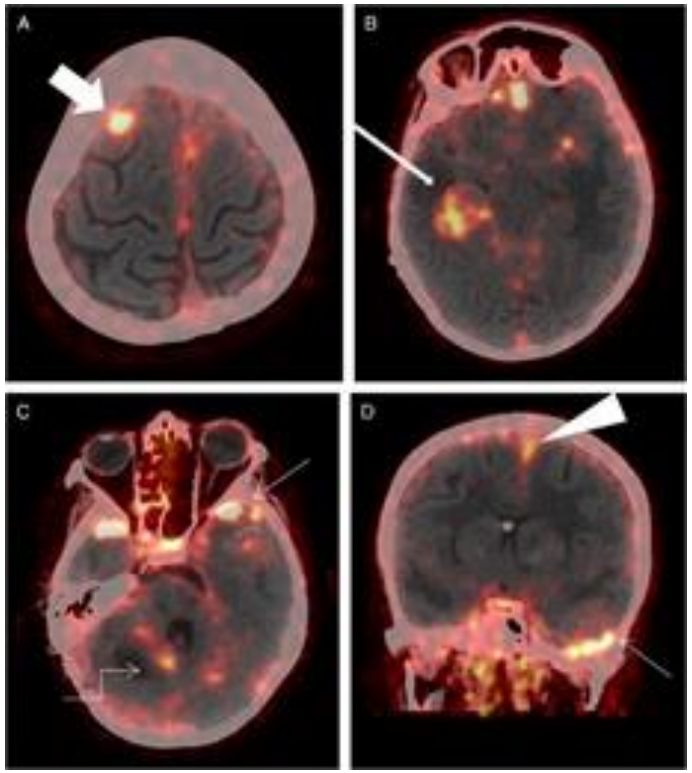
- **Pitfalls**

Pitfalls

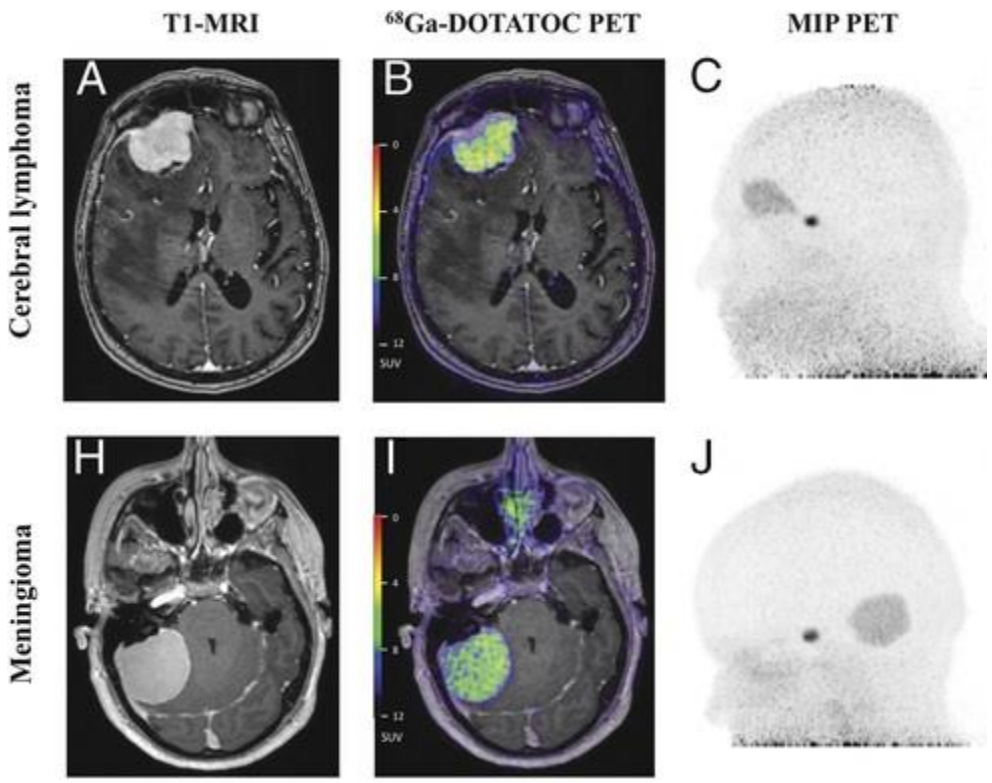
Breast cancer metastasis

Medulloblastoma (^{68}Ga-Dotanoc)

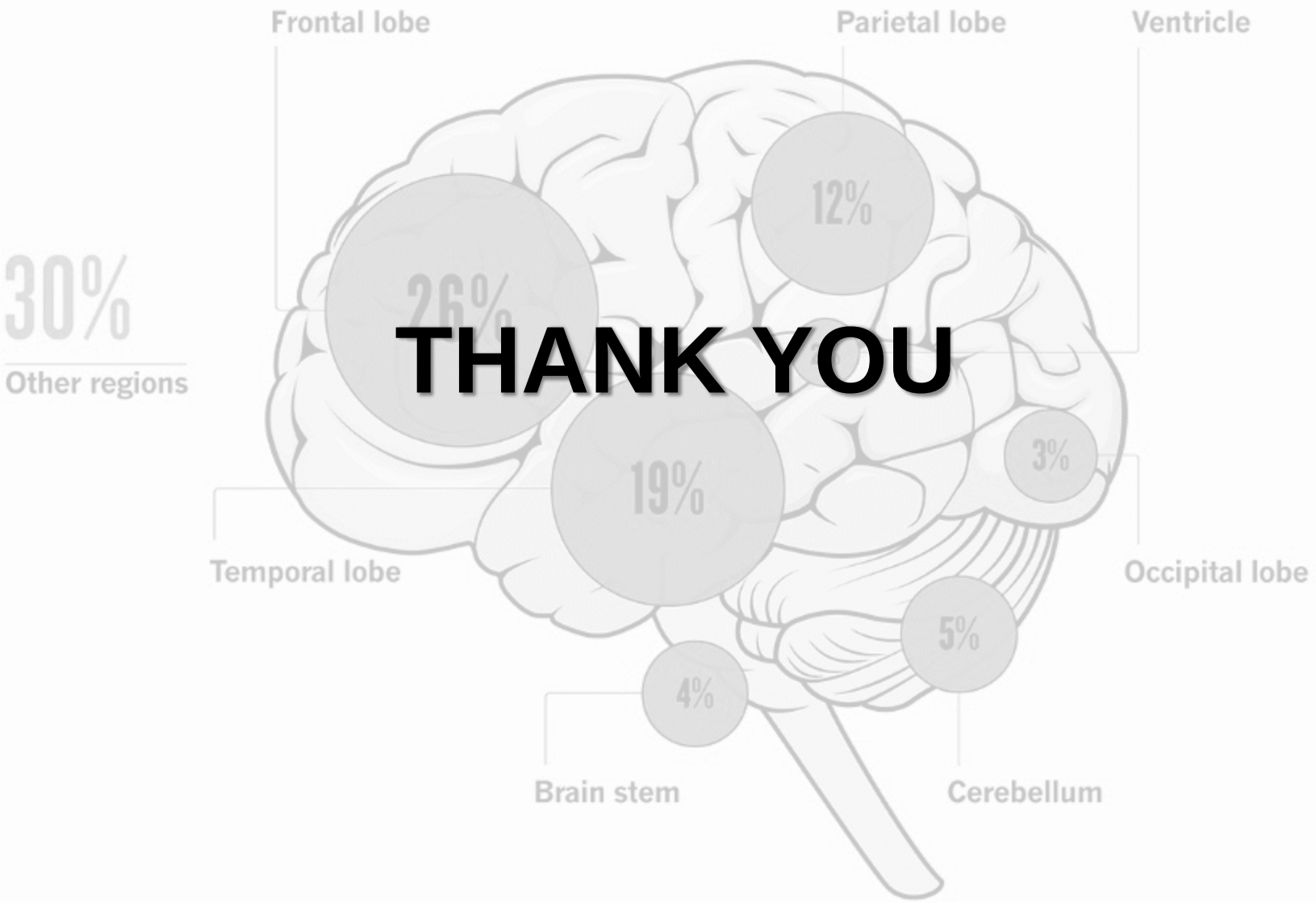


Fabritius et al. Clin Nucl Med 2021.

Pitfalls



Bashir et al. Clin Nucl Med 2020.


Frontal lobe
Parietal lobe
Ventricle
30%
Other regions
26%
12%
19%
3%
Temporal lobe
Occipital lobe
5%
4%
Brain stem
Cerebellum

THANK YOU