

XV Corso di aggiornamento per operatori dei registri tumori

Modena, 6-8 ottobre 2015



**XV Corso di aggiornamento
per operatori dei registri tumori**

I tumori cerebrali,
i tumori del polmone,
gli screening oncologici,
i registri specializzati e
il manuale di registrazione

I tumori del Sistema Nervoso Centrale: *imaging a fini diagnostici e interpretazione*

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**SERVIZIO SANITARIO REGIONALE
EMILIA-ROMAGNA**

Azienda Ospedaliera di Reggio Emilia
Arcispedale Santa Maria Nuova
Azienda Unità Sanitaria Locale di Reggio Emilia

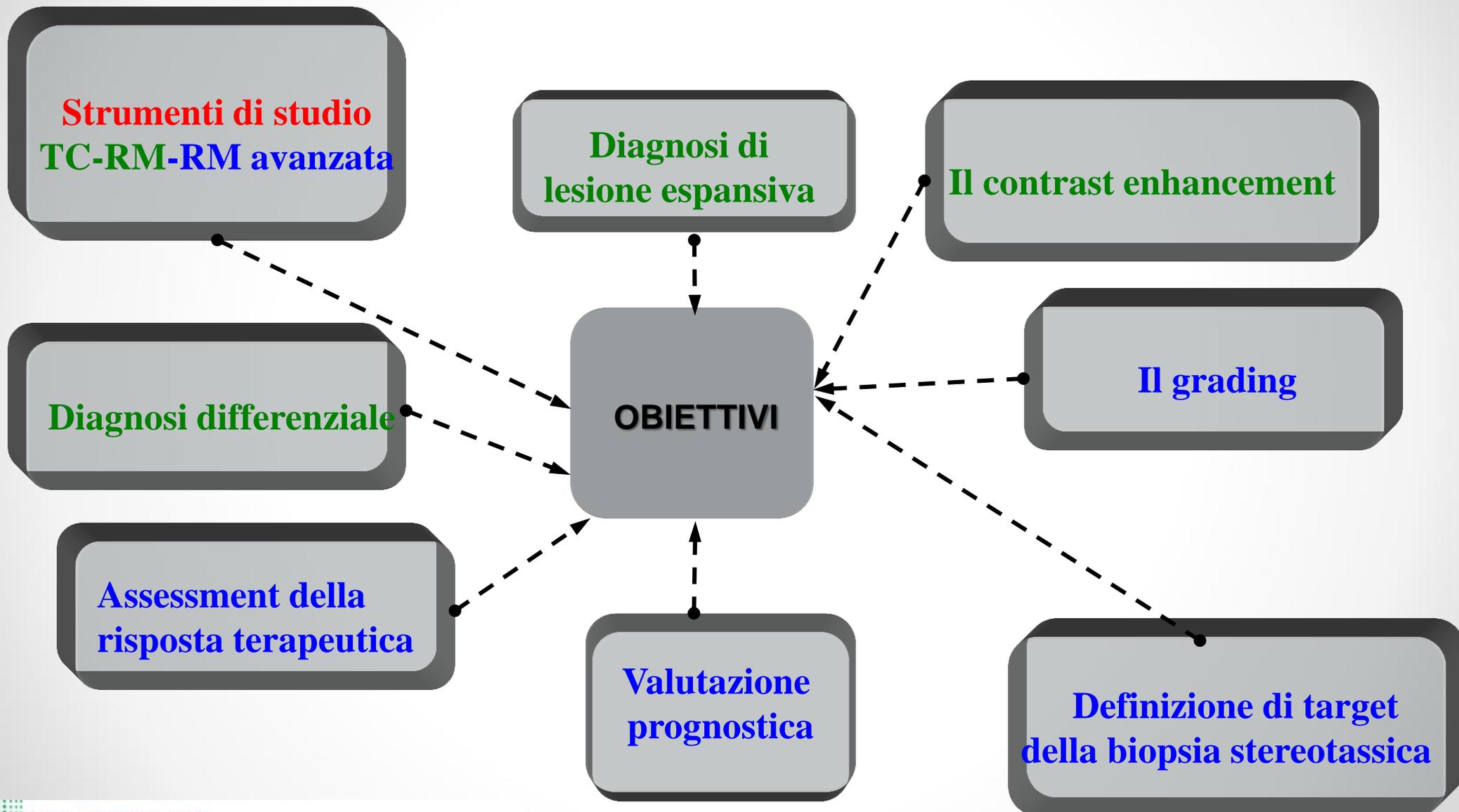
6-8 ottobre 2015

Sala Oratorio
c/o Palazzo dei Musei
viale Vittorio Veneto, 5 - Modena

MODENA



STUDIO NEURORADIOLOGICO DEI TUMORI CEREBRALI

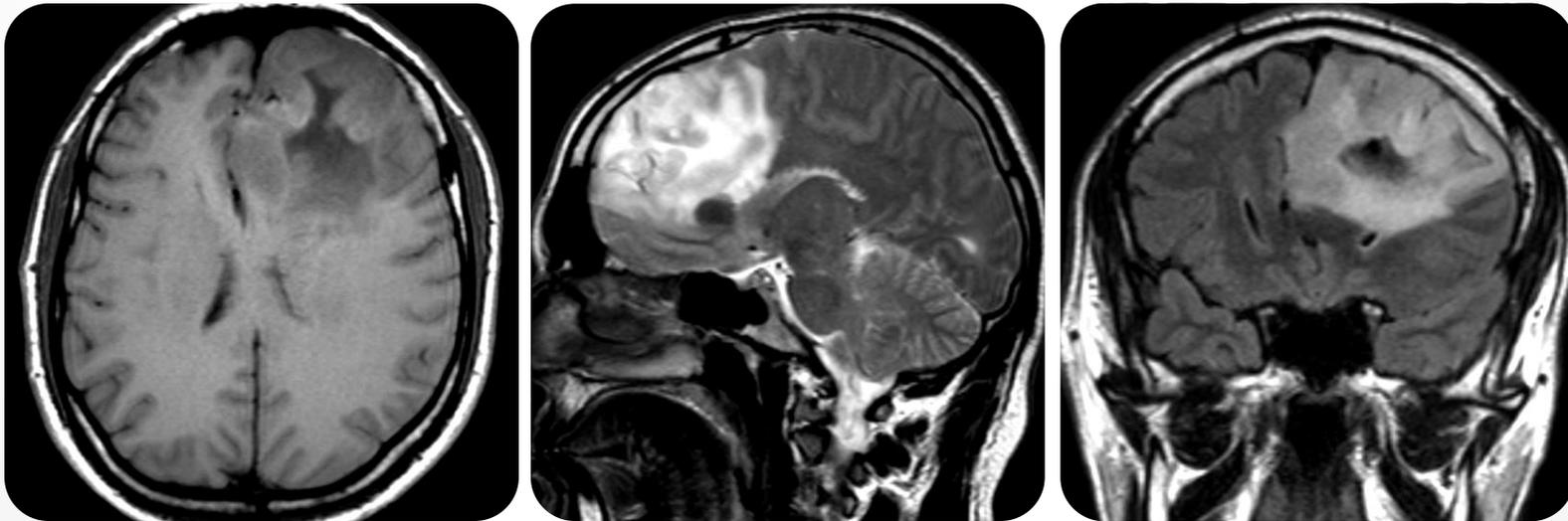


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MR Imaging of Neoplastic Central Nervous System Lesions: Review and Recommendations for Current Practice

La scelta diagnostica iniziale - RM

La Risonanza Magnetica è allo stato dell'arte la tecnica di diagnostica per immagini più accurata per visualizzare e caratterizzare le "lesioni espansive" del SNC con superiore sensibilità rispetto ad altre metodiche.



SHELLINGER PD, MEINCK HM, THRON A. DIAGNOSTIC ACCURACY OF MRI COMPARED TO CCT IN PATIENTS WITH BRAIN METASTASES. J Neurooncol 1999

ESSIG M, WEBER MA, TENGG-KOBLIGK H, ET AL. CONTRAST-ENHANCED MAGNETIC RESONANCE IMAGING OF CENTRAL NERVOUS SYSTEM TUMORS: AGENTS, MECHANISMS, AND APPLICATIONS. Top Magn Reson Imaging 2006

La scelta diagnostica iniziale - TC

La TC conserva un ruolo nell'ambito della diagnostica eseguita in regime d'urgenza per l'ampia disponibilità territoriale e temporale, per la rapidità di esecuzione e la possibilità di poter portare a termine indagine preliminare in paziente in condizioni critiche o di instabilità.

*Eventuale utilizzo a definizione ed interpretazione di quadro RM
(Calcificazioni, Emorragie)*



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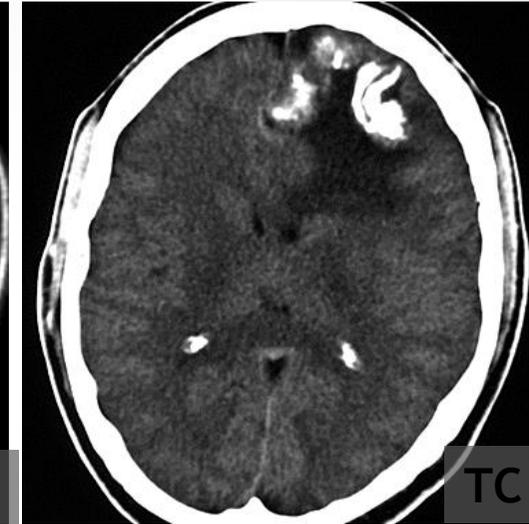
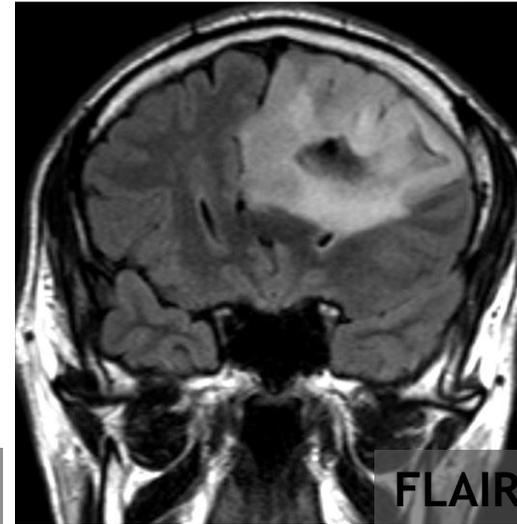
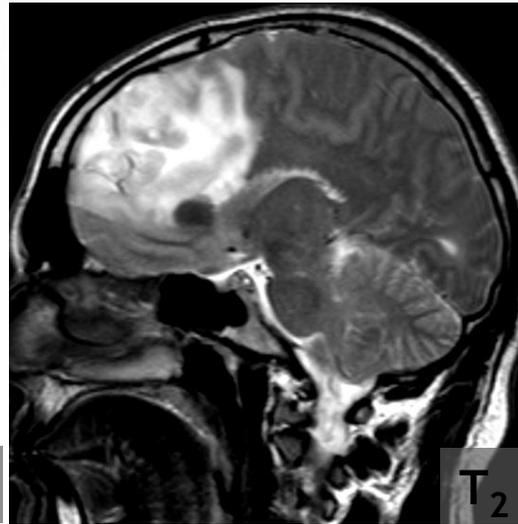
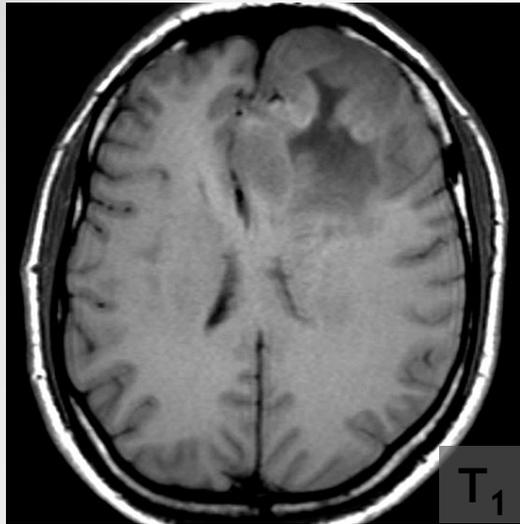
MR imaging is the technique of choice for the differential diagnosis, tumor grading, and treatment planning of neoplastic CNS lesions.

Advanced MR imaging techniques provide physiologic data relevant to diagnosis and grading that may assist conventional MR imaging.

La scelta diagnostica iniziale – RM "convenzionale"

- La diagnosi ed il planning del trattamento sono basate sull' imaging RM convenzionale:
- T2-weighted imaging,
- FLAIR,
- DWI
- T1 s MdC (TSE/FSE o GRE).
- Dopo contrasto (Gadolinio): Sequenze T1-WI, (3D GRE o 2D TSE/FSE)

La diagnosi neuroradiologica di processo espansivo

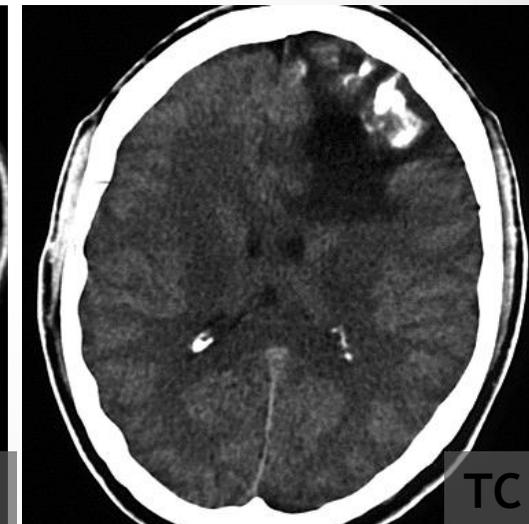
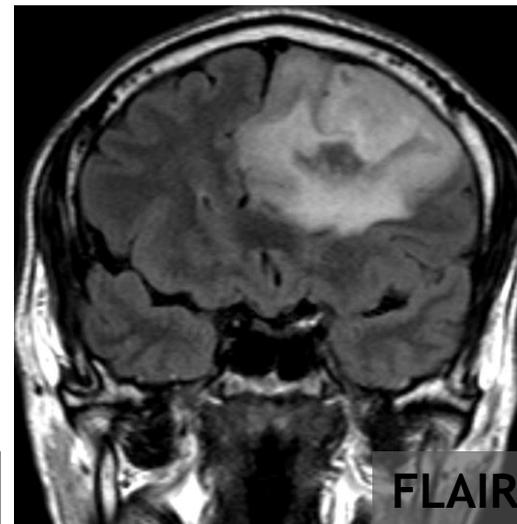
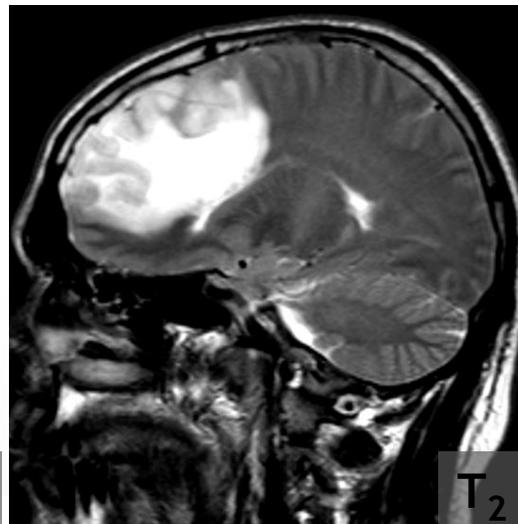
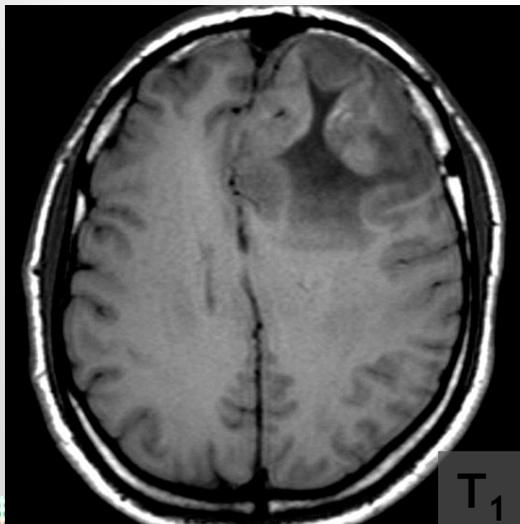


1) identificazione

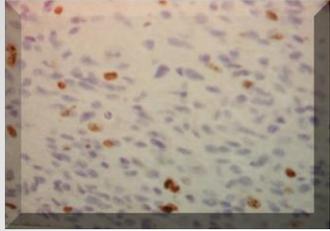
2) localizzazione

3) modalità crescita

4) caratterizzazione



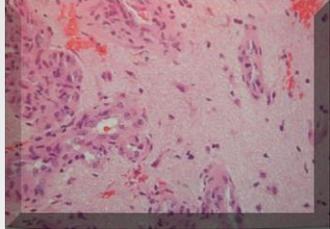
La diagnosi neuroradiologica di processo espansivo – caratteristiche di segnale



cellularità elevata



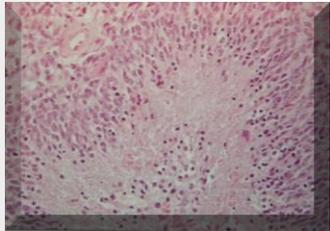
basso segnale in T₂



atipie, mitosi



-



necrosi

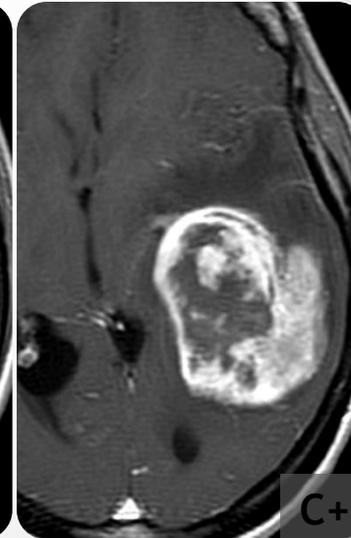
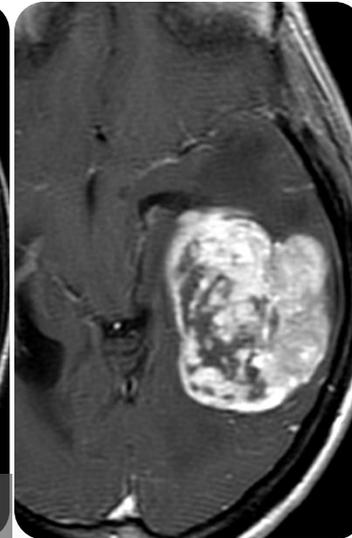
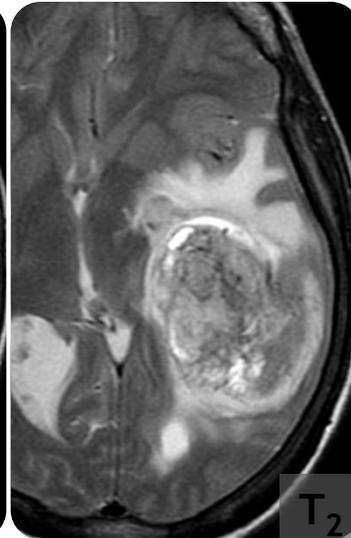
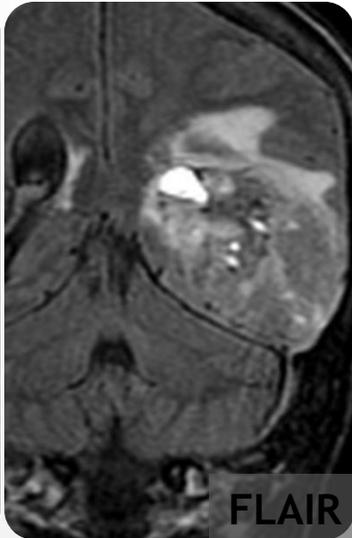
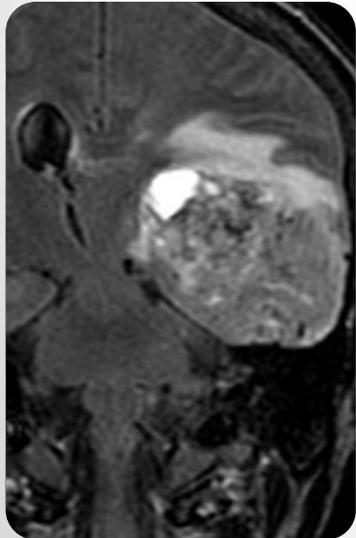


elevato segnale in T₂

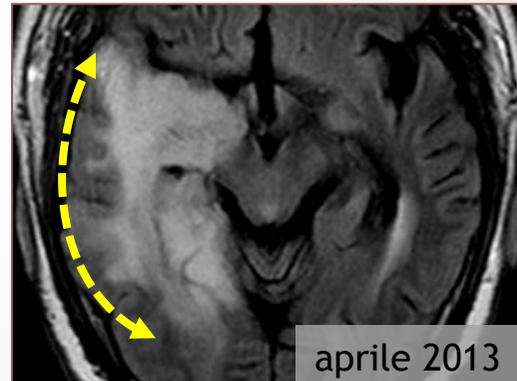
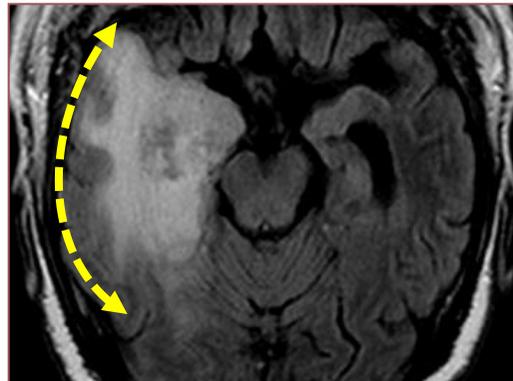
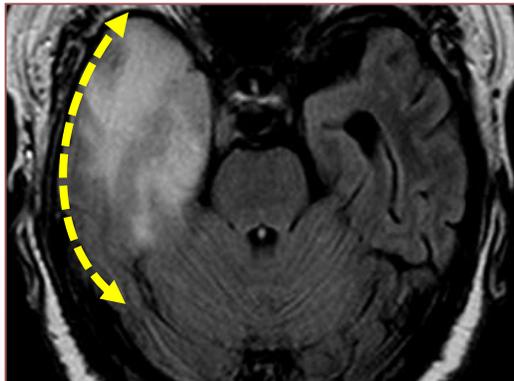
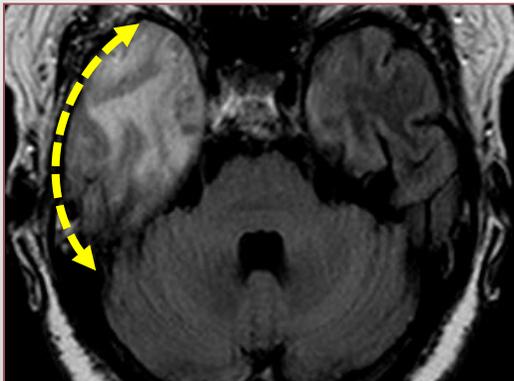
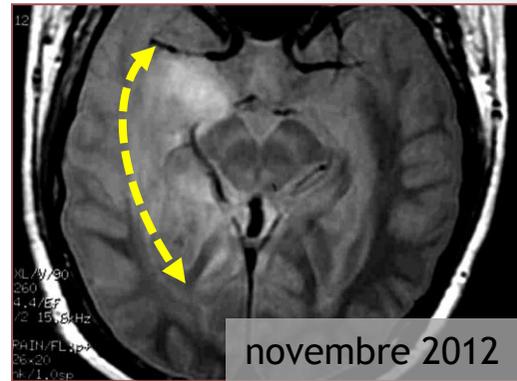
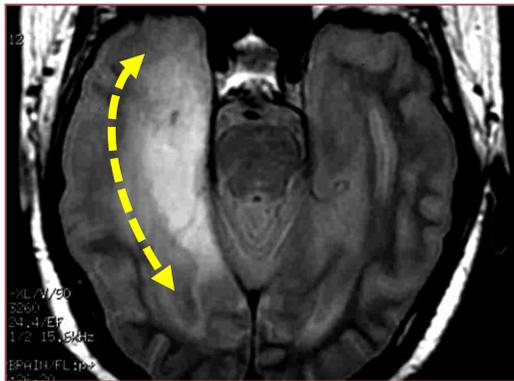
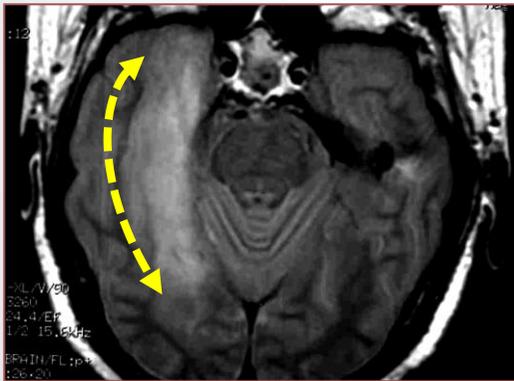
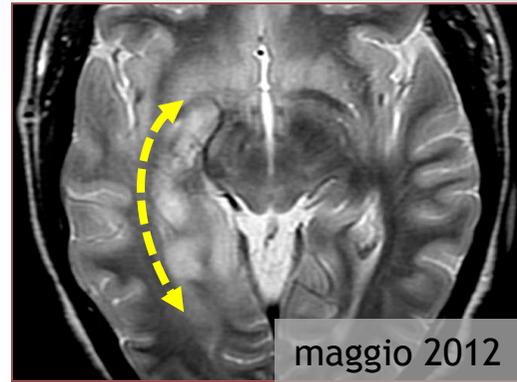
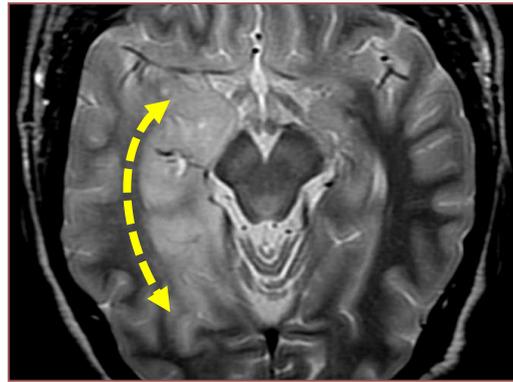
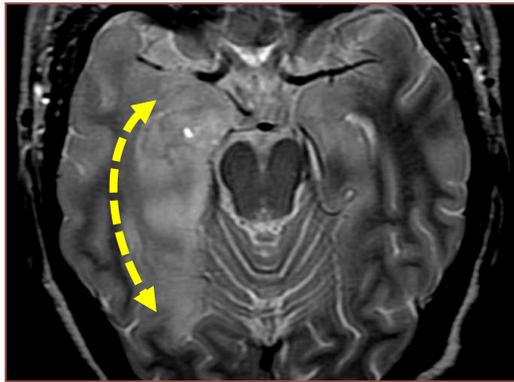
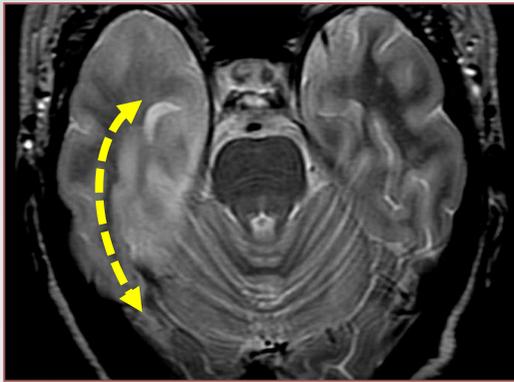
componente vascolare



“vuoto” di segnale



La diagnosi neuroradiologica di processo espansivo – pattern di accrescimento



L'utilizzo del Mezzo di Contrasto

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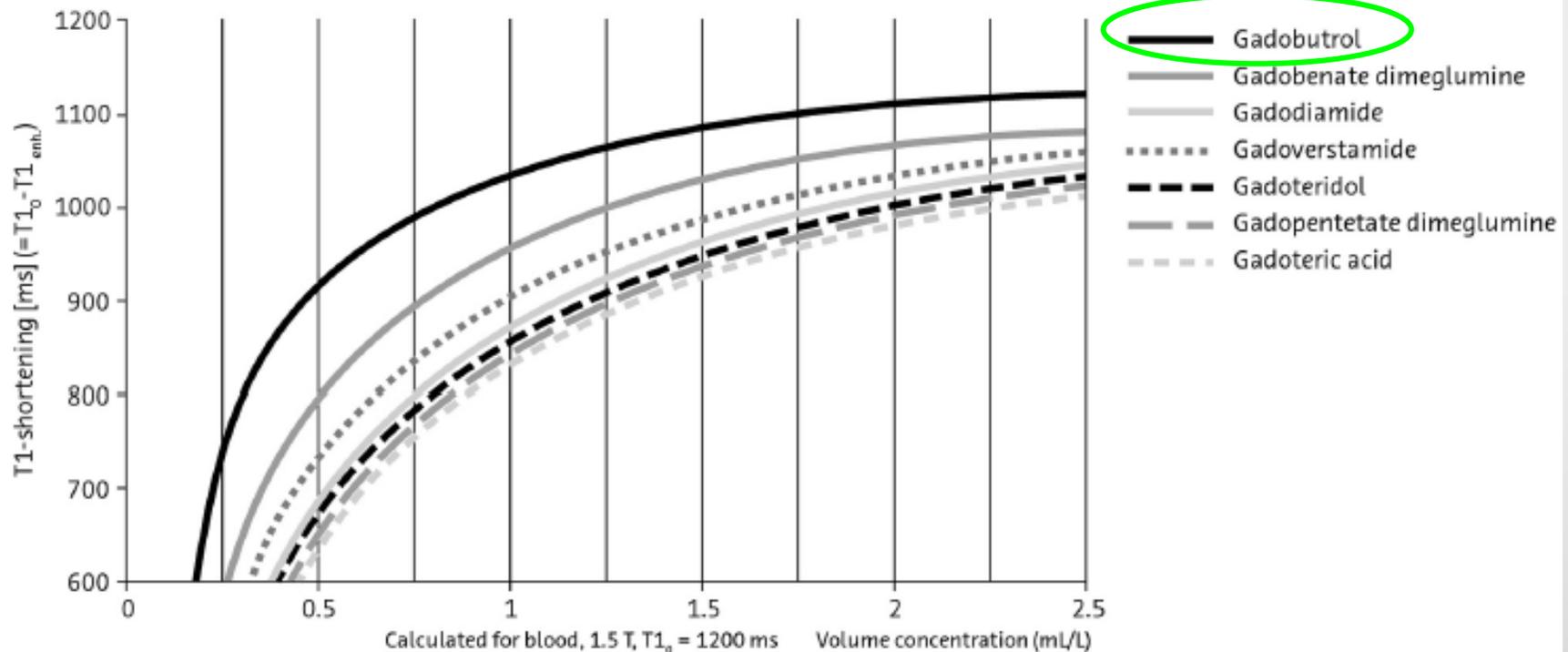
Studio RM "convenzionale" - la scelta del mezzo di contrasto

- Chelati del Gadolinio (elemento Terre Rare dotato di effetto paramagnetico):
 - ✓ **Lineari**
 - ✓ **Macro ciclici**
- "Alta Relassività vs Standard"
- Concentrazione -> 0.5 mmol/L vs 1 mmol/L

Studio RM "convenzionale" - la scelta del mezzo di contrasto

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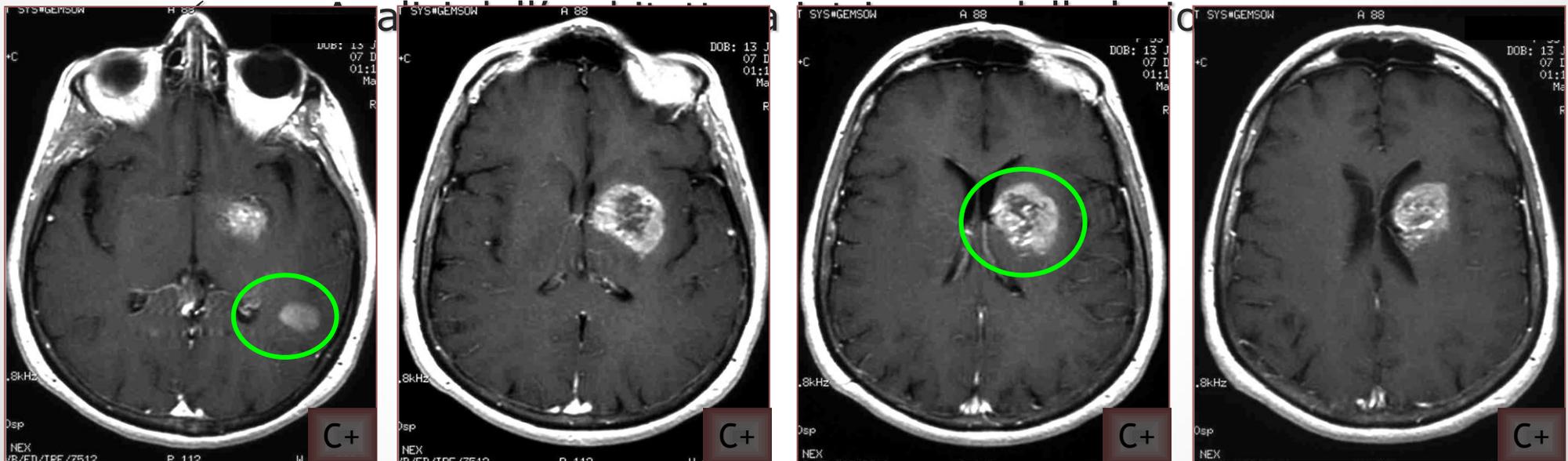
MR Imaging of Neoplastic Central Nervous System Lesions: Review and Recommendations for Current Practice

A single dose (0.1 mmol/kg of body weight) of gadolinium-based contrast medium is recommended for suspected primary lesions, with a second administration in cases of diagnostic doubt.

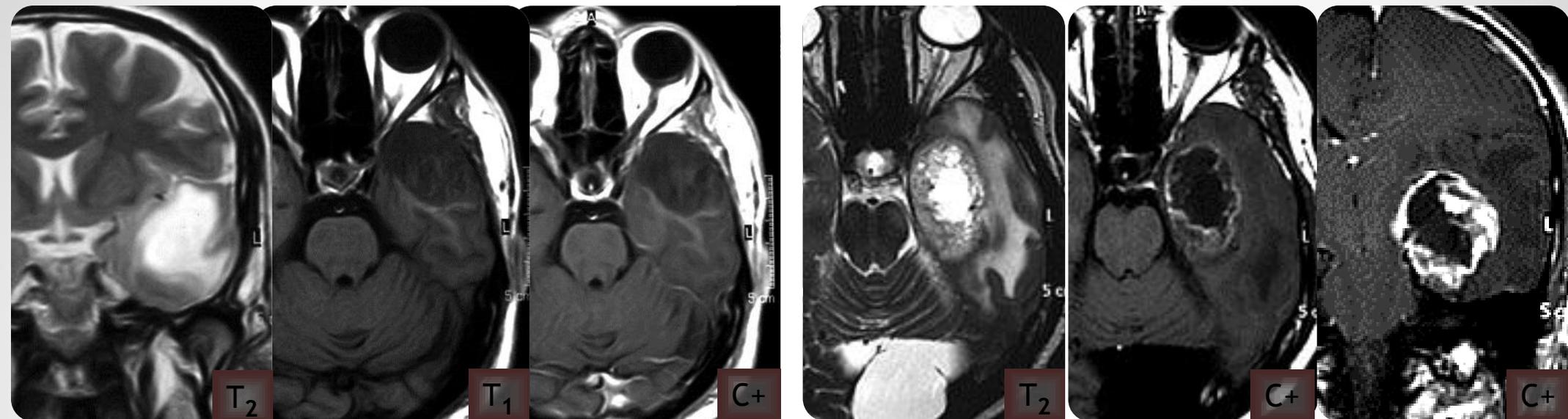
In patients with a GFR below 30 mL/min/1.73 m², a single dose only is recommended. With a GFR of 30–60 mL/min/1.73 m², a single or double dose may be used.

Studio RM "convenzionale" – l'enhancement contrastografica

- La somministrazione del MdC permette di incrementare la sensibilità nella:
 - ✓ Detezione e delineazione della numerosità
 - ✓ Attribuzione della sede topografica
 - ✓ Morfologia/infiltrazione

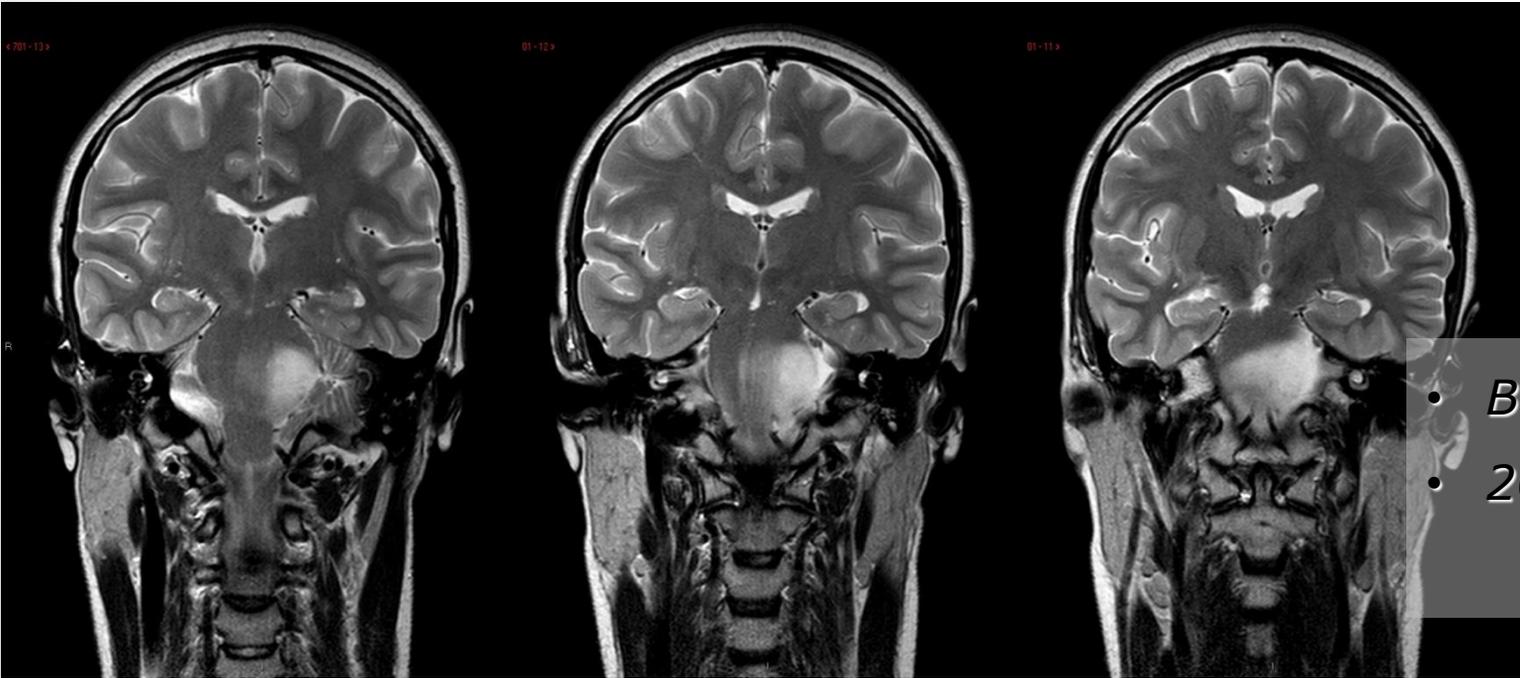
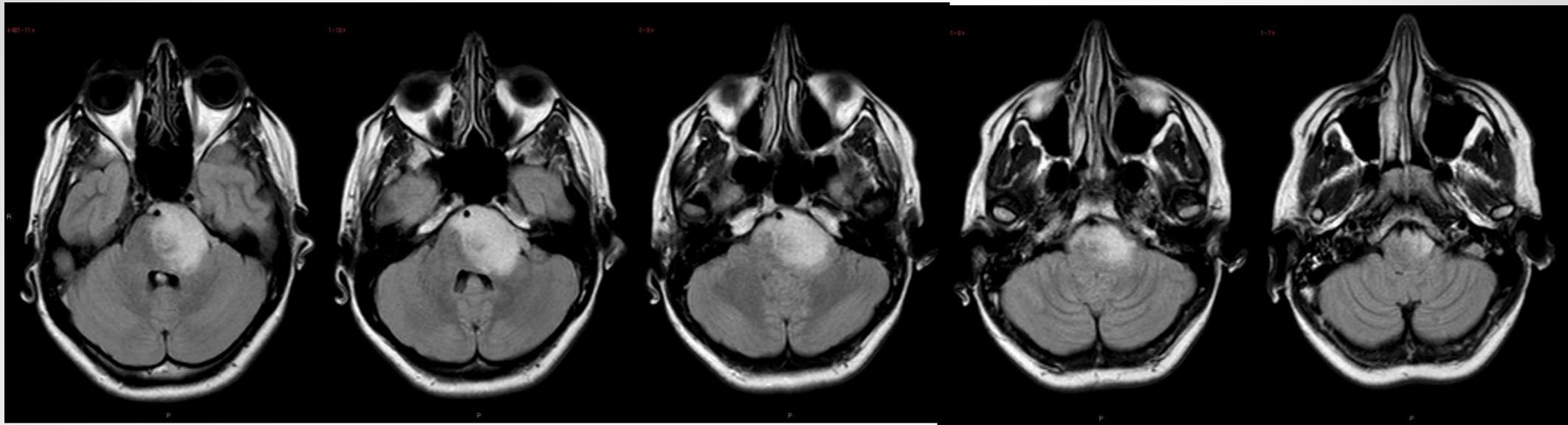


Studio RM "convenzionale" – l'enhancement contrastografico



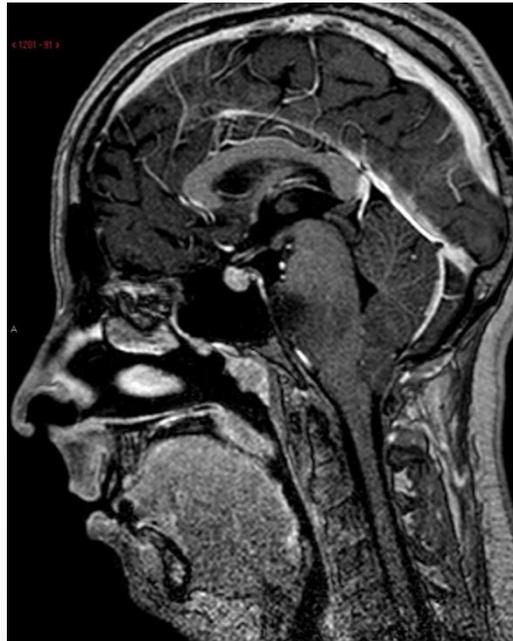
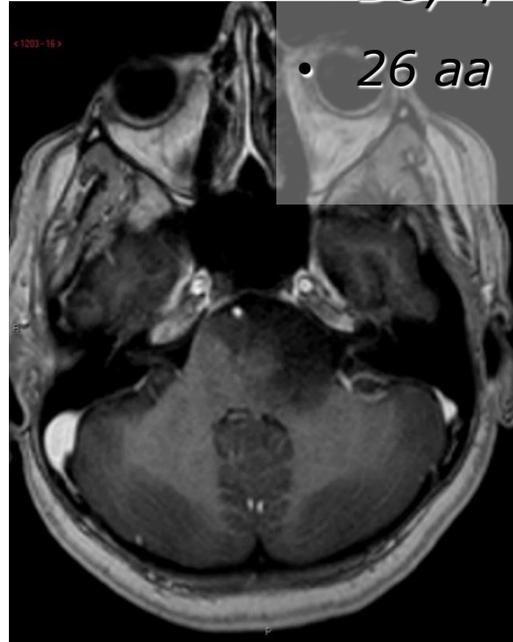
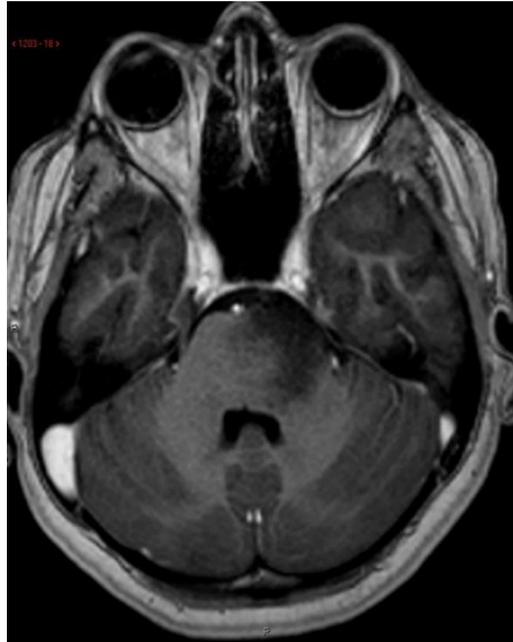
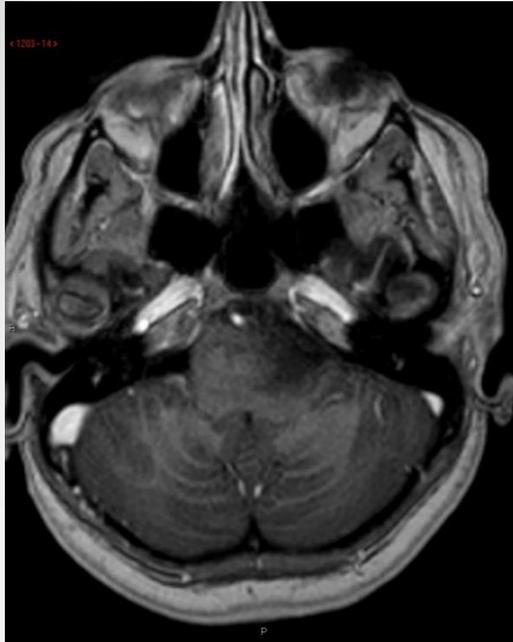
“... according to the literature, 20% of *low-grade gliomas* (LGG) enhance after the administration of Gd-based contrast agent, but approximately one-third of nonenhancing gliomas are malignant ...”

Scott JM et al: *How often are nonenhancing supratentorial gliomas malignant? A population study.*
Neurology 59: 947- 949, 2002

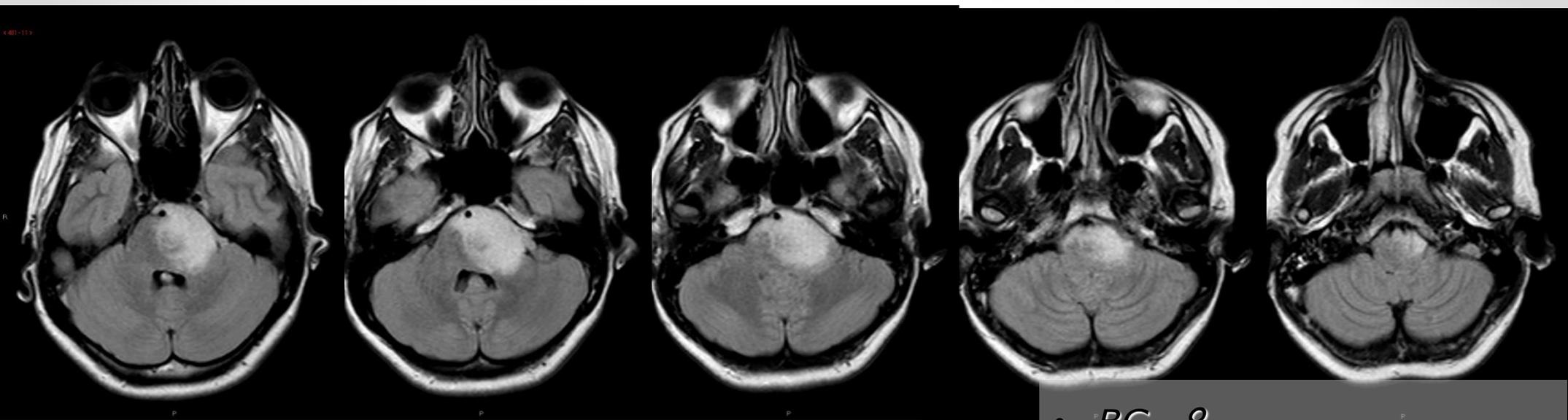


- *BG, ♀*
- *26 aa*

- BG, ♀
- 26 aa

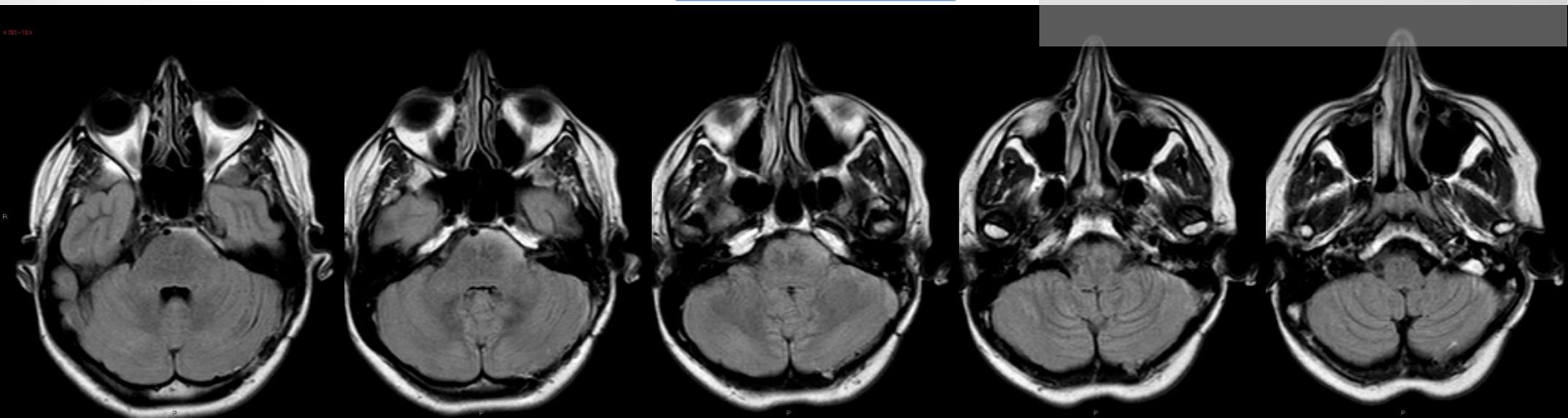


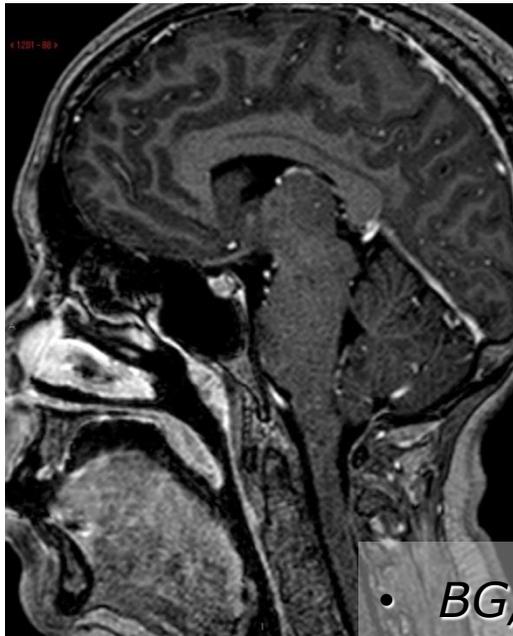
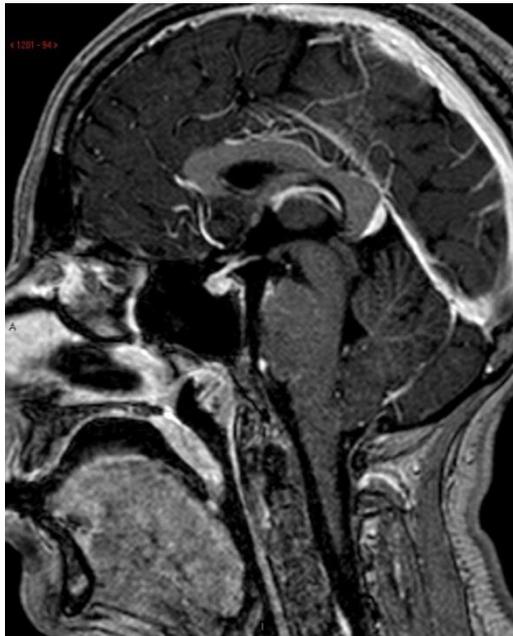
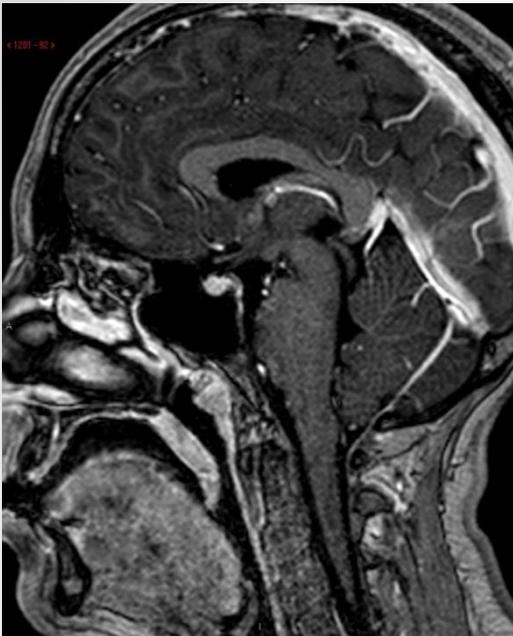
GIUGNO 2013



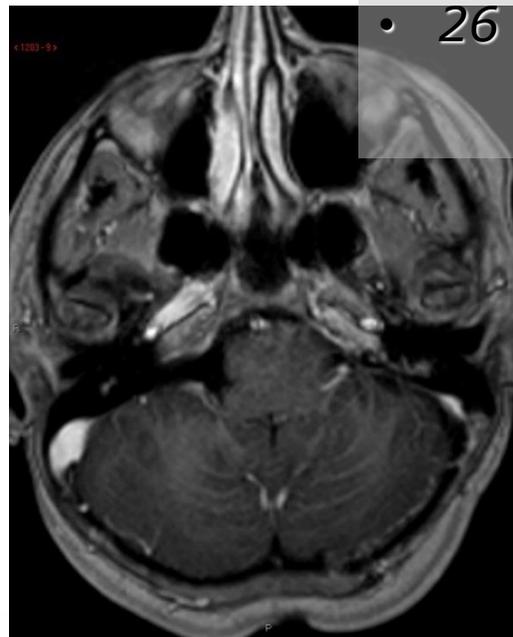
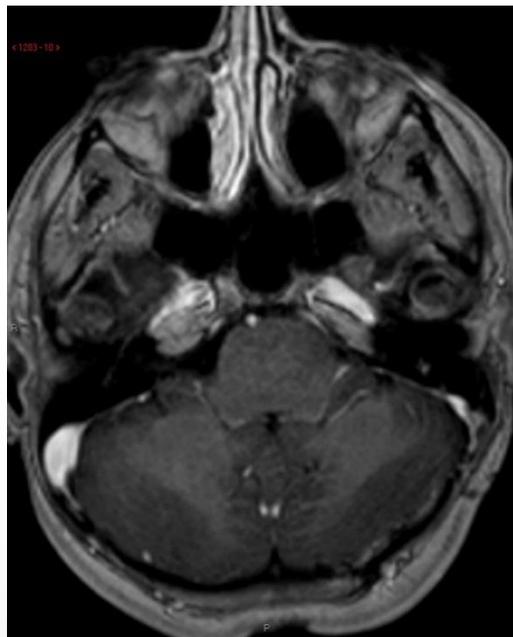
- *BG, ♀*
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SETTEMBRE 2015

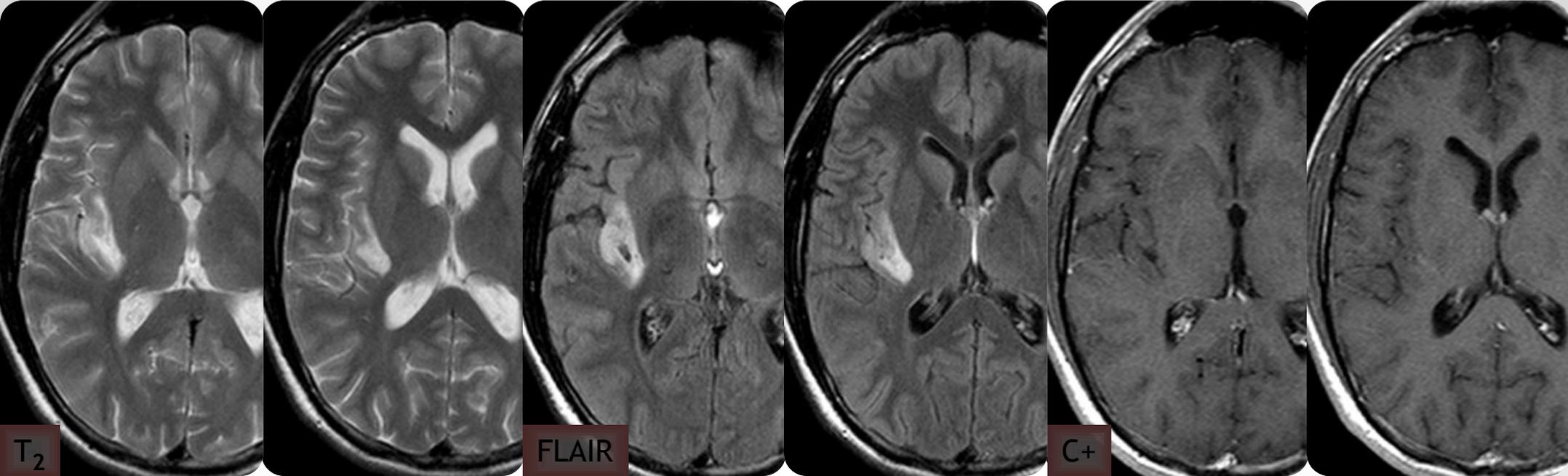




- *BG, ♀*
- *26 aa*



Studio RM "convenzionale" – l'enhancement contrastografico



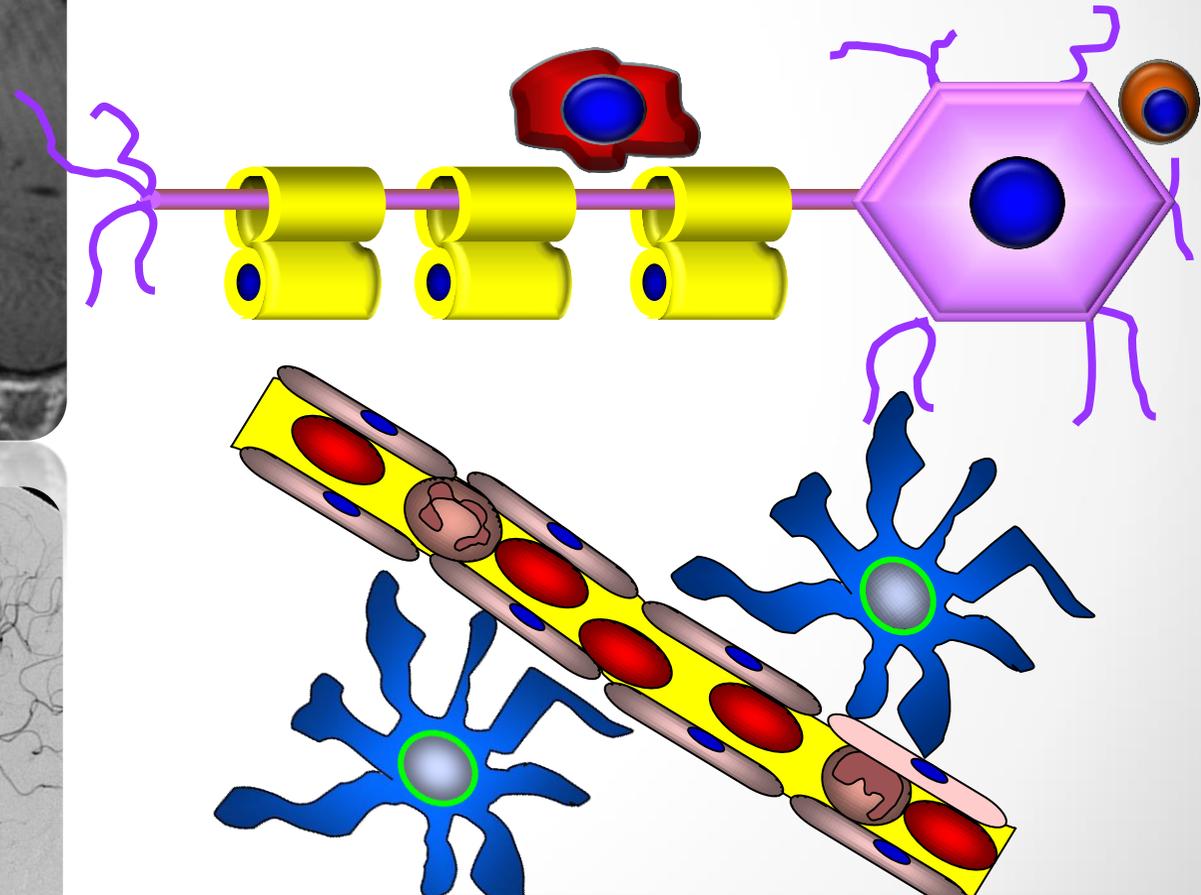
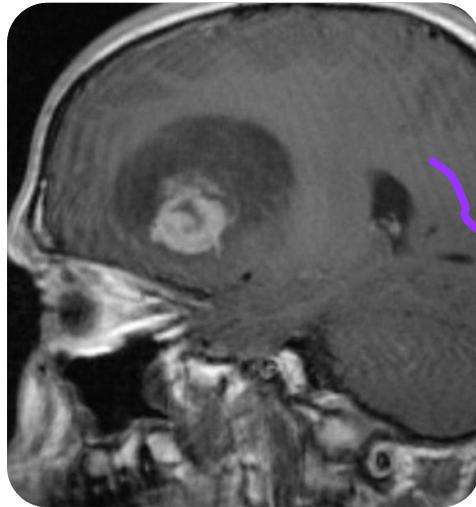
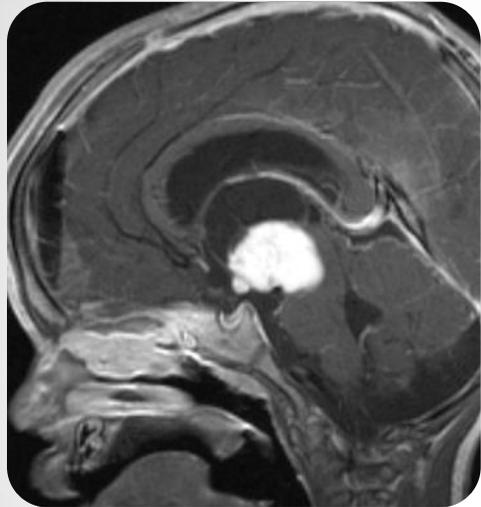
Gliomi di grado II (diagnosi neuropatologica) : impregnazione in circa il 16% dei casi (soprattutto a margini sfumati, meno comunemente nodulare, mai “ad anello”)

Pallud J, et Al: *Prognostic significance of imaging contrast enhancement for WHO grade II gliomas.*

Neuro-Oncology 2008

Studio RM "convenzionale" – l'enhancement contrastografico

l'enhancement contrastografico non è indice assoluto di proliferazione vascolare (neoangiogenesi) ma risulta indicativo **unicamente** di una "incompetenza" della Barriera Emato-Encefalica



alterazione di barriera

neoangiogenesi

BARRIERA-EMATO-ENCEFALICA

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Studio RM "convenzionale" – protocollo d'esame RM

MR Imaging of Neoplastic Central Nervous System Lesions: Review and Recommendations for Current Practice

Optimization of the protocol sequence enhances CNS lesion characterization.

A standardized protocol sequence for conventional MR imaging includes T1-weighted precontrast, T2-weighted, DWI, and T1-weighted contrast imaging.

Higher field strengths (eg, 3T versus 1.5T) provide superior image quality, if available.

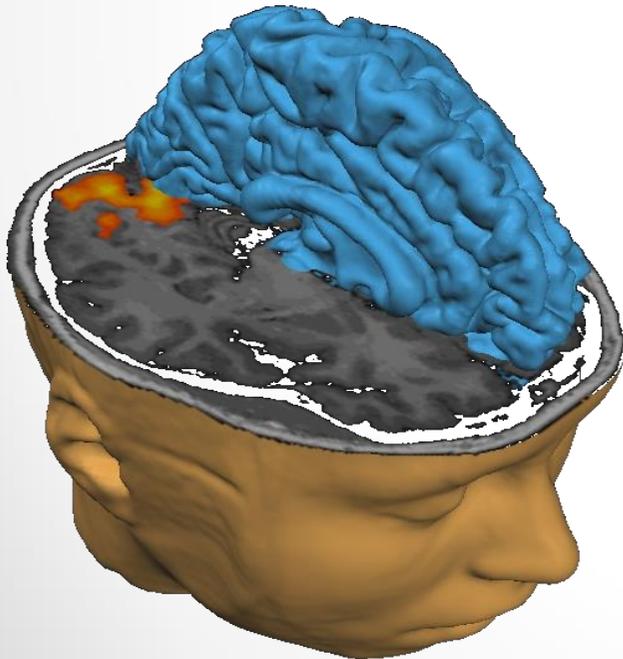
Delay is recommended. Image acquisition at up to 20 minutes postcontrast injection offers improved lesion detection.

Additional advanced MR imaging techniques can be selected according to the clinical scenario.

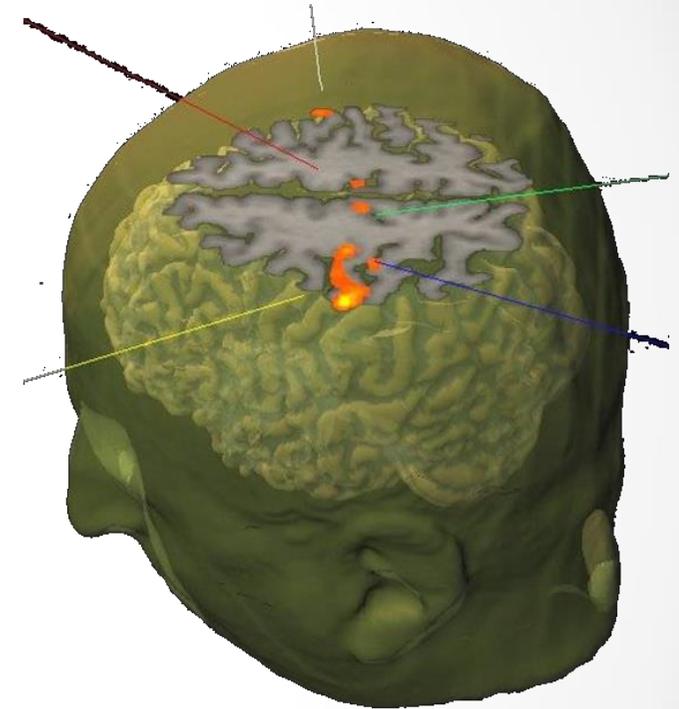
Approfondimento diagnostico – studio RM funzionale

RM TECNICHE AVANZATE

**RM
DIFFUSIONE**



**RM
PERFUSIONE**



**RM
SPETTROSCOPIA**

Approfondimento diagnostico – studio RM funzionale

DIFFUSIONE



cellularità

TENSORE



rapporto fasci di fibre

PERFUSIONE



angiogenesi

SPETTROSCOPIA

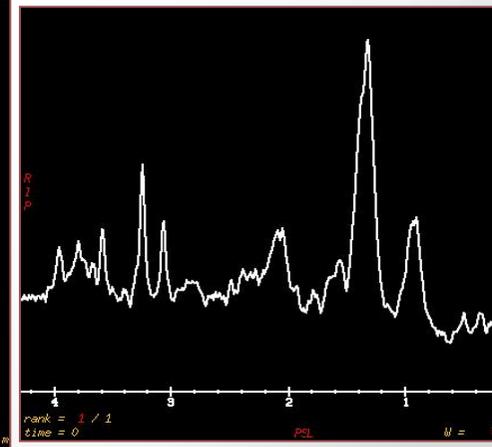
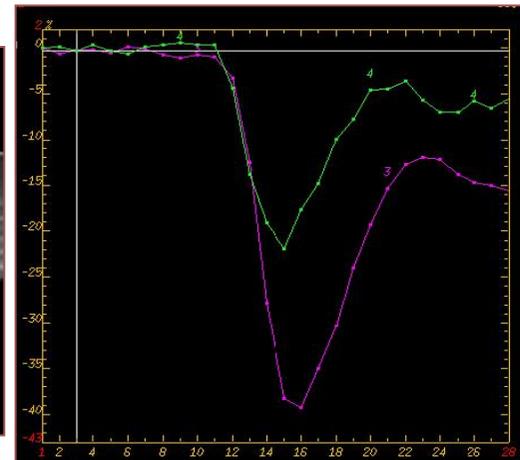
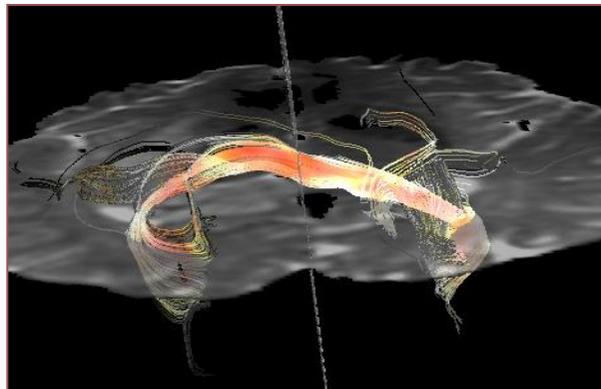
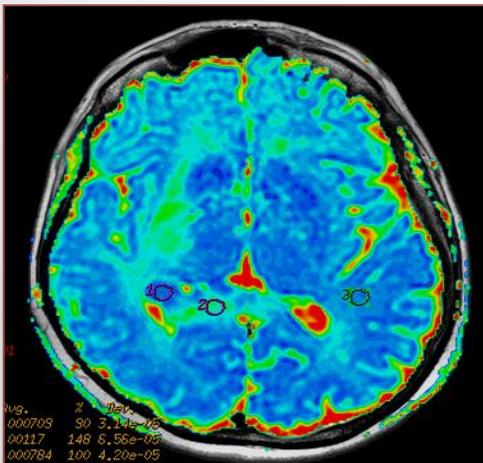
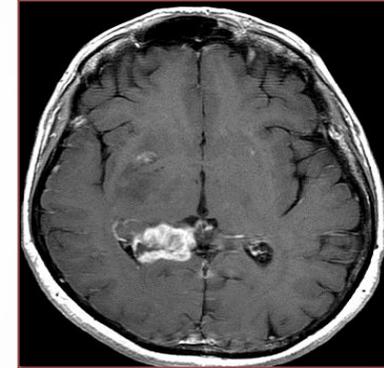


metaboliti tissutali

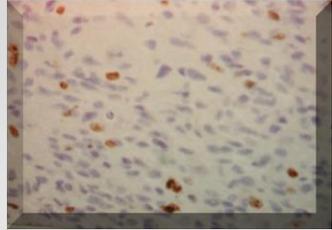
FUNZIONALE



rapporto aree eloquenti



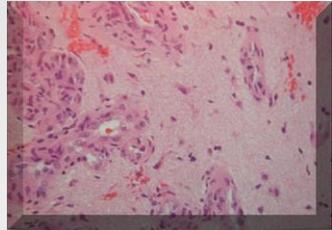
Criteria neuropatologici di malignità



cellularità elevata



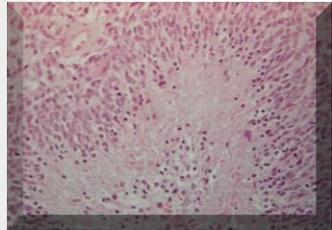
**basso segnale in T₂
restrizione diffusività**



atipie, mitosi



-



necrosi

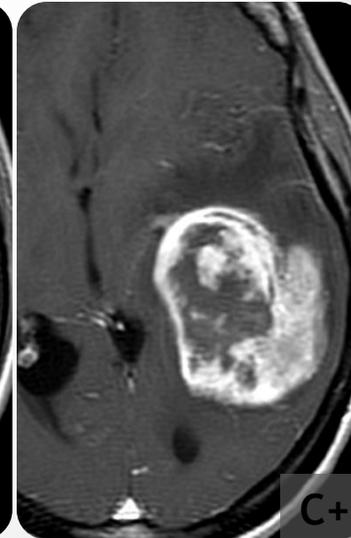
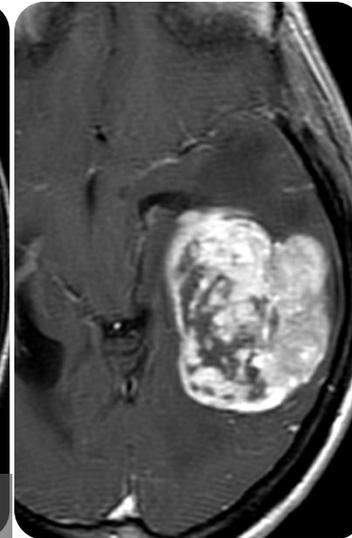
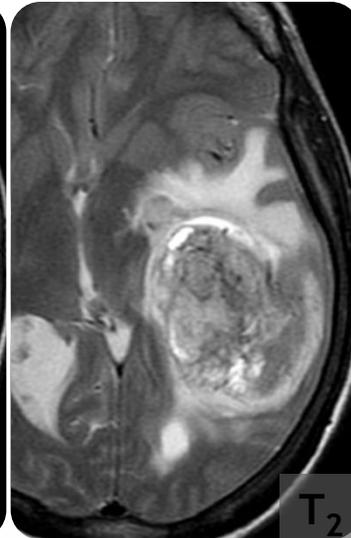
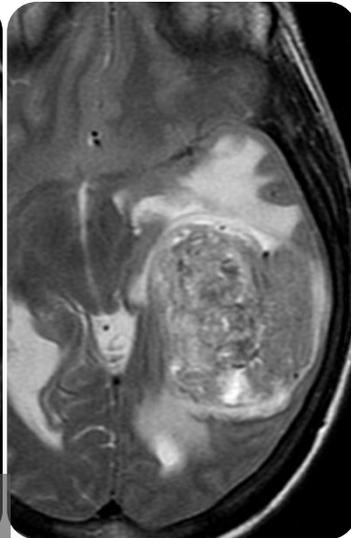
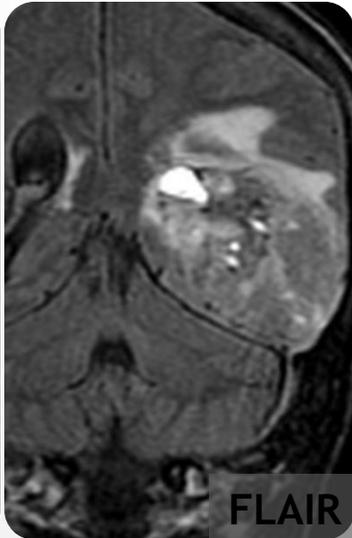
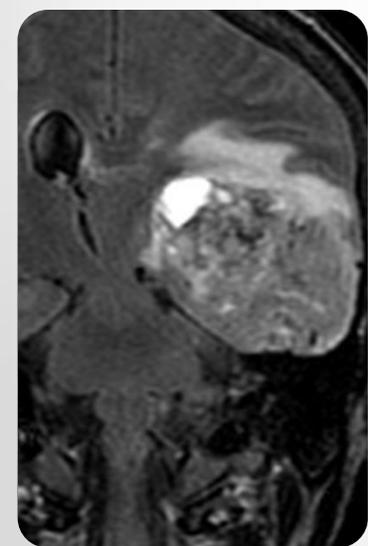


**elevato segnale in T₂
presenza Lat e Lip**

neoangiogenesi



elevato rCBV

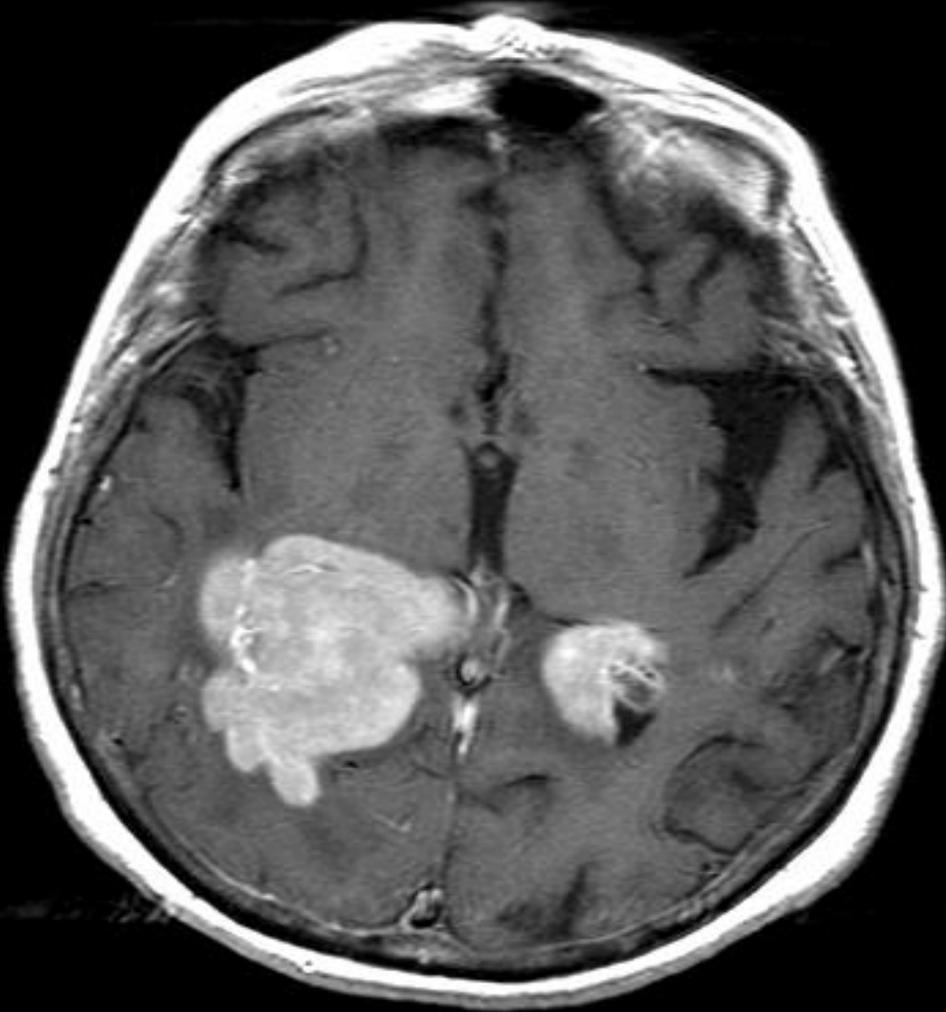


Diffusion Weighted Imaging DWI

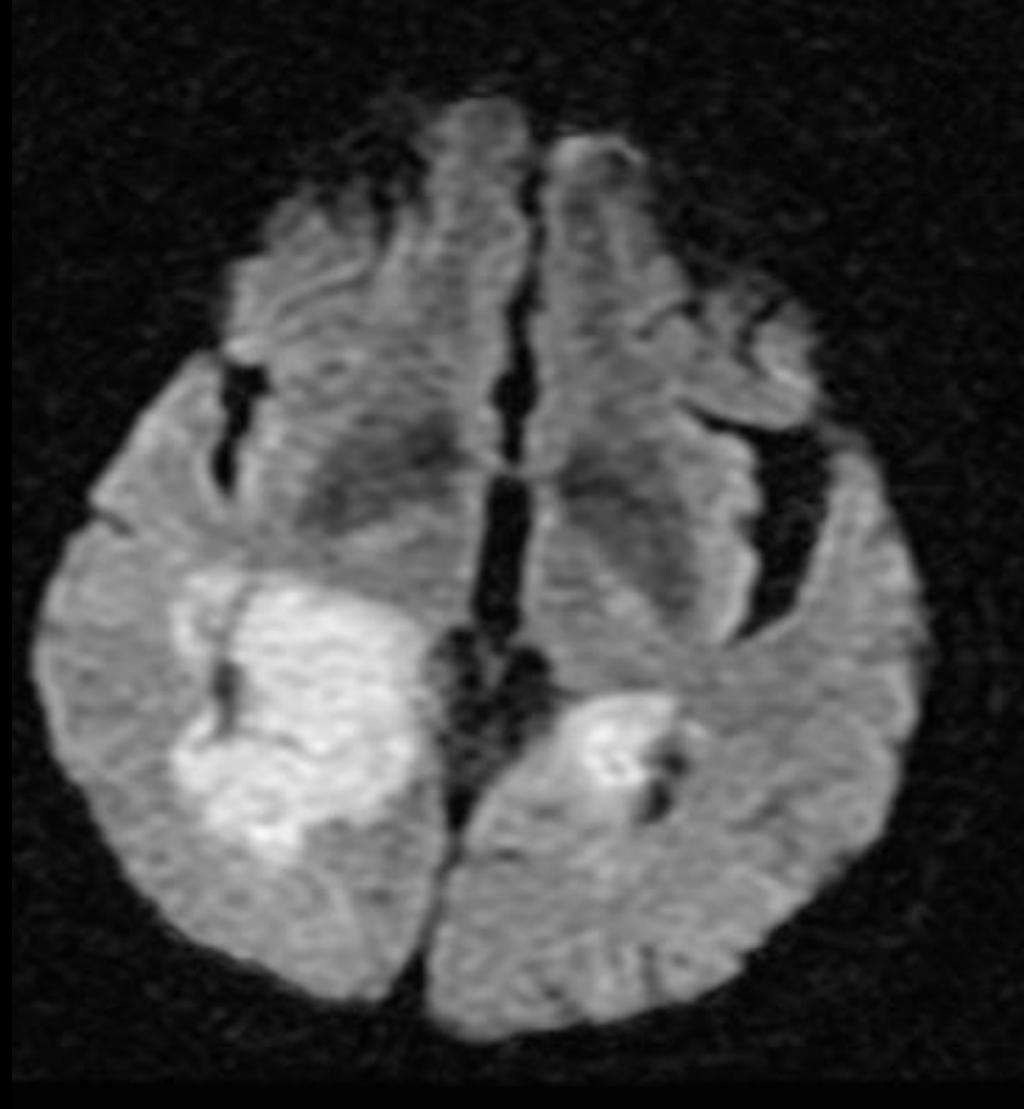
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Studio RM funzionale – DWI

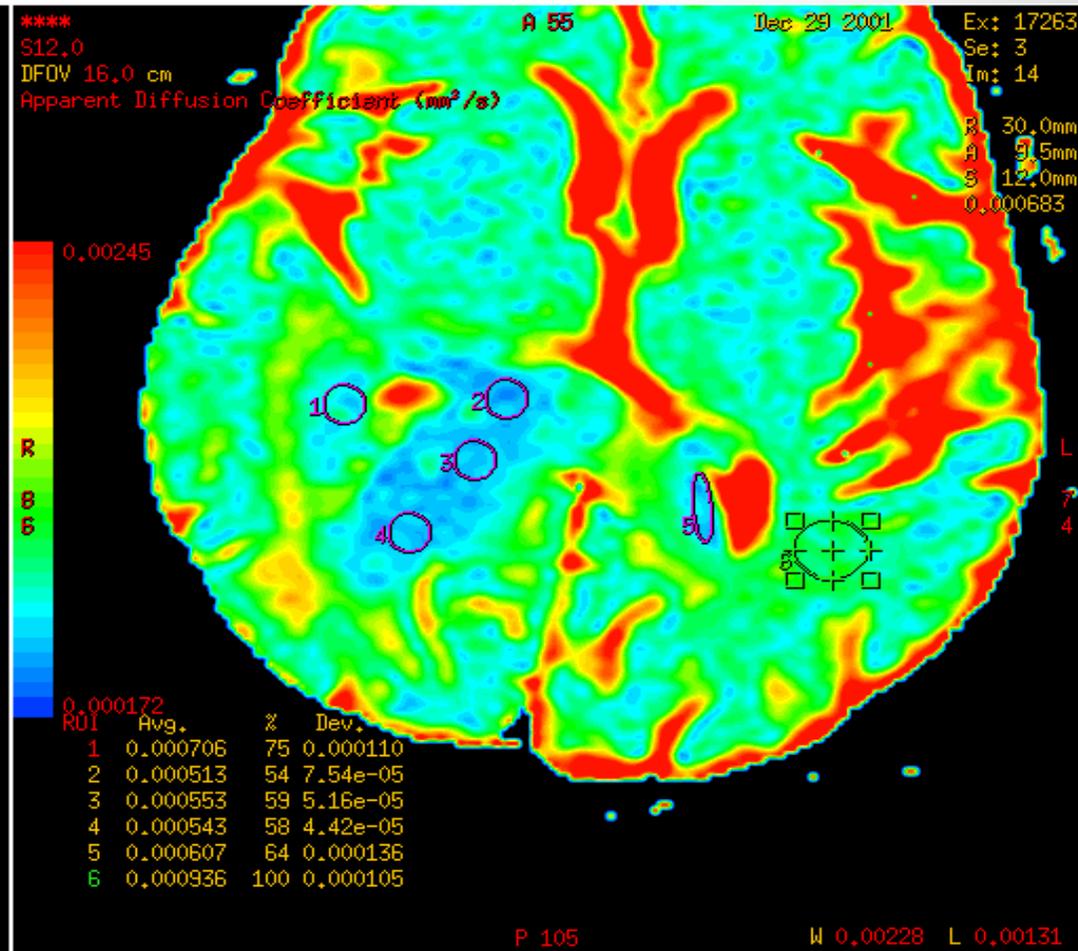
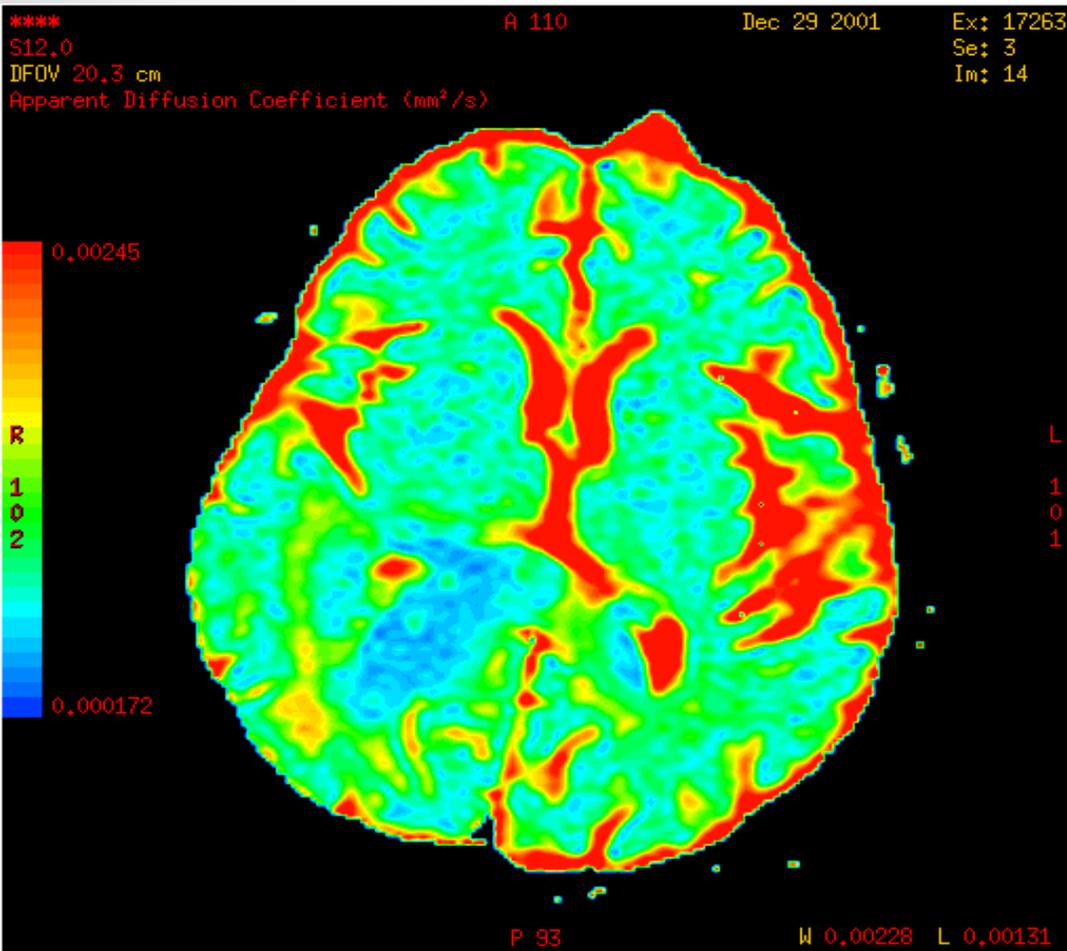
SE mdc



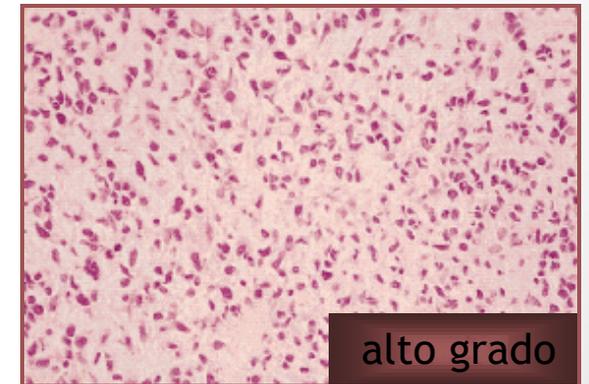
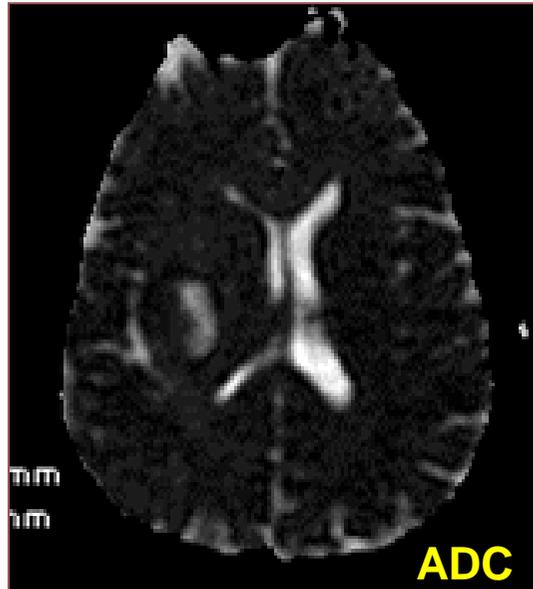
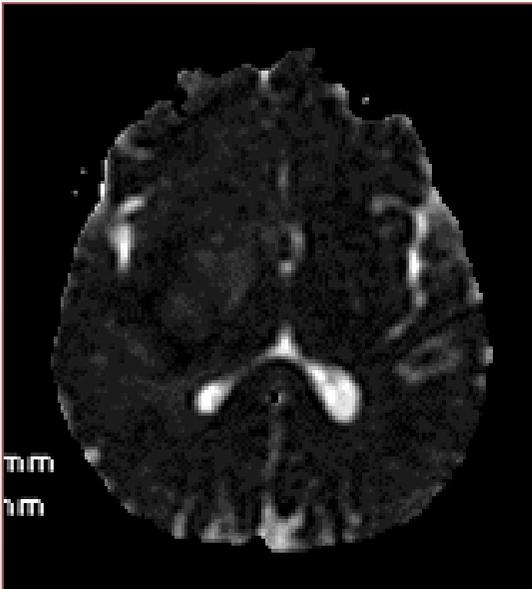
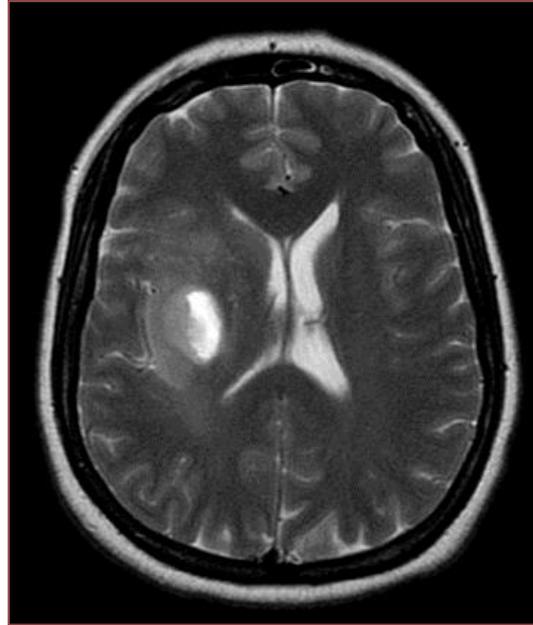
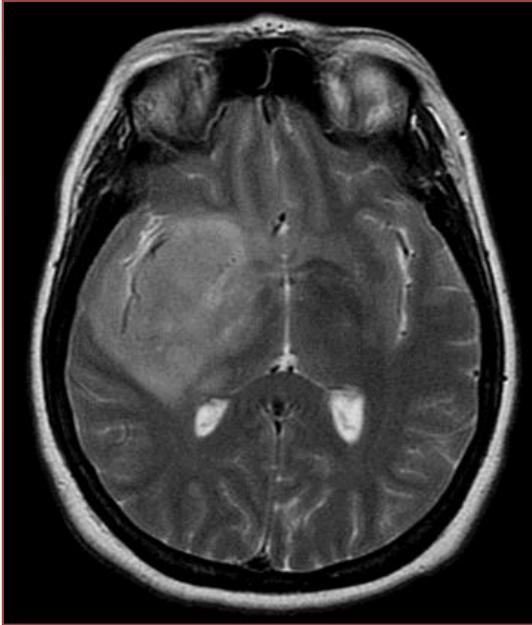
DWI (b=1000)



ADC

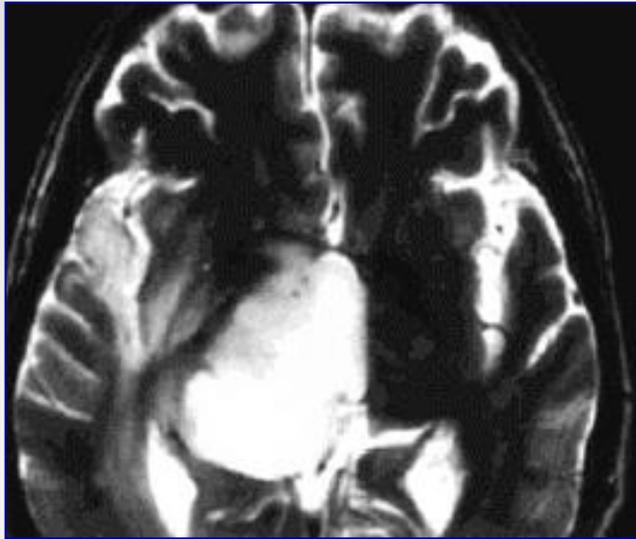


Studio RM funzionale – DWI



**Basso valore di ADC
in rapporto alla elevata
cellularità della lesione**

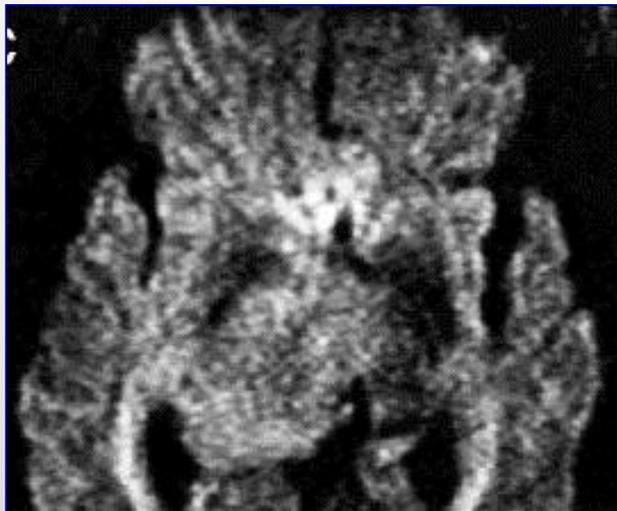
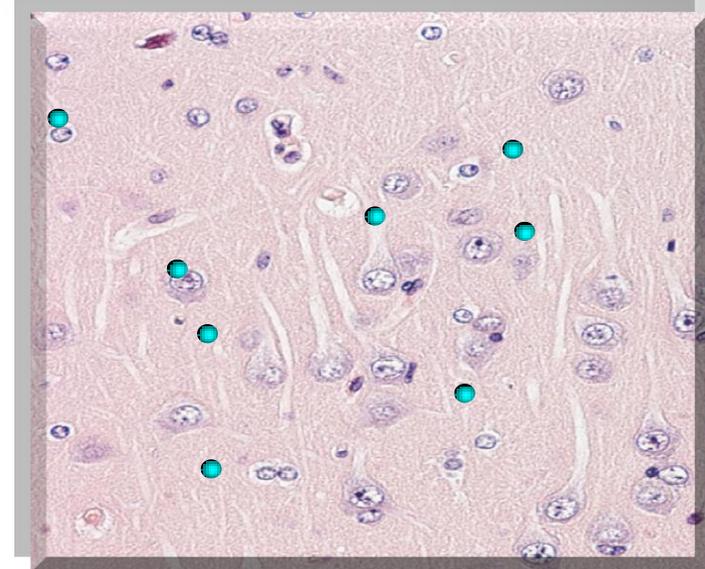
Studio RM funzionale – DWI



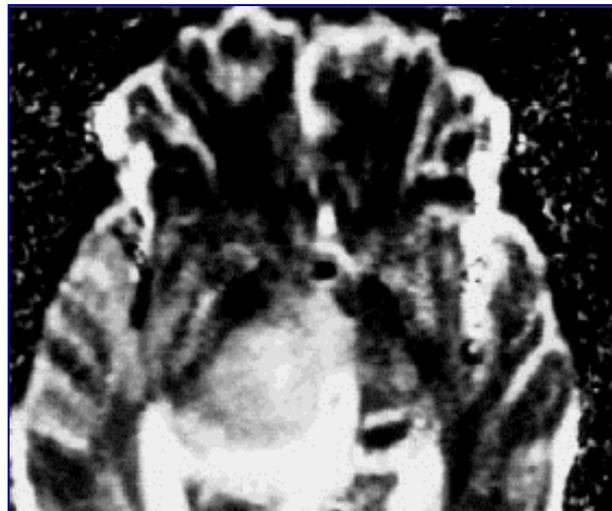
T2



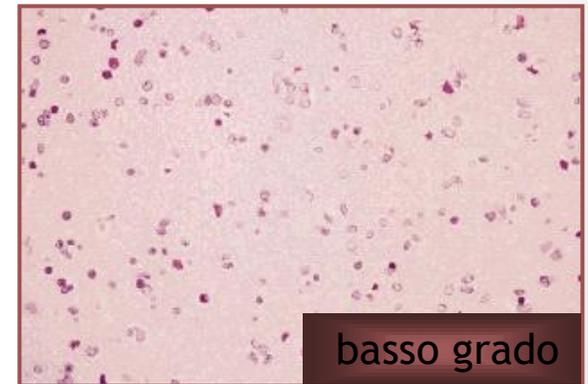
M.D.C.



DWI



ADC



**Alto valore di ADC
in rapporto alla
scarsa cellularità.**

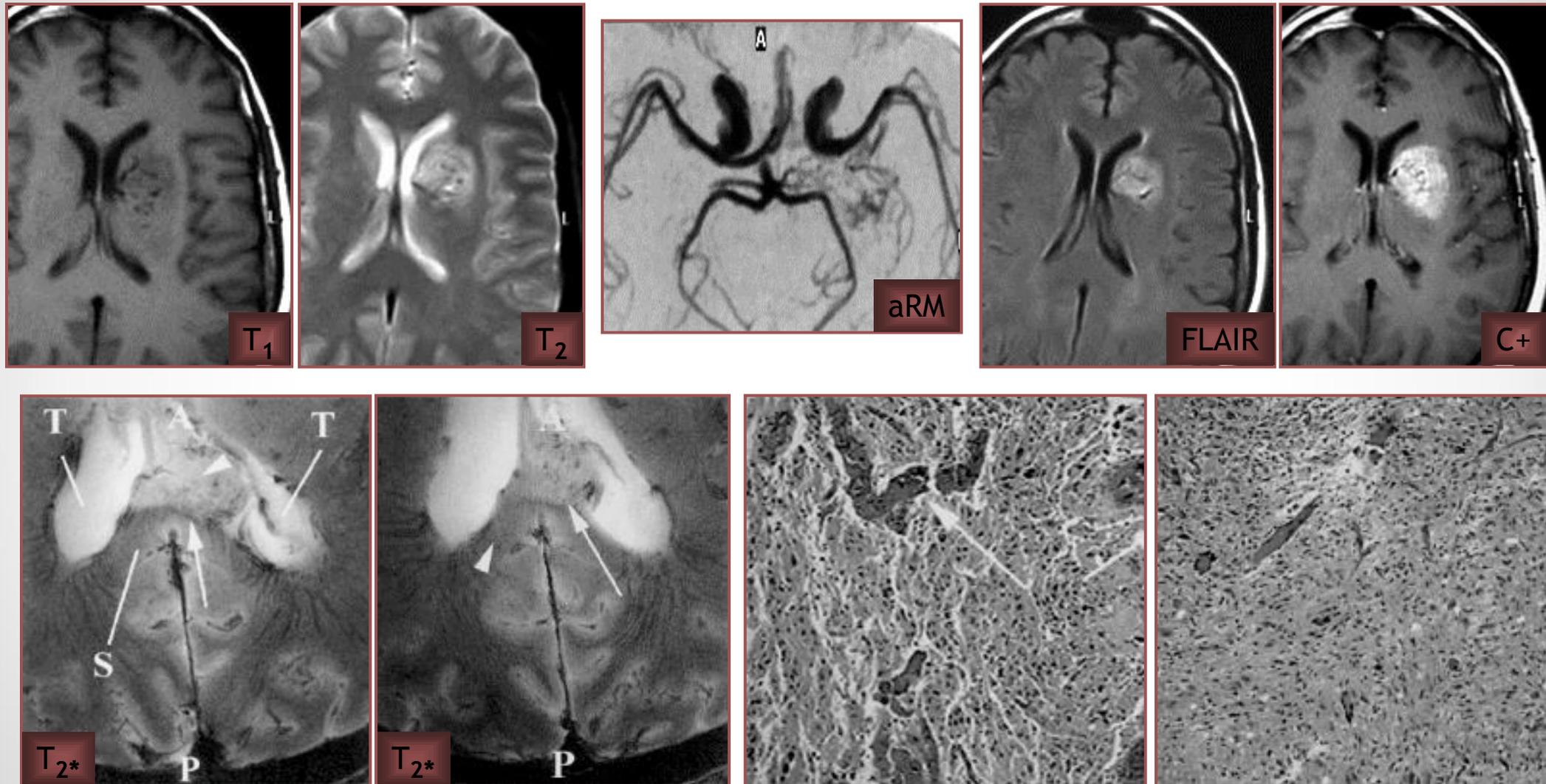
La valutazione della componente microvascolare

La Perfusione

• • •

Perfusion-Weighted Imaging
Dynamic Susceptibility Contrast

Neoangiogenesis



Christoforidis GA, et Al: *Susceptibility-based imaging of glioblastoma microvasculature at 8 T: correlation of MR imaging and postmortem pathology.* **AJNR** 25: 756-760, 2004

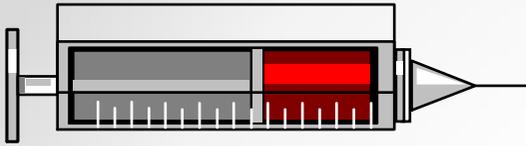
Osservazione della cinetica di un tracciante:

1. iniezione di un bolo di mezzo di contrasto (gadolinio) (5-10 ml/s)
2. il passaggio del mezzo di contrasto provoca un'attenuazione del segnale RM
3. facendo più acquisizioni RM nel tempo si studia la cinetica del mezzo di contrasto
4. dalla cinetica si calcolano alcuni parametri di interesse clinico, con cui vengono costruite le mappe di perfusione

Principali parametri:

- **volume di sangue cerebrale (CBV)**
- **tempo di transito medio (MTT)**
- **flusso (CBF)**

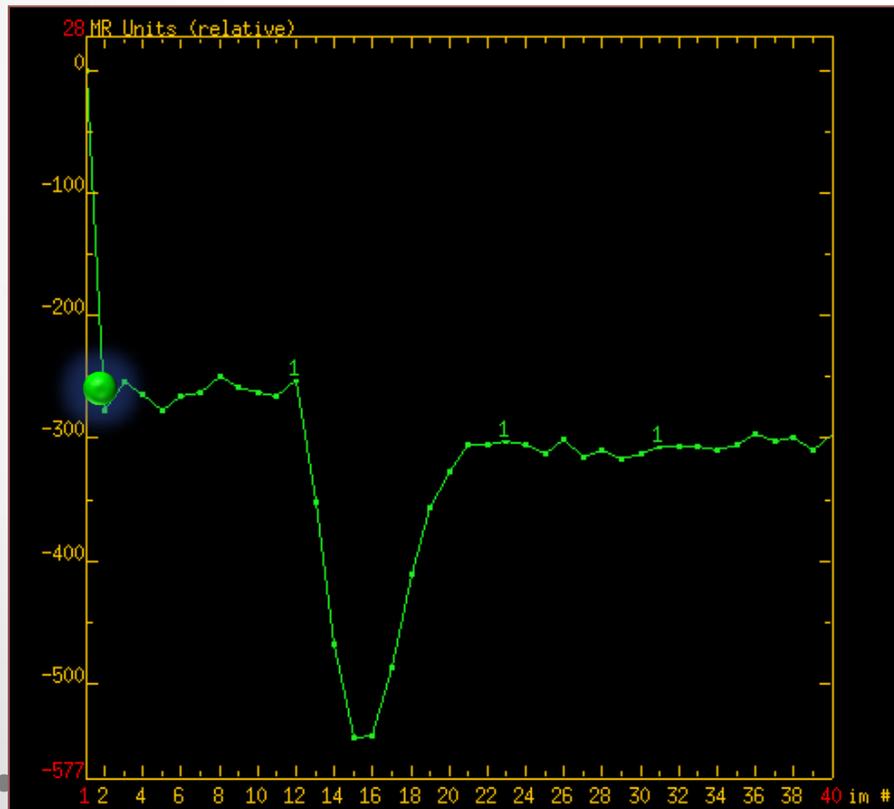
Studio RM funzionale – PWI DSC



CADUTA DEL T2

- concentrazione del mdc
- velocità di iniezione
- effetto T_2 del mdc
- volume mdc nel microcircolo

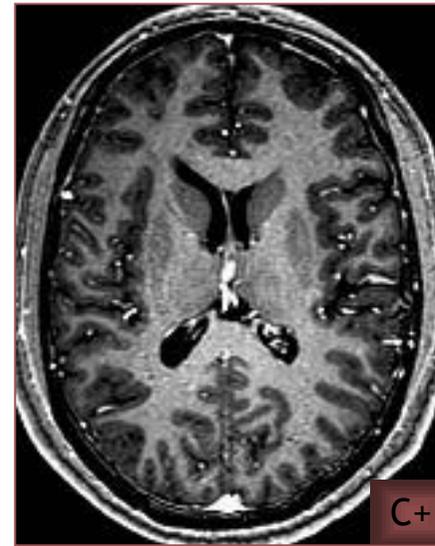
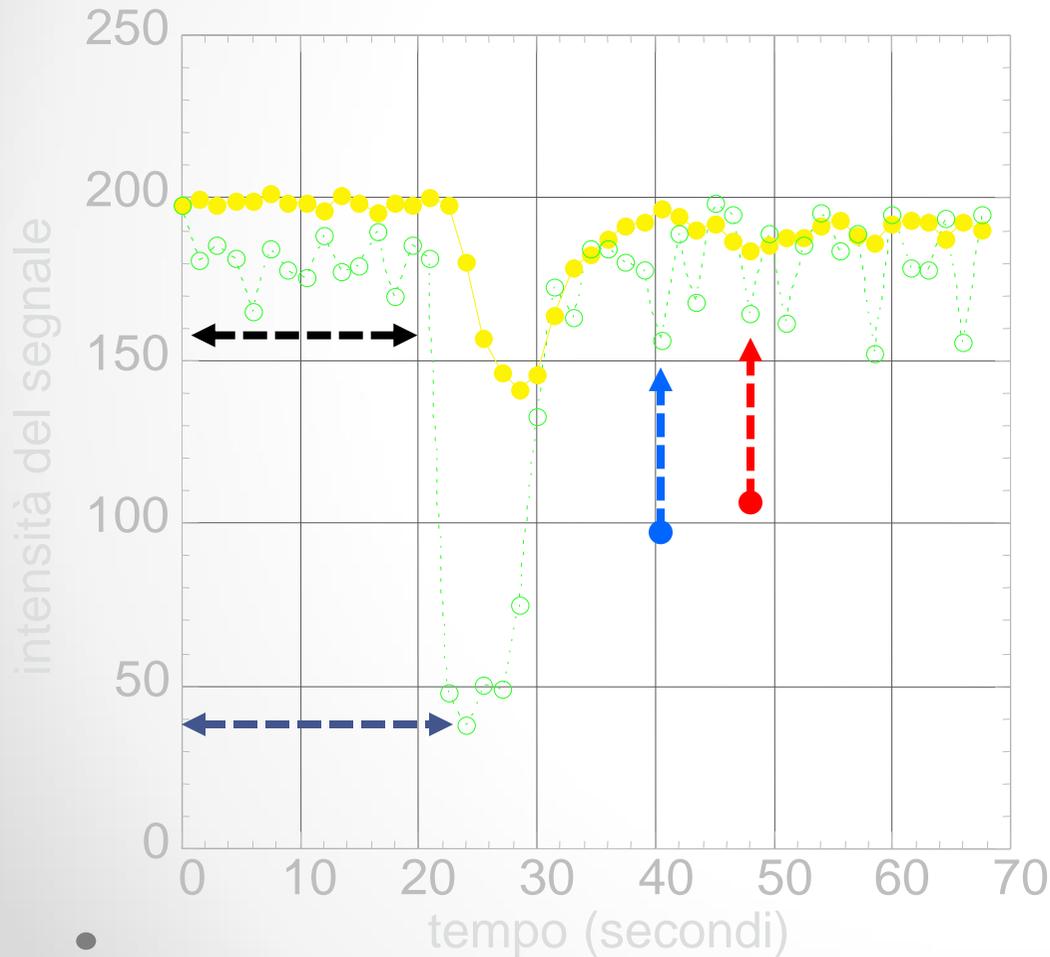
intensità del segnale



tempo (secondi)

Studio RM funzionale – PWI DSC: analisi della curva

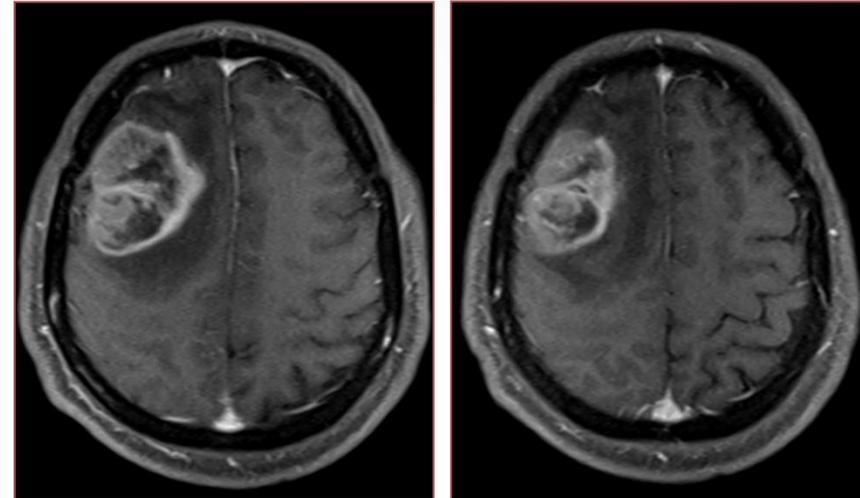
slice



- ← - - - - - → stato basale
- ← - - - - - → picco di variazione del segnale
- - - - - - → picco di ricircolo
- - - - - - → caduta stato basale

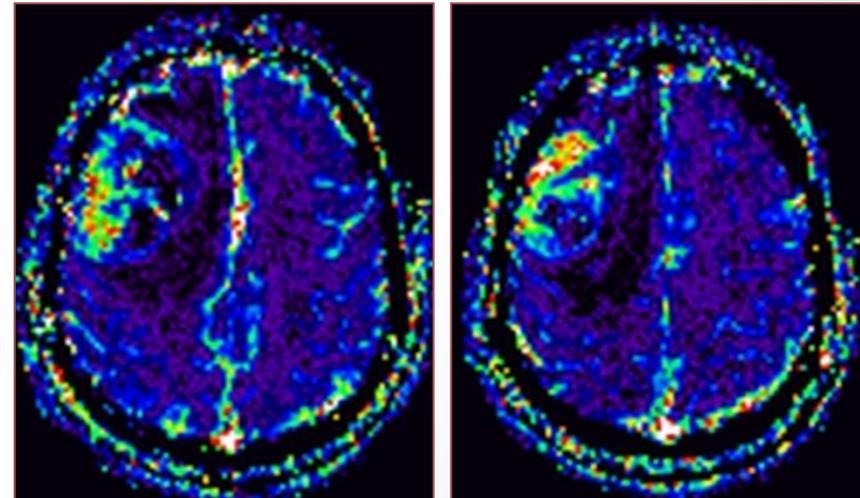
➤ **STANDARDIZZAZIONE DELLA TECNICA**

- Spin-Echo vs Gradient-Echo EPI
- Risoluzione temporale ($TR < 1.5$ s)
- Iniezione di mdc pre-dose



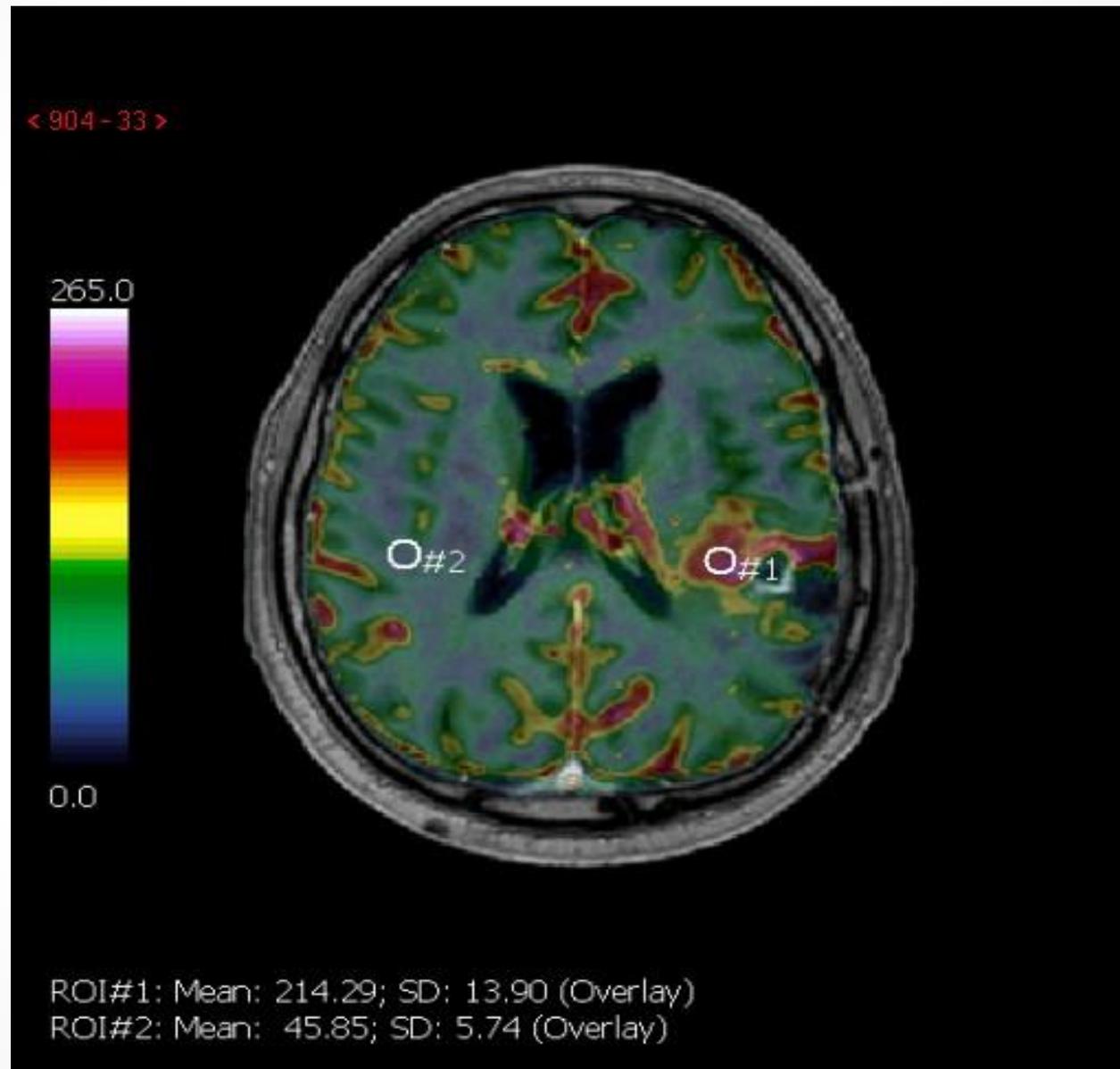
➤ **ANALISI MEDIANTE ROI**

- Normalizzazione con SG o SB controlaterale
- Esclusione vasi intratumorali e piali
- Analisi mediante istogrammi

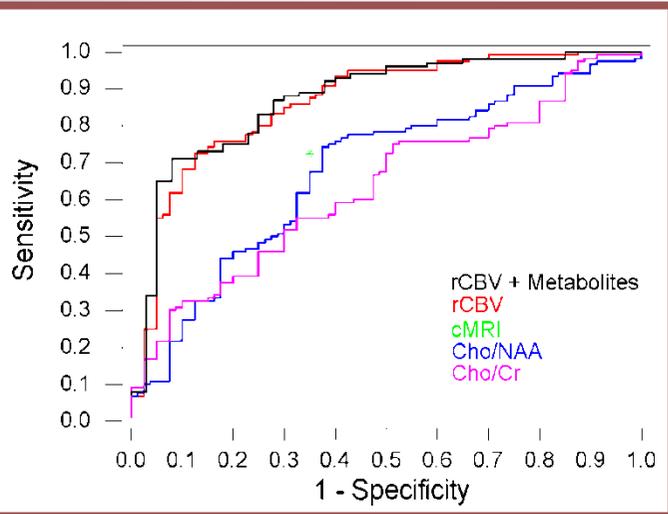


➤ **CONFRONTO TRA STUDI DI CENTRI DIVERSI**

Studio RM funzionale – PWI DSC



Studio RM funzionale – PWI DSC: grado di malignità

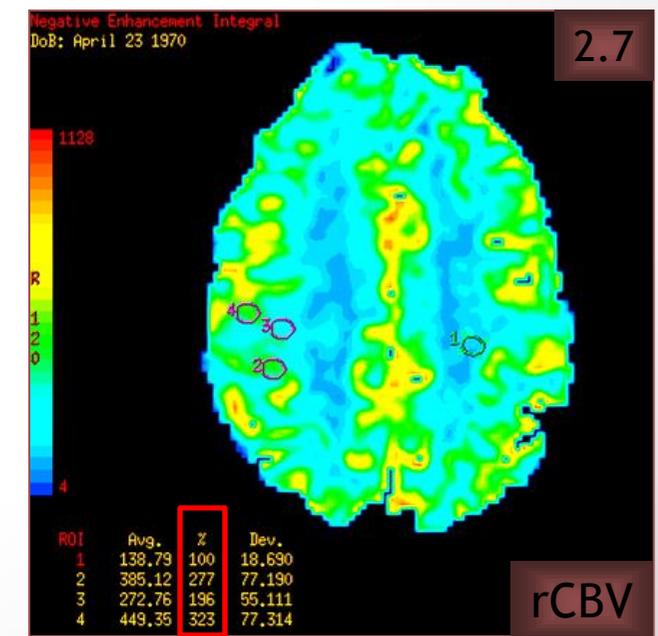
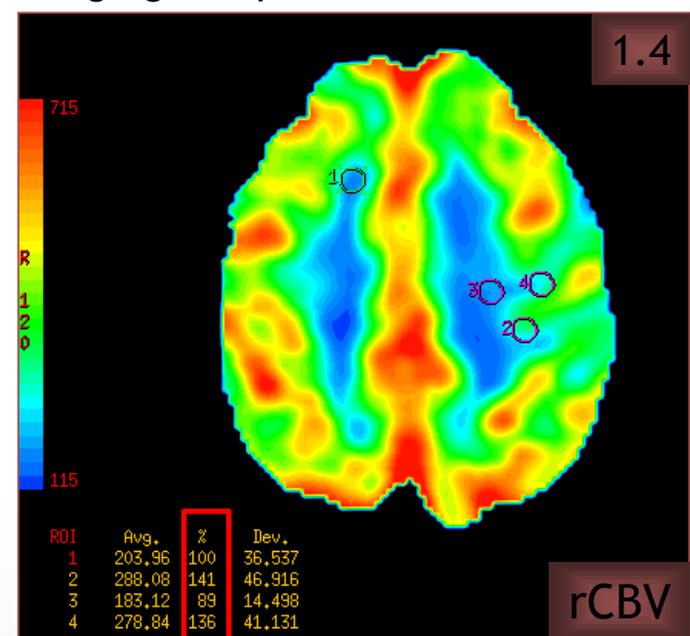
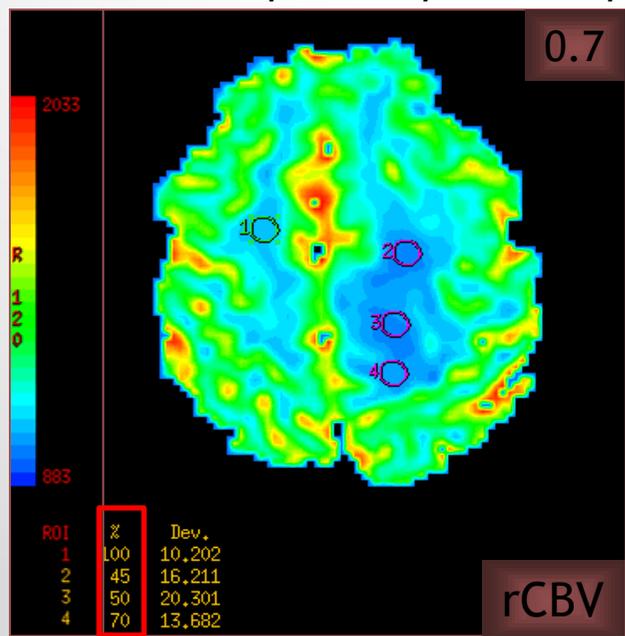


rCBV 1.75

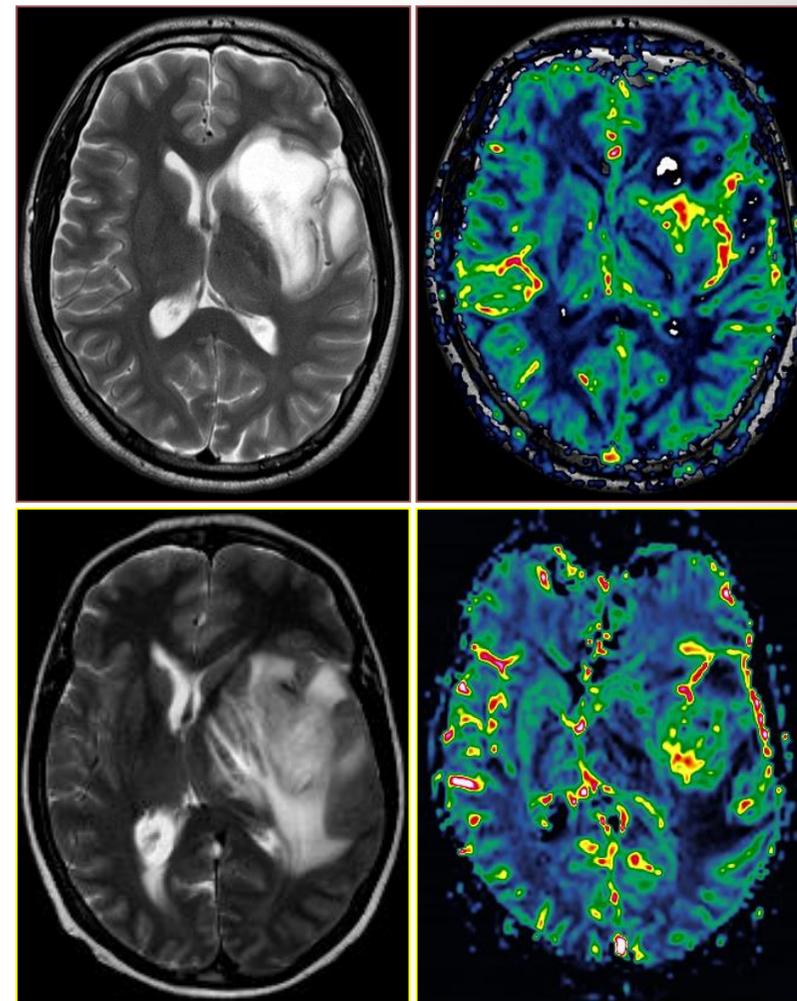
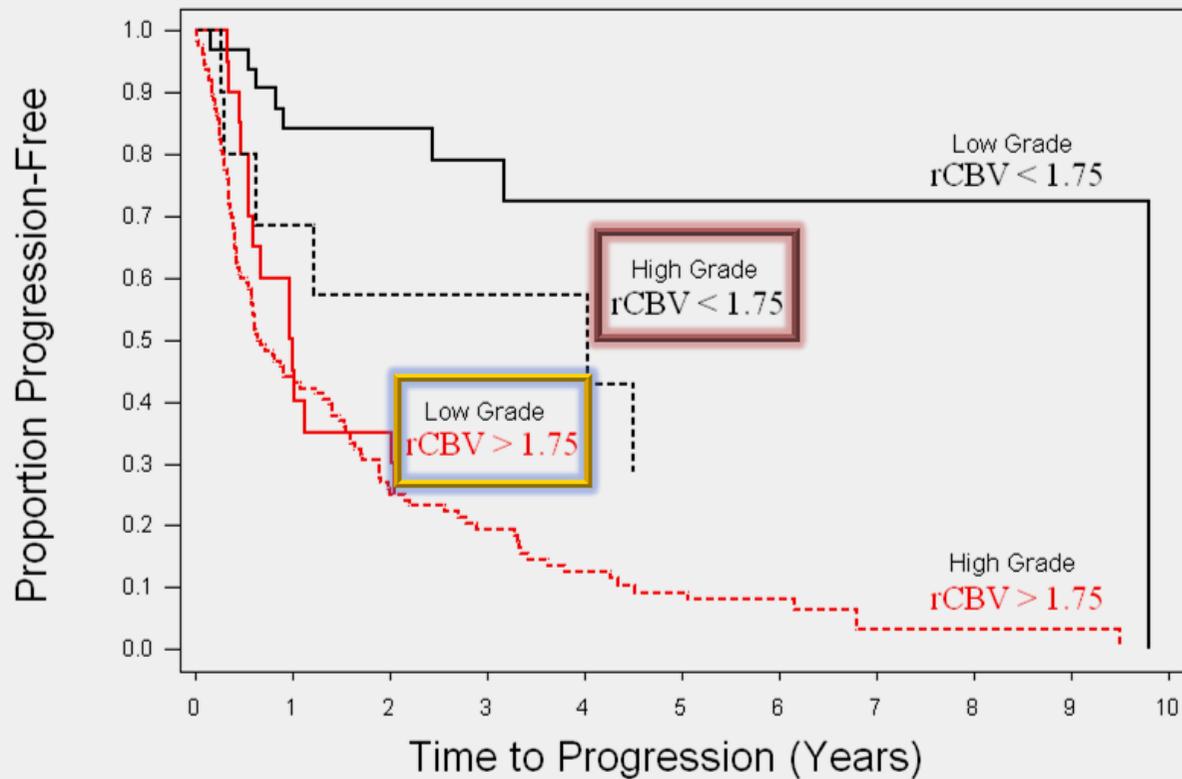
- ✓ Sensibilità 95.0%
- ✓ Specificità 57.5%
- ✓ PPV 87.0%
- ✓ NPV 79.3%

“ ... rCBV better than Cho/NAA and Cho/Cr ... ”

Law M, et Al: Glioma grading: sensitivity, specificity, and predictive value of perfusion MRI and proton spectroscopy imaging compared with conventional MRI. **AJNR** 24: 1989-1998, 2003



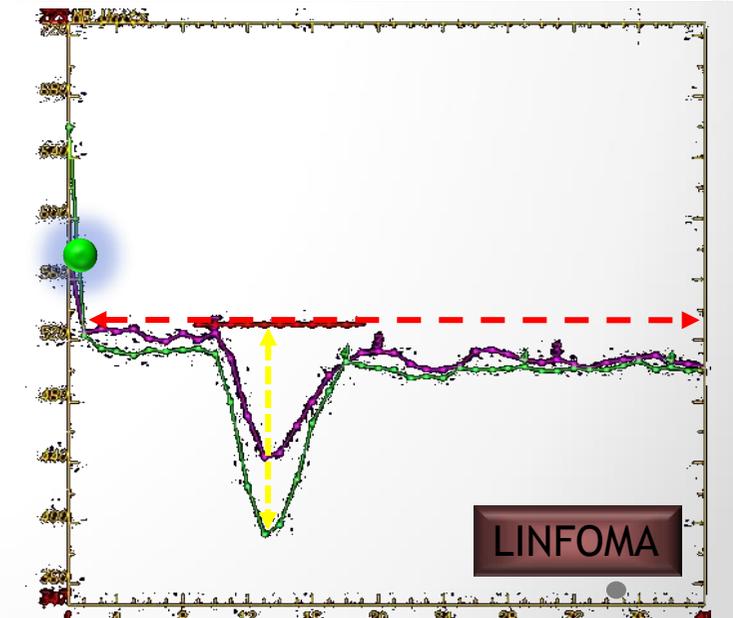
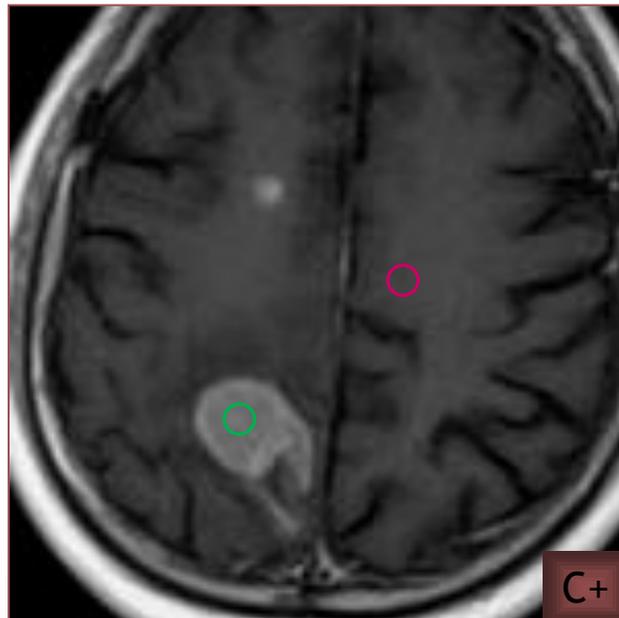
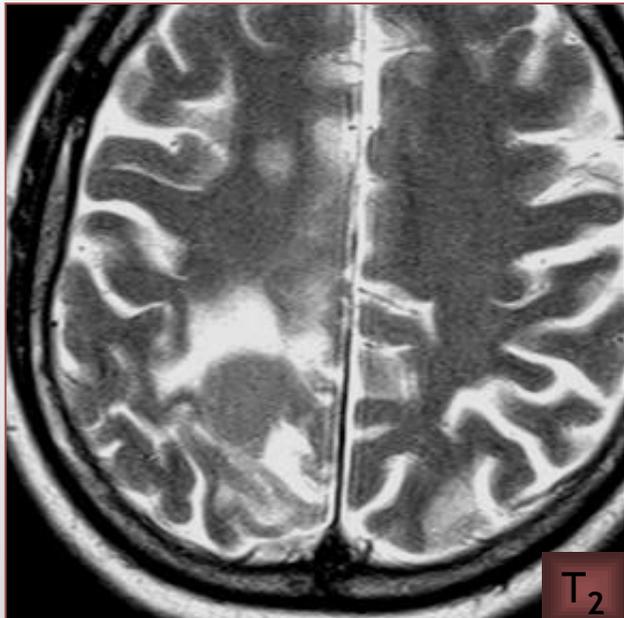
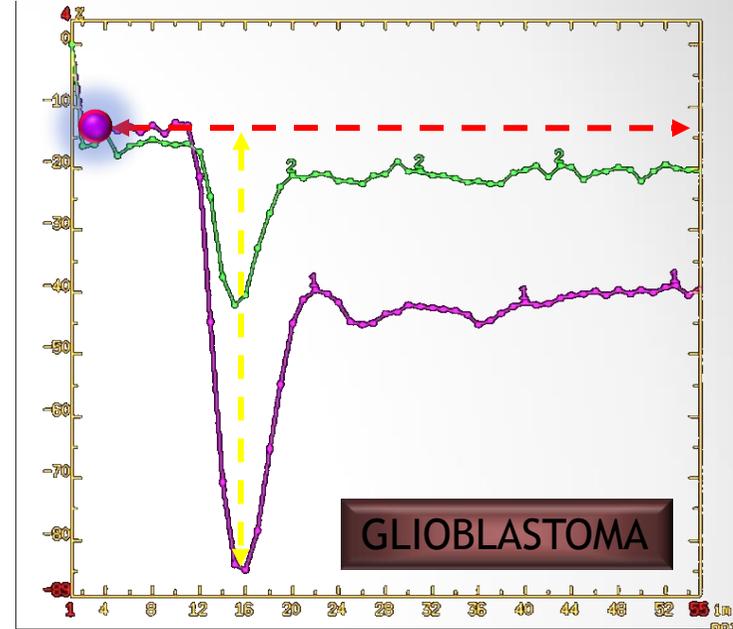
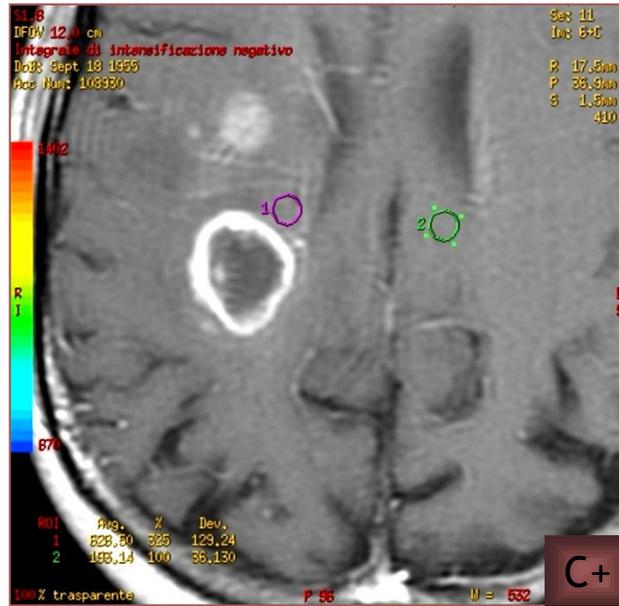
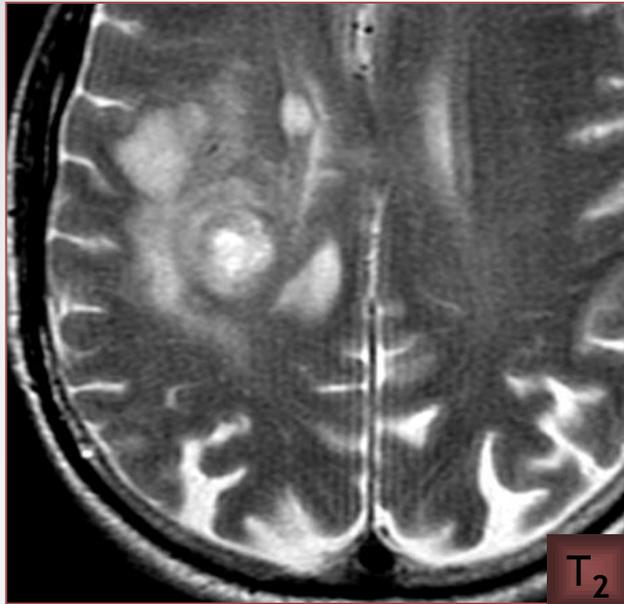
Studio RM funzionale – PWI DSC: grado di malignità



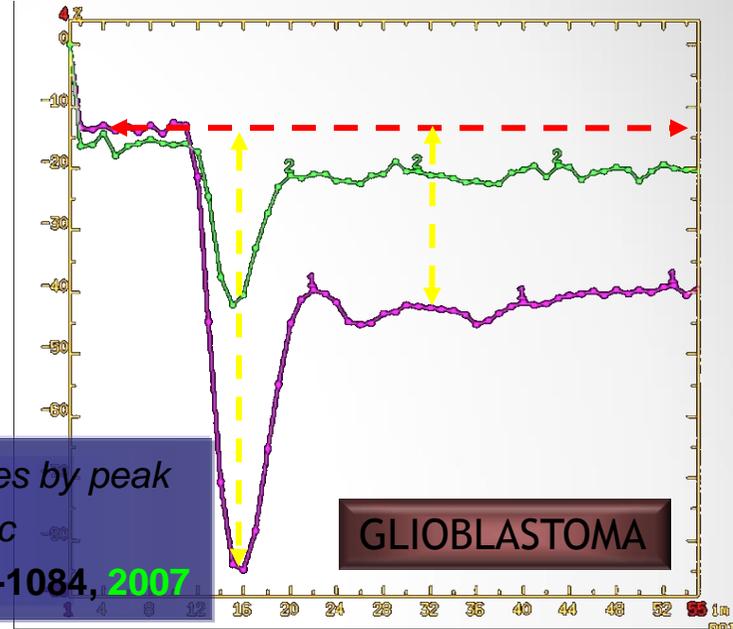
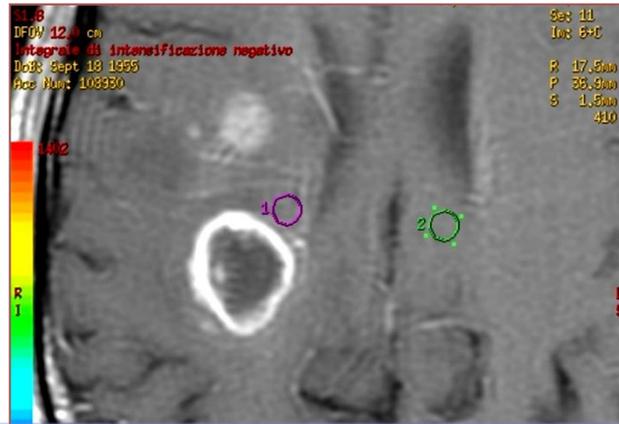
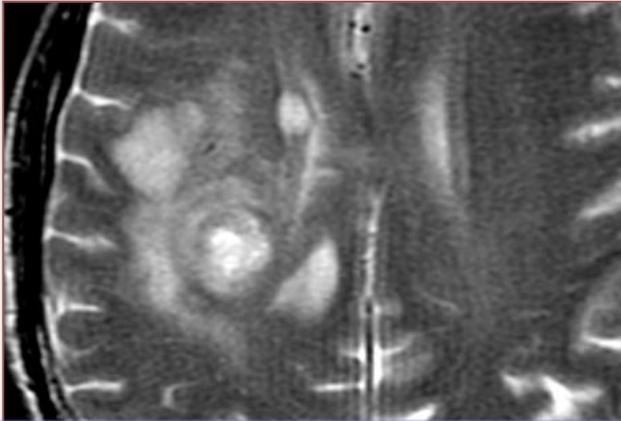
LGG con basso CBV hanno la prognosi migliore
LGG con alto CBV hanno scarsa sopravvivenza
HGG con basso CBV hanno migliore sopravvivenza dei LGG
HGG with alto CBV hanno la sopravvivenza minore

Law M, et Al: *Gliomas: predicting time to progression or survival with cerebral blood volume measurements at dynamic susceptibility-weighted contrast-enhanced perfusion MR imaging*. *Radiology* 247: 490-498, 2008

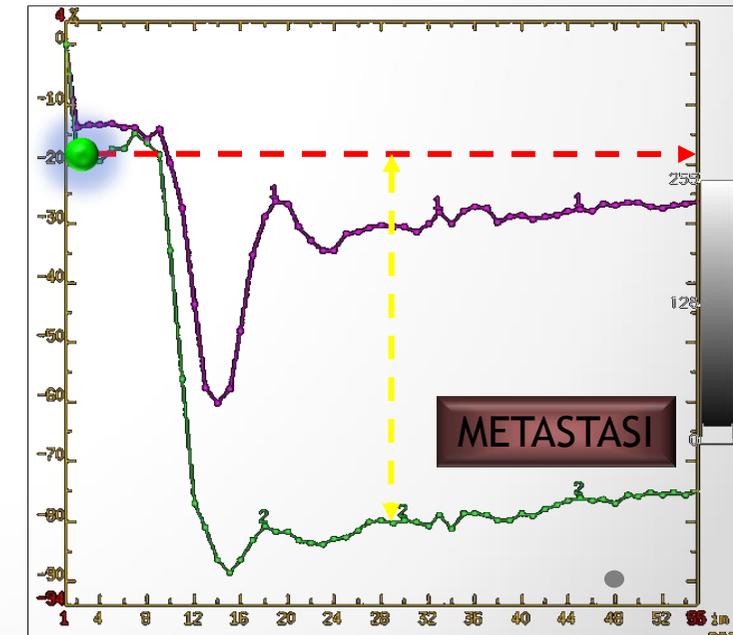
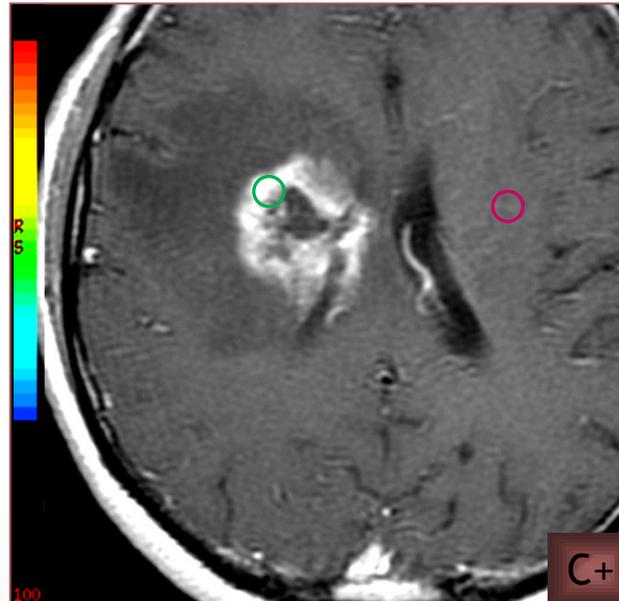
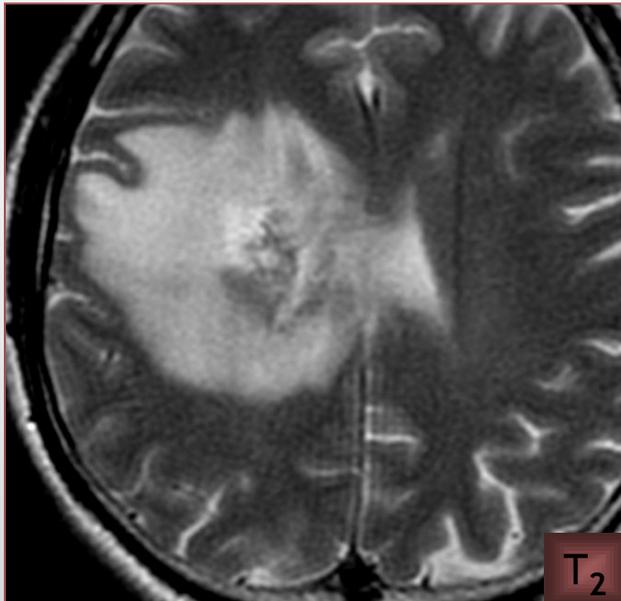
Studio RM funzionale – PWI DSC: diagnosi differenziale



Studio RM funzionale – PWI DSC: diagnosi differenziale



Cha S et al: Differentiation of glioblastoma multiforme and single brain metastases by peak height and percentage of signal intensity recovery derived from dynamic susceptibility-weighted contrast-enhanced perfusion MR imaging. **AJNR 28: 1078-1084, 2007**



MRI

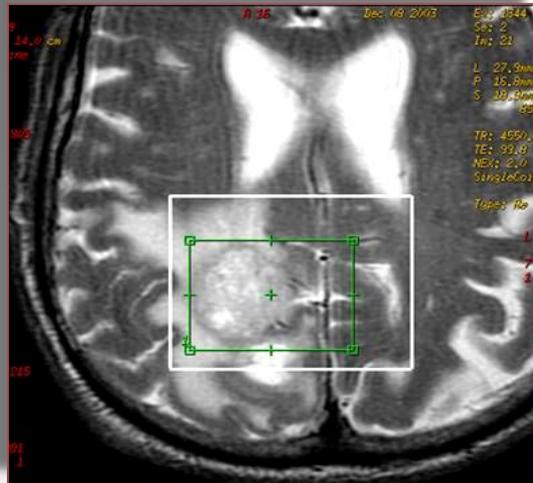
- Analizza il segnale dei protoni (H+) dell'H₂O
 - Ottengo una IMMAGINE

MRS (spettroscopia)

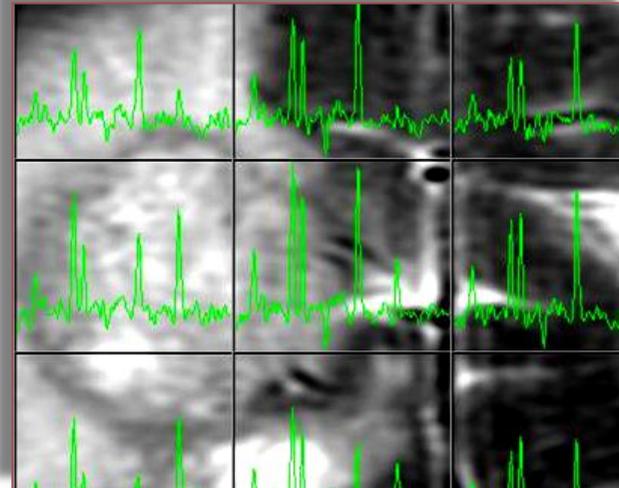
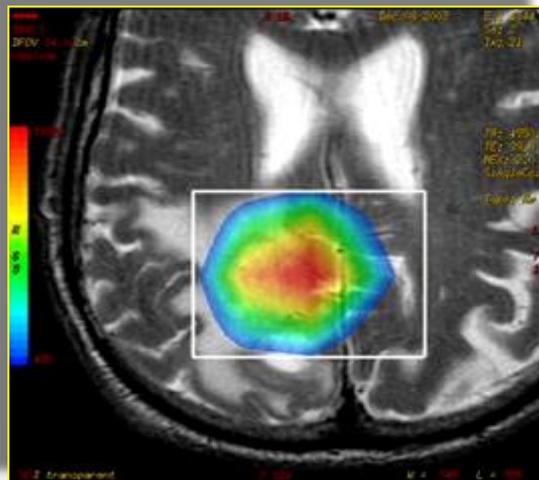
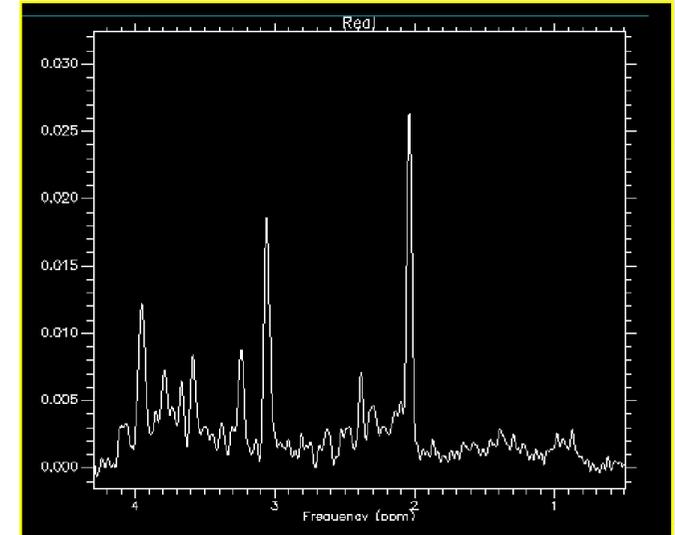
- Analizza il segnale di un determinato nucleo di soluti disciolti nei tessuti, definiti **metaboliti**
 - Ottengo uno SPETTRO

Studio RM funzionale – Spettroscopia

studio dei processi metabolici di tessuti ed organi “in vivo”



NAA marker neuronale
Cho marker di membrana
Cr valore controllo
Lac glicolisi anaerobia
mI marker gliale
Lip indice di necrosi

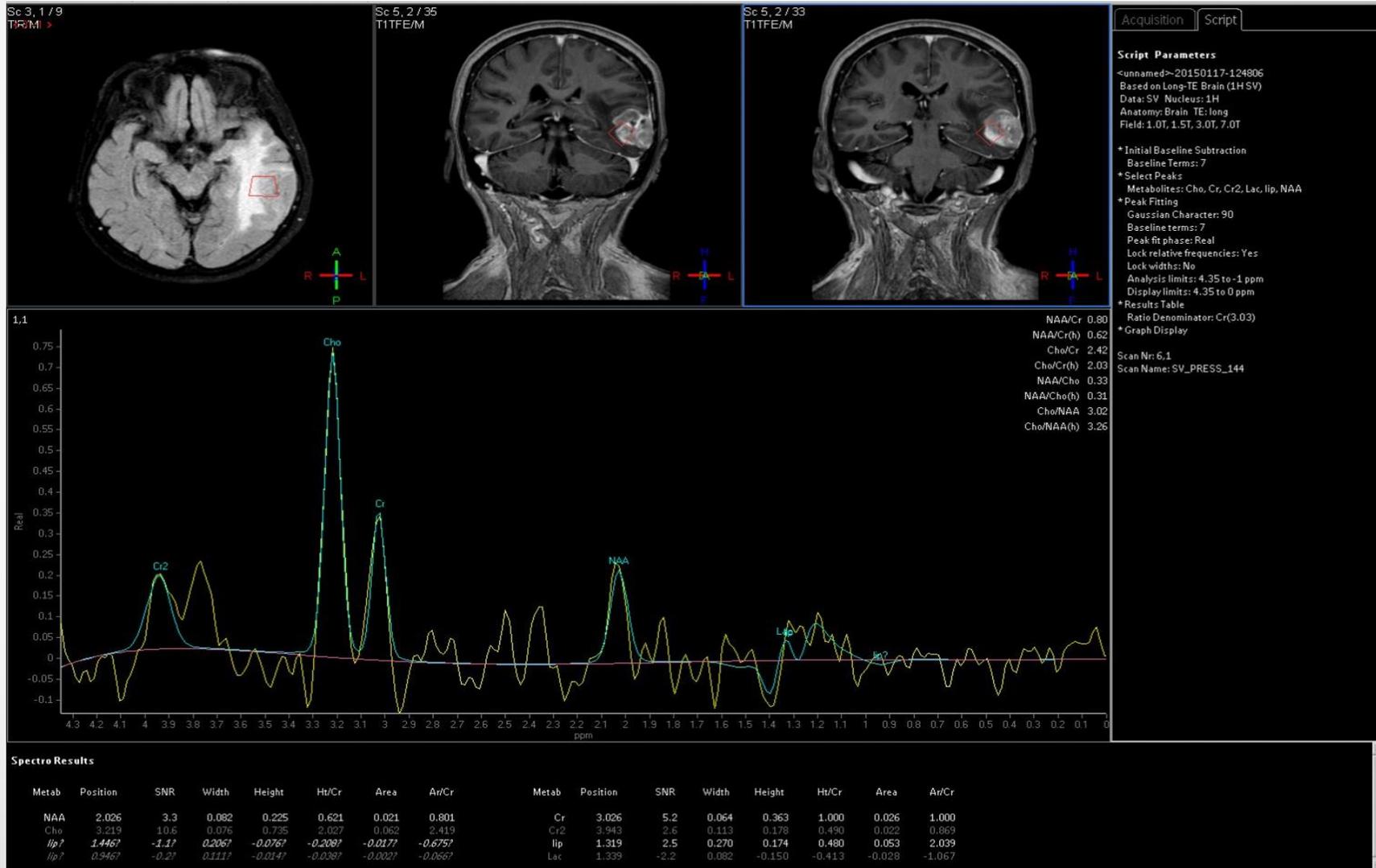


SINGLE VOXEL

MULTI VOXEL

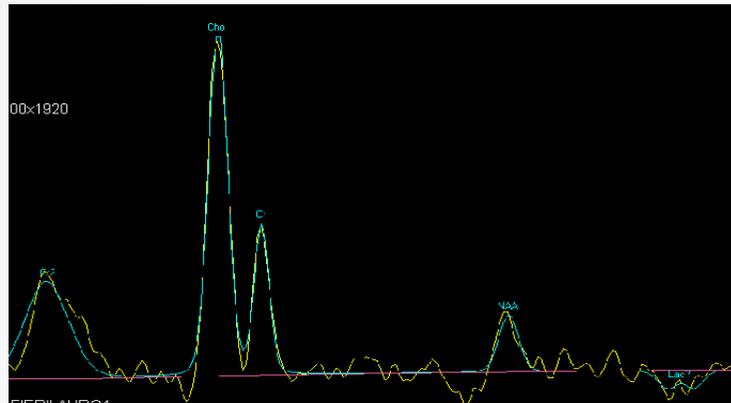
Studio RM funzionale – Spettroscopia Single Voxel (SV)

Ottiene uno spettro da un volume di interesse specifico

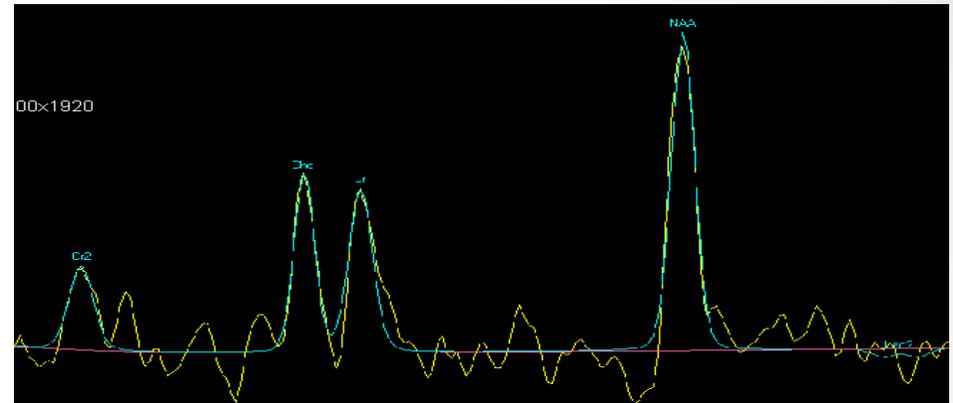


Studio RM funzionale – Spettroscopia

Acquisizione di voxel su regione malata e su area priva di alterazione (controlaterale)



Tessuto patologico



Tessuto sano

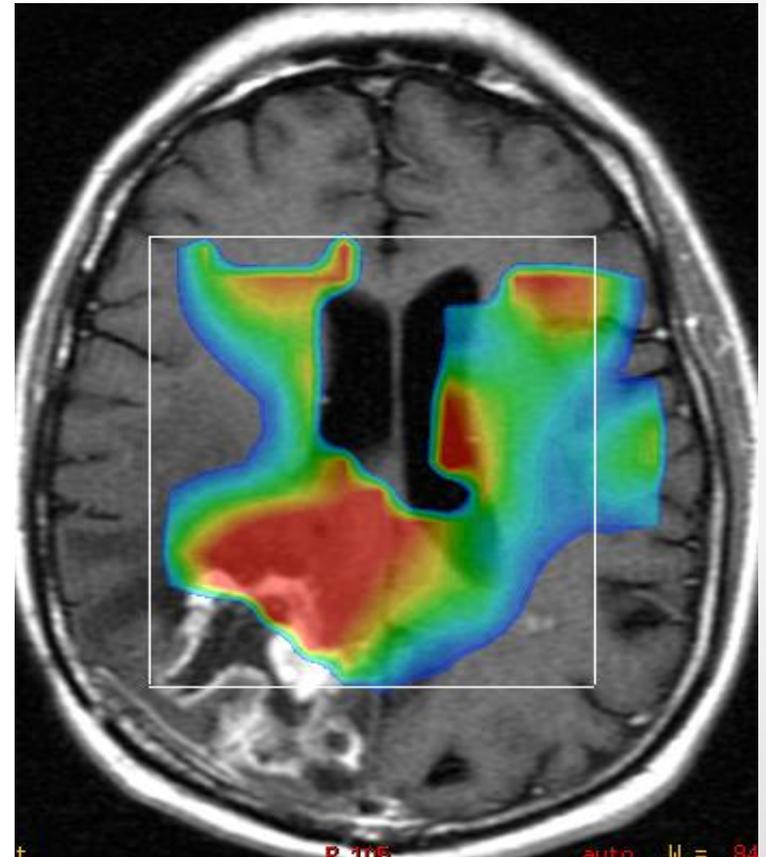
In campo oncologico la spettroscopia con Risonanza Magnetica permette di:

- ❖ diagnosi differenziale
- ❖ Indirizzo diagnostico / monitoraggio della terapia

Studio RM funzionale – Spettroscopia Multi-Voxel (MV)

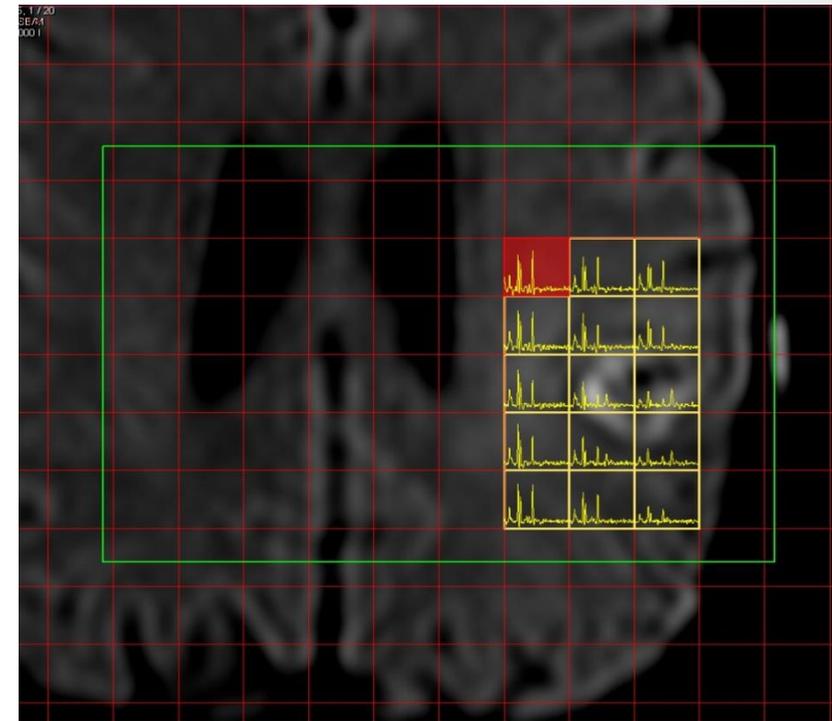
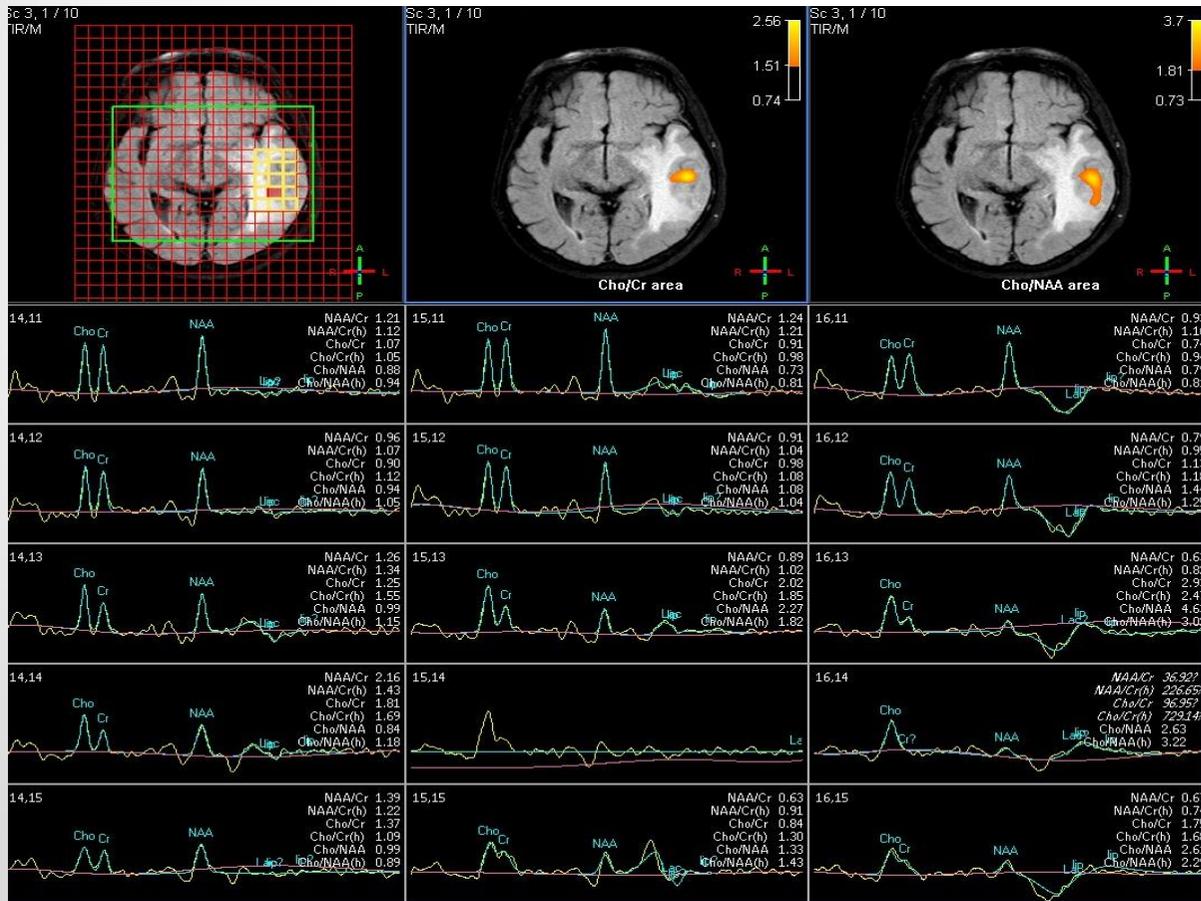
- Si definisce un volume di interesse (su uno o più strati) e si fa una misura spettroscopica del volume suddividendolo in un certo numero di voxel
- L'acquisizione può essere 2D (spettroscopia su singolo strato) o 3D (spettroscopia su un volume)

Mappe in scala di colore in relazione alla concentrazione dei metaboliti/rapporti



Studio RM funzionale – Spettroscopia Multi-Voxel (MV)

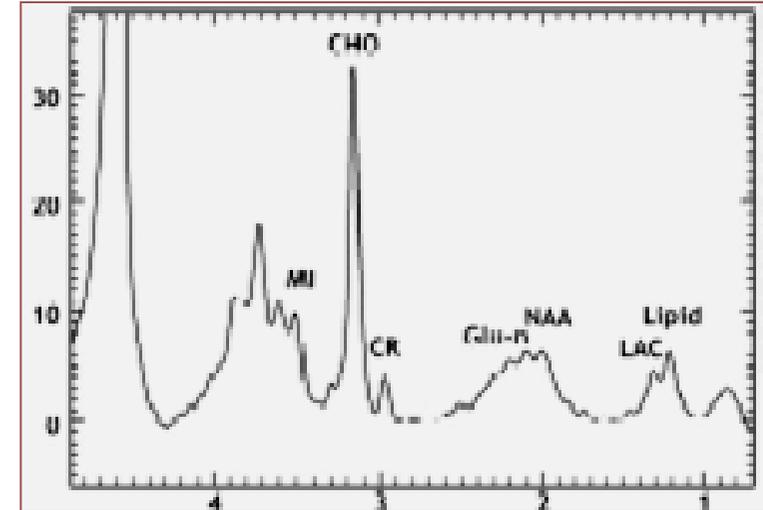
informazione spettroscopica
+
localizzazione più precisa dei metaboliti



Studio RM funzionale – Spettroscopia: diagnosi differenziale

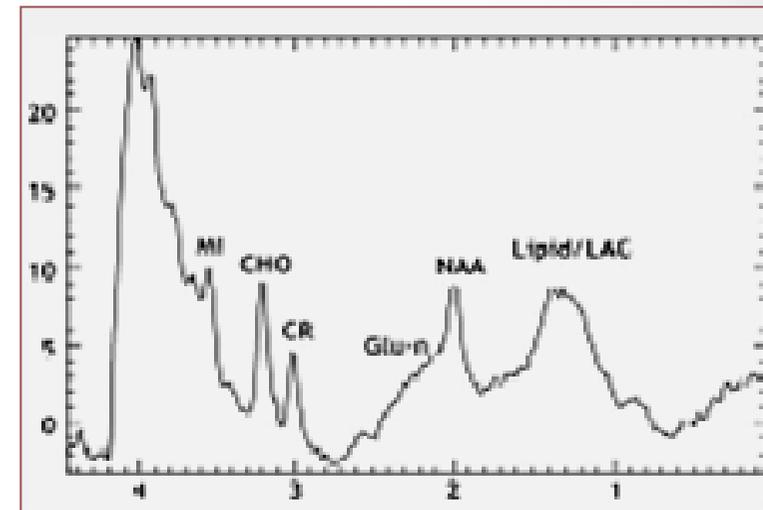
GLIOBLASTOMA

- ✓ elevati livelli colina (tumorale e peritumorale)
- ✓ elevato rapporto colina/creatina
- ✓ elevati livelli mioinositolo (tumorale)



METASTASI

- ✓ lieve incremento colina (solo area tumorale)
- ✓ elevati livelli di lattato e lipidi (tumorale)

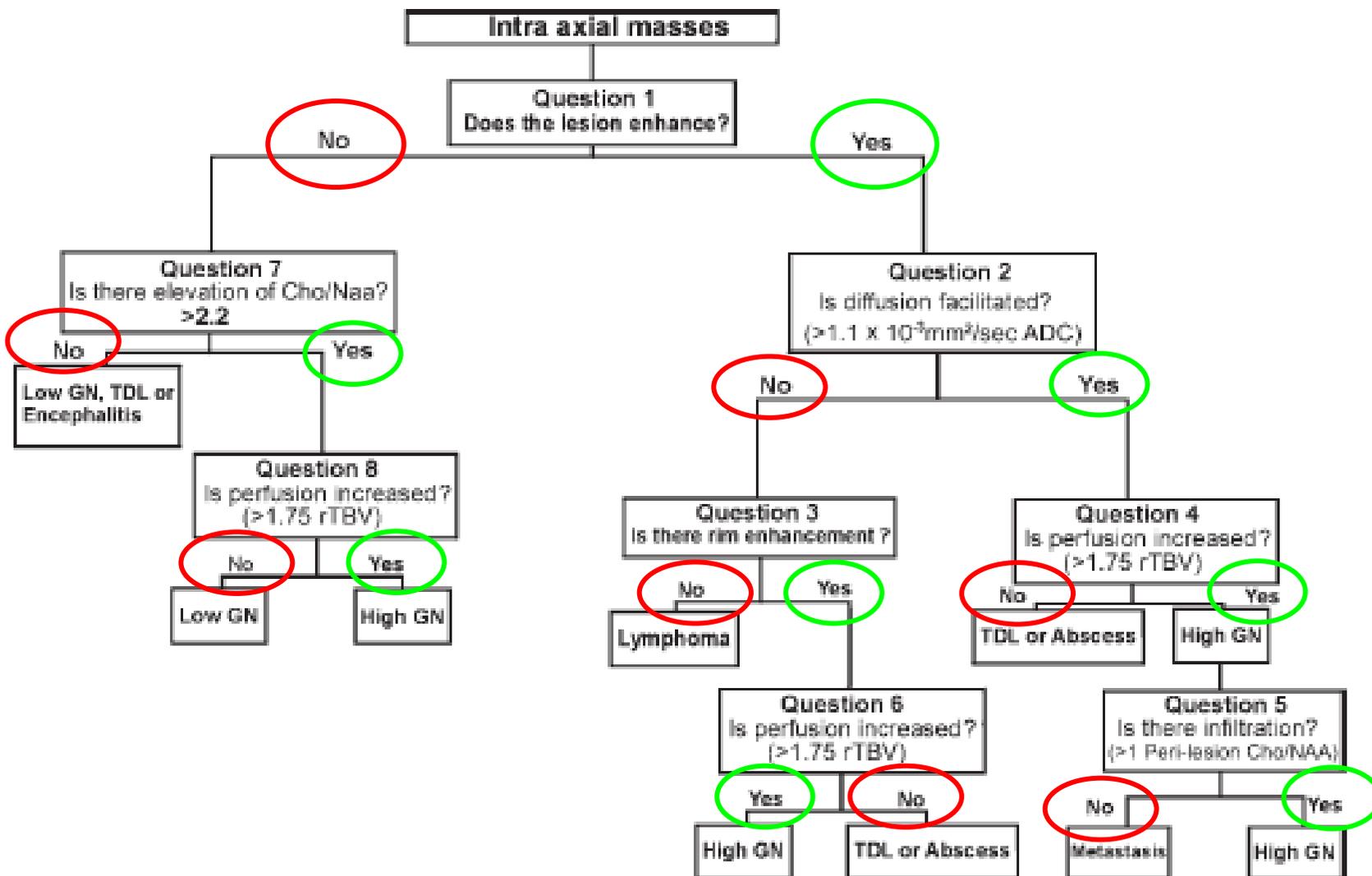


Advanced MR Imaging Techniques in the Diagnosis of Intraaxial Brain Tumors in Adults¹

Al-Okaili et al

RadioGraphics 2006; 26:S173-S189

Studio RM multiparametrico

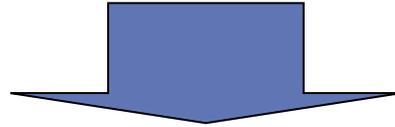


Diffusion Tensor Imaging

DTI

...

- **Tecnica:** acquisizione DWI in multipli direzioni non collineari



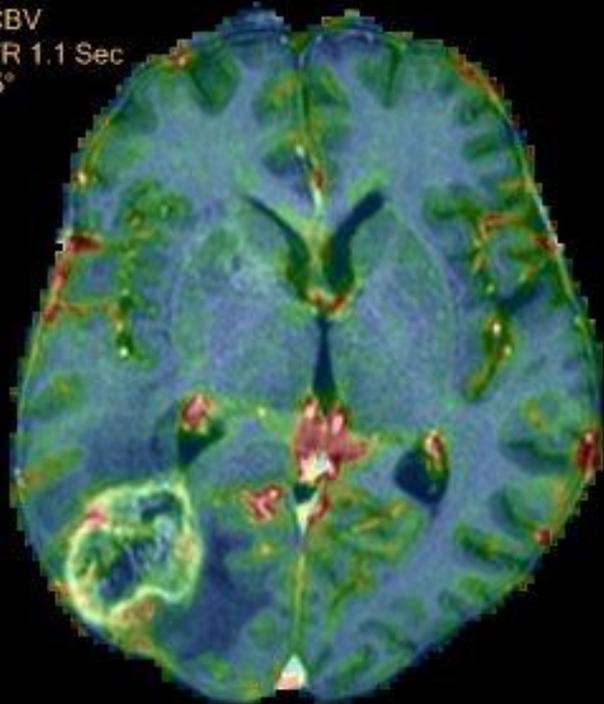
Modello matematico (“tensore”) 3D del profilo di diffusione

- **Applicazione clinica** : Caratterizzazione architetturale non invasiva fasci sostanza bianca - Anisotropia Frazionaria (FA)
- Terminologia:
- Deviazione - Infiltrazione – interruzione – Degenerazione - Separazione

5 Oct, 2015 / 14:18:42.71
nrelCBVAIFRegrCBV/T1 Gd
Series 905 - Slice 6
Pos:3552.5 mm
/GR
FEEPI/RELCBV
TE 40ms - TR 1.1 Sec
Flip Angle 75°

A.S.M.N.REGGIO E-1.5 T
Philips Medical Systems, Achieva
FOV 224.0 mm
Zoom 1.00

R



PHILIPS

P

10 cm

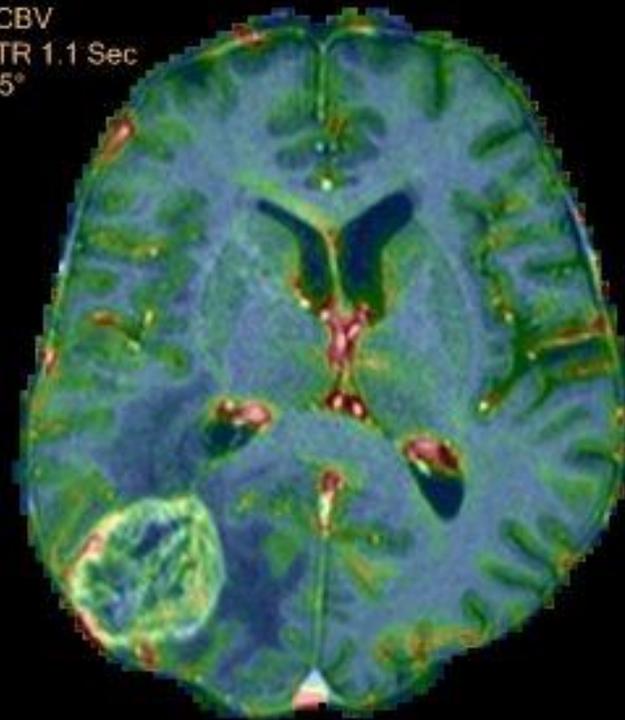
R

PHILIPS

P

5 Oct, 2015 / 14:18:42.71
nrelCBVAIFRegrCBV/T1 Gd
Series 905 - Slice 7
Pos:3546.5 mm
/GR
FEEPI/RELCBV
TE 40ms - TR 1.1 Sec
Flip Angle 75°

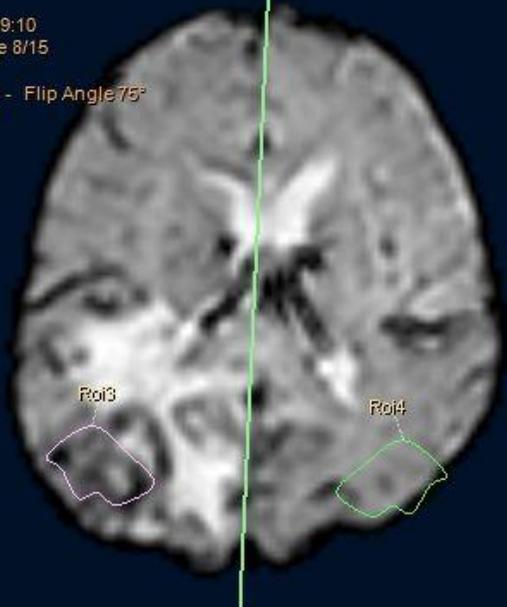
A.S.M.N.REGGIO E-1.5 T
Philips Medical Systems, Achieva
FOV 224.0 mm
Zoom 1.00



10 cm

236355
 3/8/1942 F
 05-Oct-2015 / 14:19:10
 Scan Nr. 9, 1 - Slice 8/15
 FEEPI/M
 TE 40ms - TR 1.1s - Flip Angle 75°

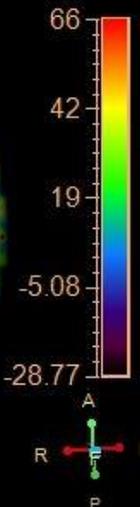
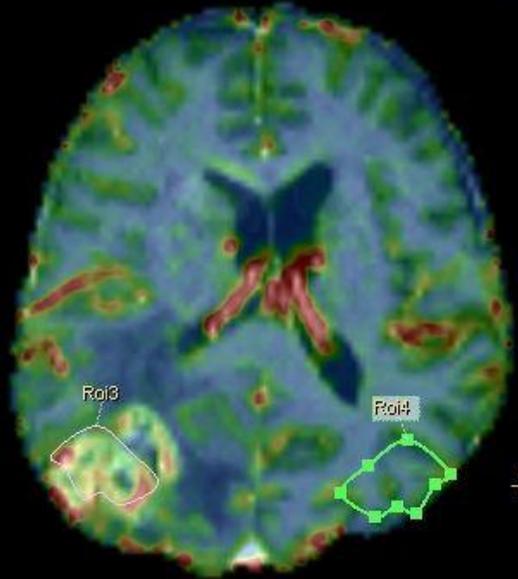
t



Dt 27.5s
 L 929
 W 1615

relCBV [ml/100g]

Slice Thk 5.0 / 1.0
 FOV 224 mm
 Zoom 114%



L 19
 W 95

Table Viewer

Anatomical Viewer

	Pixel Location
Patient frame (mm):	-0.3 , 72.1 , 30.3
Image frame:	104 , 63

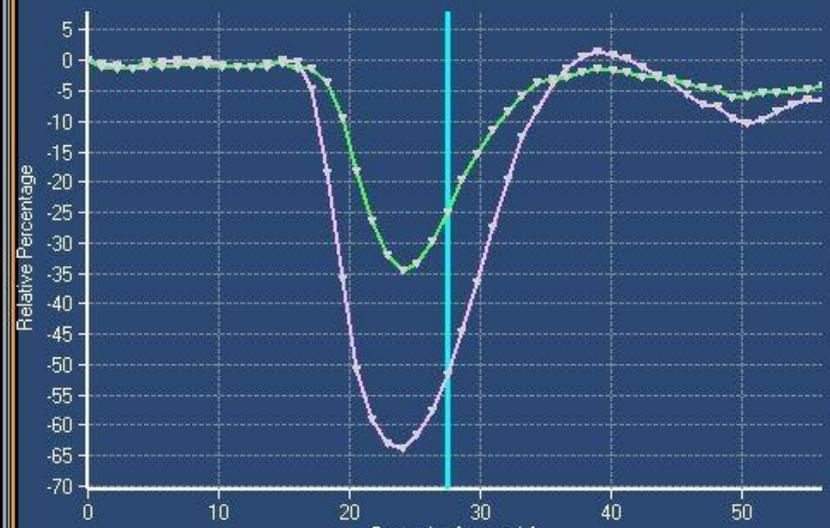
	Roi1	Roi2	Roi3	Roi4
relCBF (ml/100g/min):	332.02	131.55	312.11	133.37
relCBV (ml/100g):	35.91	12.08	30.57	12.34
MTT(s):	6.49	5.51	5.88	5.55
TTP (s):	24.03	25.17	24.03	24.03
T0 (s) :	18.31	19.45	17.16	18.31
Delay(s) :	2.29	3.43	2.29	2.29
Roi Area (mm²) :	346.96	346.96	375.89	375.88

	Roi1 / Roi2	Roi3 / Roi4
relCBF Ratio (%):	252.39	234.03
relCBV Ratio (%):	297.27	247.62

Graph Viewer

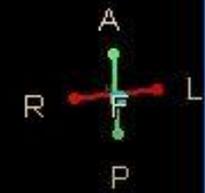
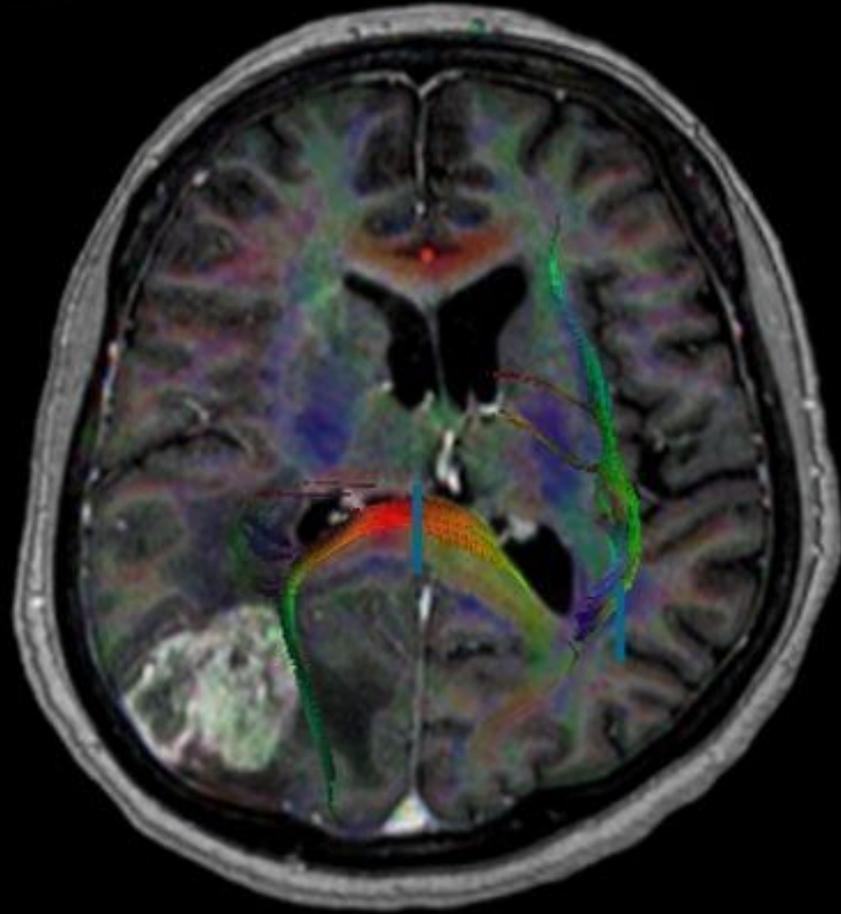
Anatomical Viewer

- Dynamic Reference Line [27.5]
- Roi1
- Roi3
- AIF
- Roi2
- Roi4



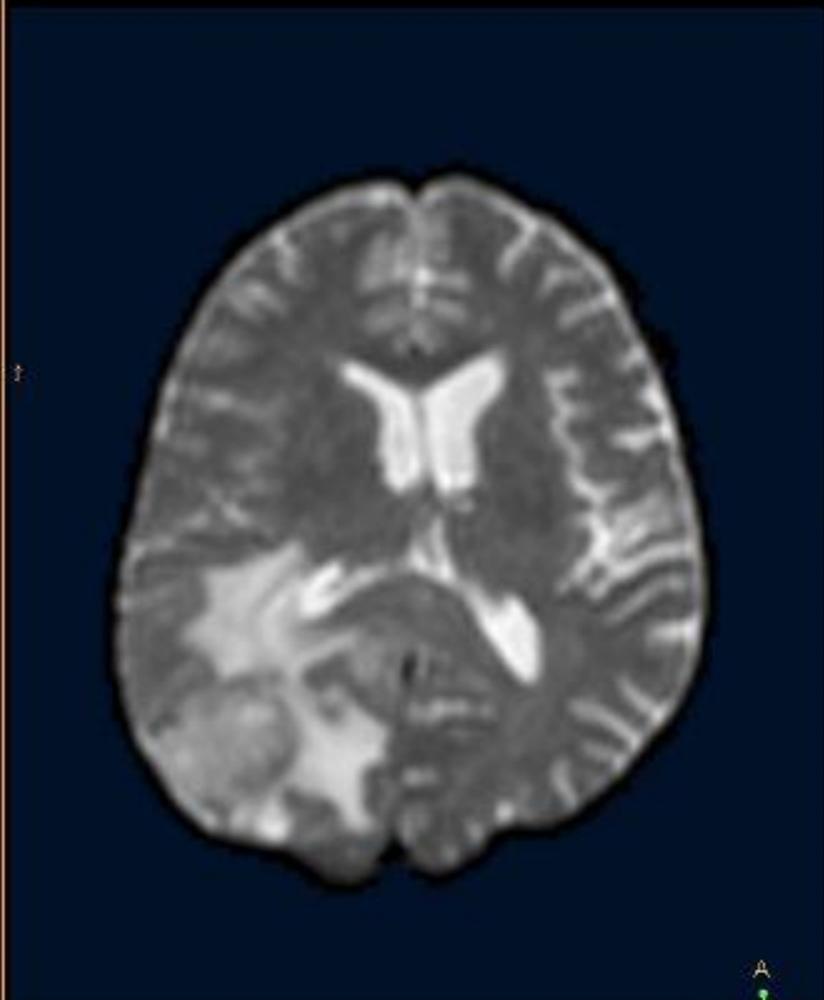
3/8/1942 F
05-Oct-2015 14:19:52
MR1: Scan Nr. 10, 1
MR2: Scan Nr. 8, 1
MR1: T1TFEM
MR2: DwiSE/FAD
MR1: TE 3ms - TR 7ms
MR1: Flip Angle 8°
Threshold B0 : 32

MR1: FOV 224 mm
MR2: FOV 224 mm
Zoom 114%



3001942 F
05-Oct-2015 / 14:11:35
Scan No. 6, 1 - Slice 17/30
DWI SEM
TE 75ms - TR 4.3s - Flip Angle 90°
b 01

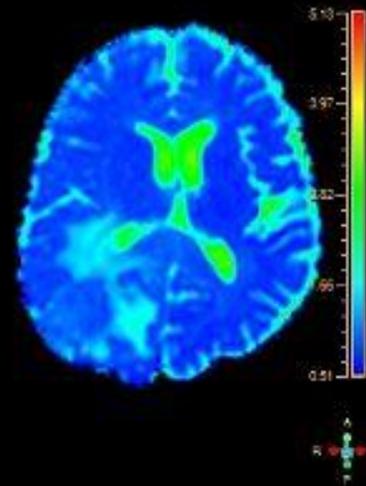
FOV 224 mm
Zoom 123%



L 1126
W 1957

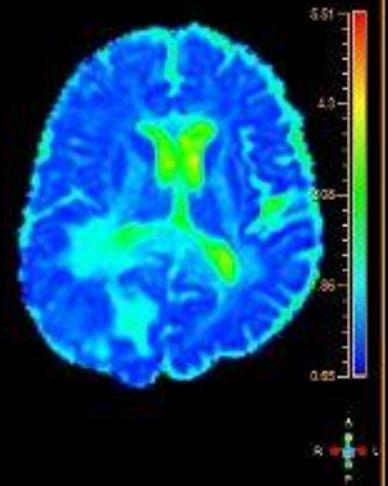


L 9 P3 H30



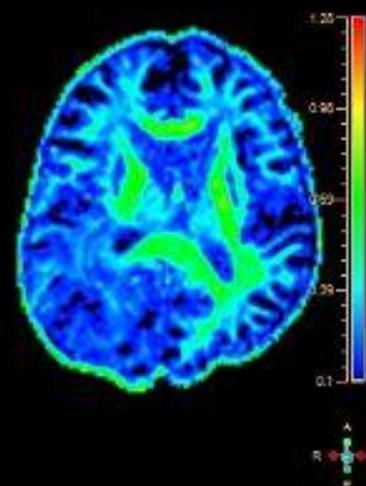
L 2.8
W 4.8

FA

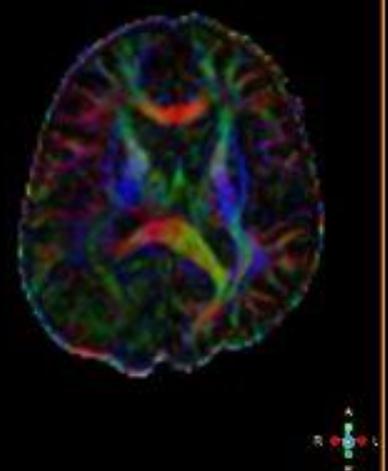


L 3.1
W 4.9

FA direction



L 0.88
W 1.2



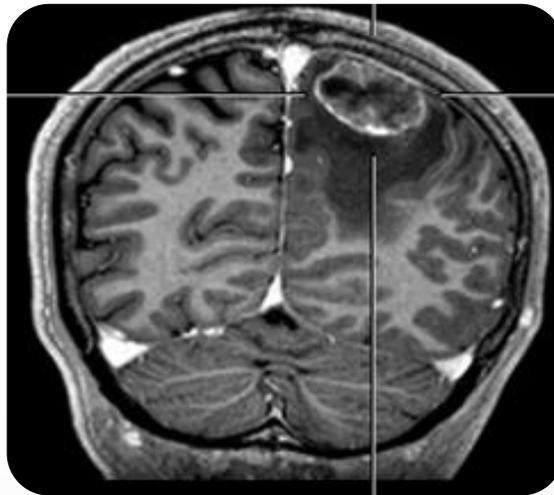
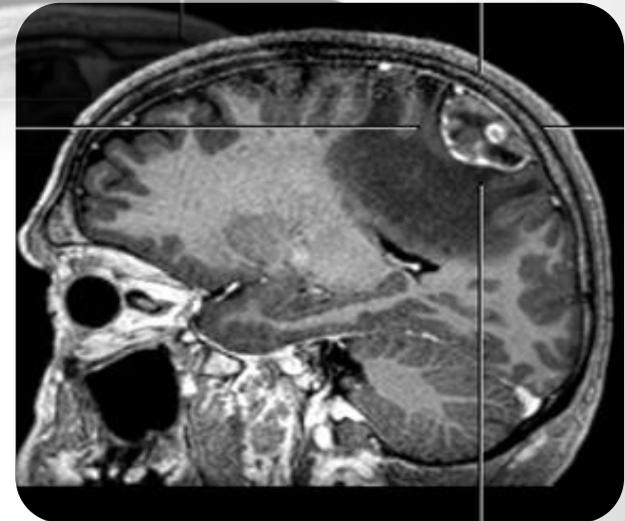
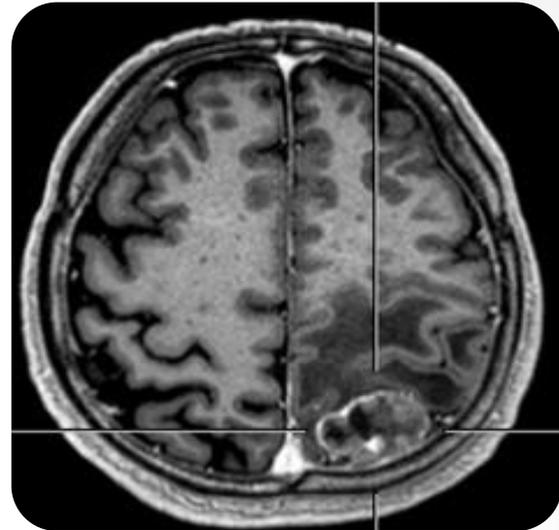
L'esame pre-operatorio:
La Neuronavigazione ed la
scelta del Target della Biopsia
Stereotassica

...

Neuronavigazione: protocollo RM (Philips Achieva 1.5 T)

T 1

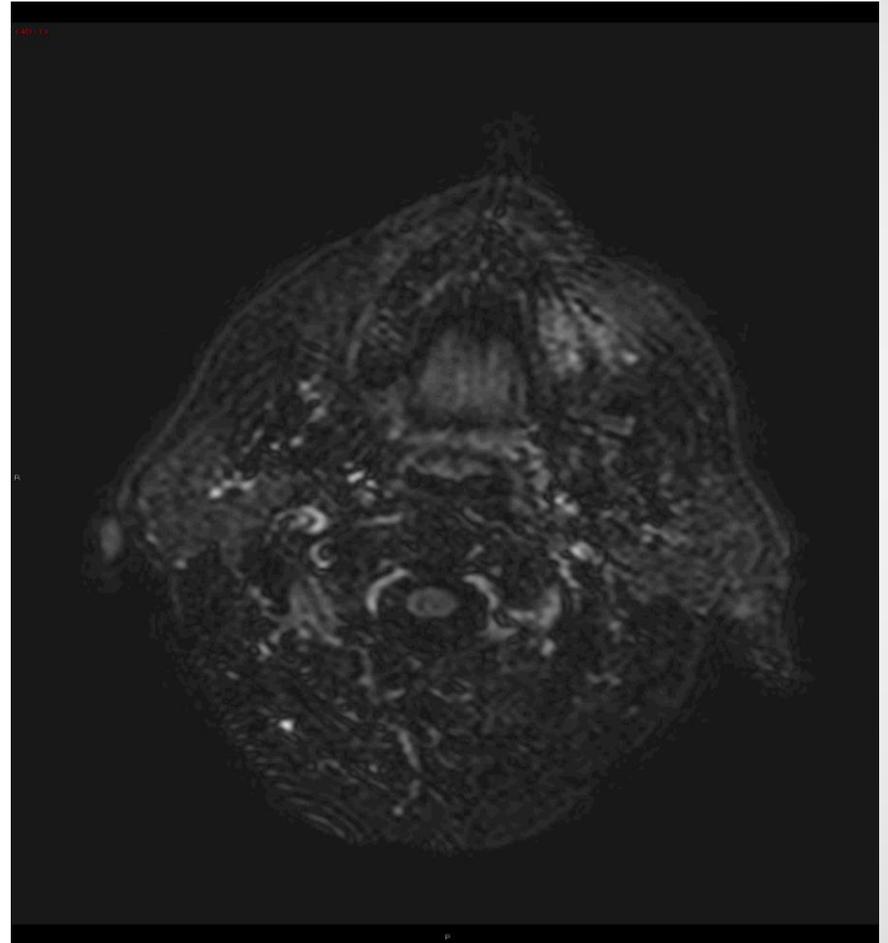
- 3 D – FFE – piano assiale
- FOV: 256 x 256
- TR: 7,2
- TE: 3,2
- FA: 8
- Voxel acquisizione: 0,9 x 1,1 x 0,9
- Voxel ricostruzione: 0,67 x 0,67 x 0,9
- Matrice acquisizione: 284 x 232
- Matrice ricostruzione: 384 x 384
- NEX: 1
- TFE factor: 232
- SENSE factor: 1,4
- **180 slices**
- Durata: 9 min



Neuronavigazione: protocollo RM (Philips Achieva 1.5 T)

FLAIR

- 3D – TSE – piano assiale
- FOV: 250
- TR: 8000
- TE: 281
- FA: 60
- IR: 2400 ms
- (SPIR)
- Voxel acquisizione: 1,3 x 1,4 x 3
- Voxel ricostruzione: 0,58 x 0,58 x 1,5
- Matrice acquisizione: 192 x 177
- Matrice ricostruzione: 432 x 432
- NEX: 1
- TFE factor: 130
- SENSE factor: 1,9
- Durata: 4 min

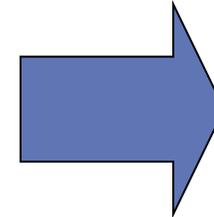


Neuronavigazione: protocollo RM (Philips Achieva 1.5 T)

DWI

- Sequenza EPI
- **Slice thickness: 3 mm**
- **Gap: 0,4 mm**
- **Voxel acquisizione: 2 x 2.5 mm**
- **Voxel ricostruzione: 0.9 x 0.9 x 3 mm**
- TR: 6500
- TE: 57
- b value: 0 / 1000
- IR: 2400 ms
- SPIR
- Matrice acquisizione: 256 x 256

- Durata: 1 min 15 sec

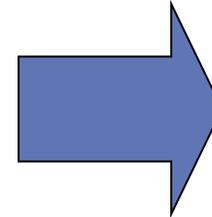


post-processing
MPR

Neuronavigazione: protocollo RM (Philips Achieva 1.5 T)

PWI

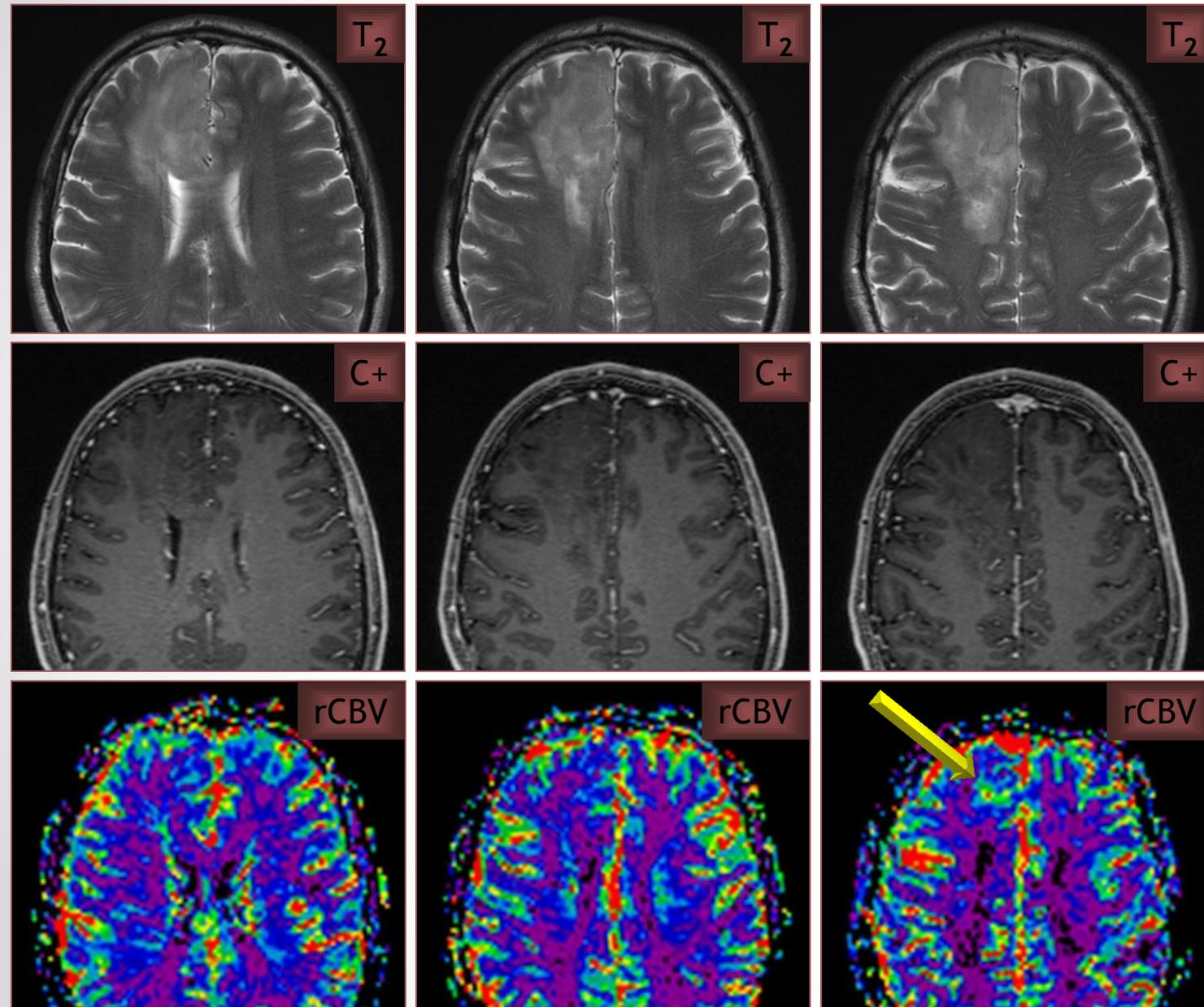
- Sequenza EPI
- **Slice thickness : 5 mm**
- **Gap : 1 mm**
- **Voxel acquisizione: 2.5 x 2,5 x 5 mm**
- **Voxel ricostruzione: 1.75 x 1.75 x 5 mm**
- TR: 1122
- TE: 40
- FA: 75
- SPIR
- Matrice acquisizione: 88 x 88
- Matrice ricostruzione: 128 x 128
- **Studio di un volume limitato**



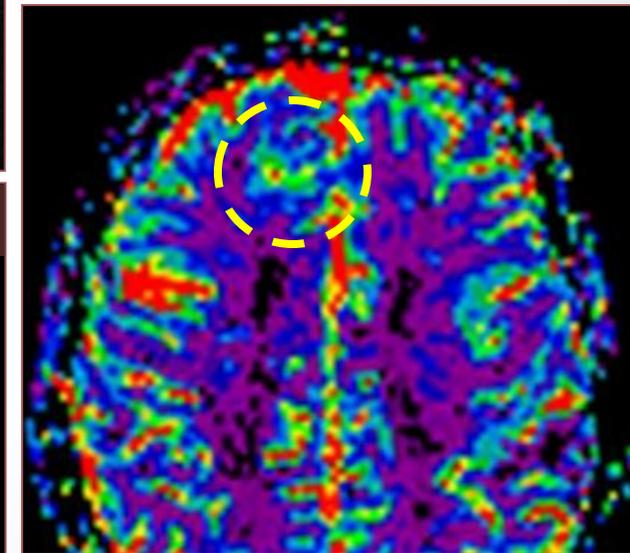
**post-
processing
MPR + fusione
T1 / FLAIR**

Durata: 1 min

Studio RM funzionale – PWI DSC: guida alla biopsia



The "HOT SPOT"



Assessment della Risposta Terapeutica

...

Approfondimento diagnostico – monitoraggio e valutazione post-terapia

Table 2: New criteria for response assessment of high-grade gliomas^a

Standardization of Imaging Definitions ←

Measurable and nonmeasurable disease for contrast-enhancing lesions

Measurable disease: 2D contrast-enhancing lesions with clearly defined margins, with 2 perpendicular diameters of at least 10 mm, visible on ≥ 2 axial sections that are preferably, at most, 5 mm apart

Nonmeasurable disease: either unidimensionally measurable lesions, masses with margins not clearly defined, or lesions with maximal perpendicular diameters < 10 mm

Multiple lesions ←

A minimum of 2 (maximum of 5) largest lesions should be measured on the basis of the sum of products of perpendicular diameters

Enhancing lesions are considered target lesions for evaluation of response

Definition of progression ←

$\geq 25\%$ increase in sum of products of perpendicular diameters of enhancing lesions compared with smallest tumor measurement at reference scan (if no decrease) or best response after initiation of therapy

Significant increase in T2/FLAIR nonenhancing lesion compared with reference scan or best response

Clear progression of nonmeasurable disease

Clear clinical deterioration

Reference MR imaging ←

Criteria for determining progression are dependent on the time from initial chemotherapy

If obtaining the reference MR image immediately postoperative, MR imaging in the first 12 weeks may represent pseudoprogression and pseudoresponse

If obtaining the reference scan after that initial 12-week period, then it reduces the likelihood of confusion with pseudoprogression

Take note of enhancement outside radiation field; it may indicate progression (Fig 6)

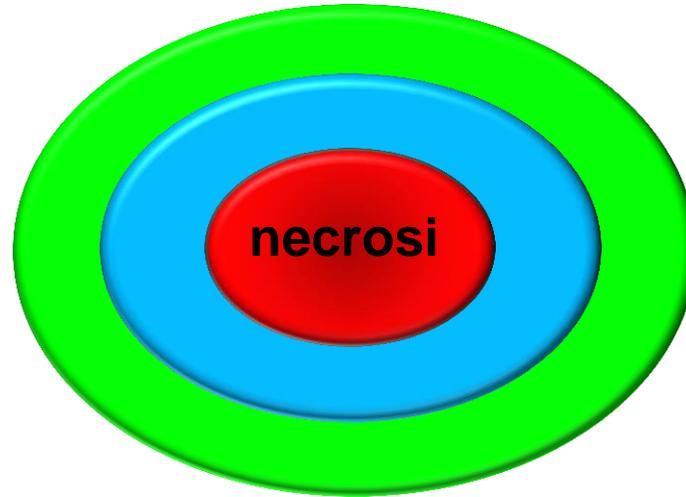
A reference MR image should ideally be obtained within 24–48 hours after surgery and no later than 72 hours after surgery, to avoid interpretation of postoperative changes as residual enhancing disease

^a Based on Wen et al 2010.⁶⁷

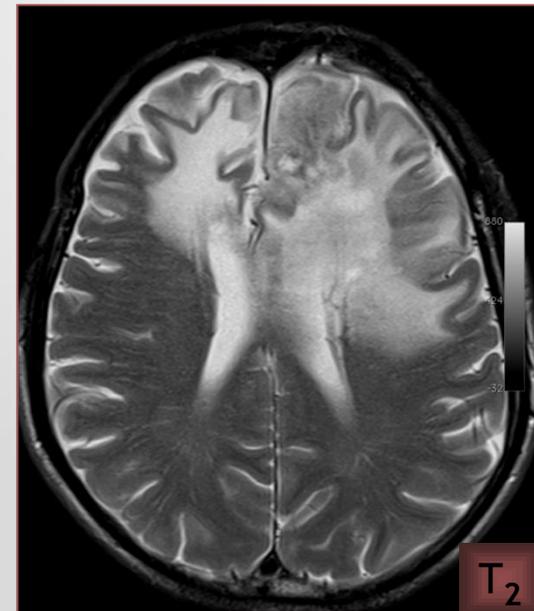
Studio RM funzionale – PWI DSC: bilancio post-terapia

RADIONECROSI

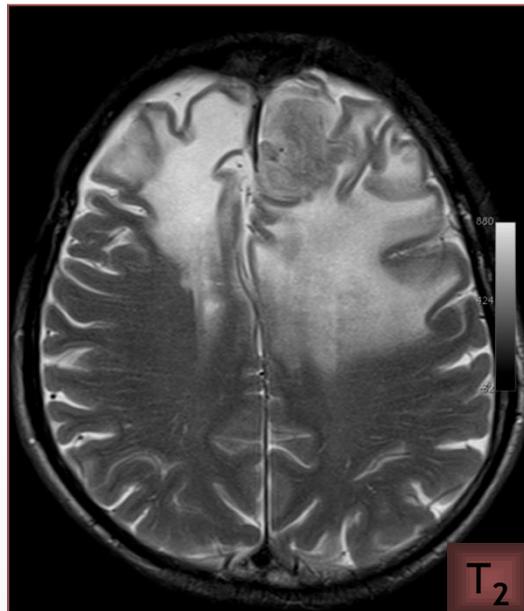
- ✓ demielinizzazione
- ✓ microcalcificazioni
- ✓ depositi emosiderina



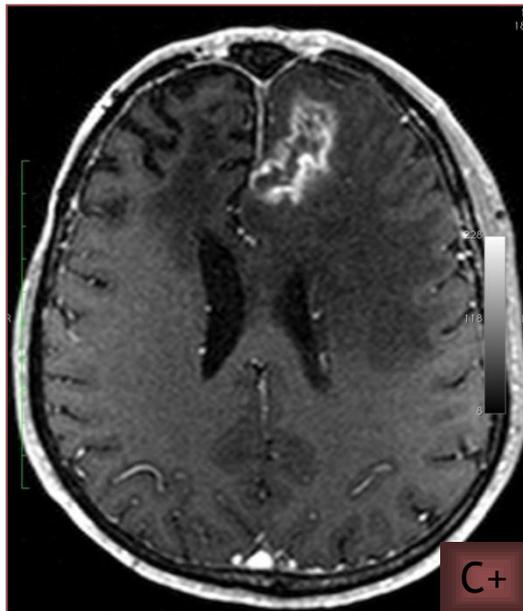
- ✓ necrosi fibrinoide arteriole
- ✓ teleangectasie
- ✓ proliferazione gliale
- ✓ infiltrati linfocitari



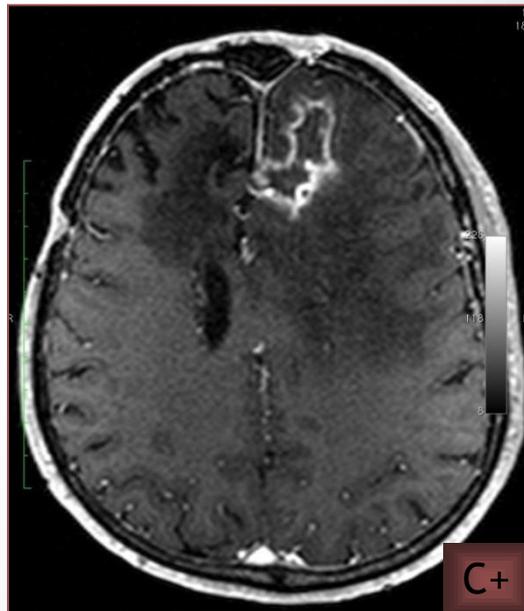
T₂



T₂



C+

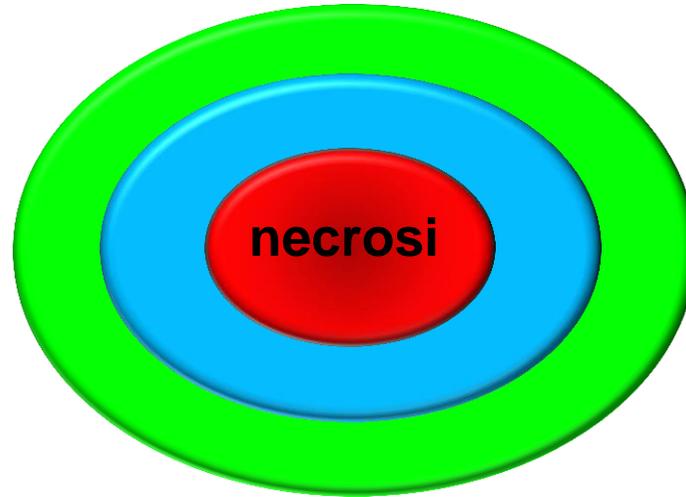


C+

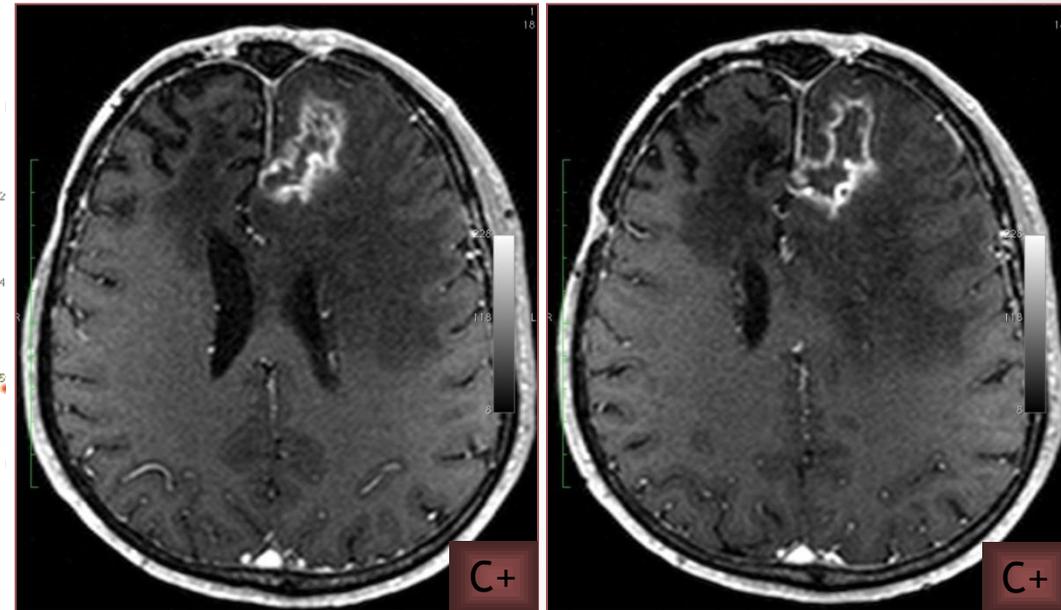
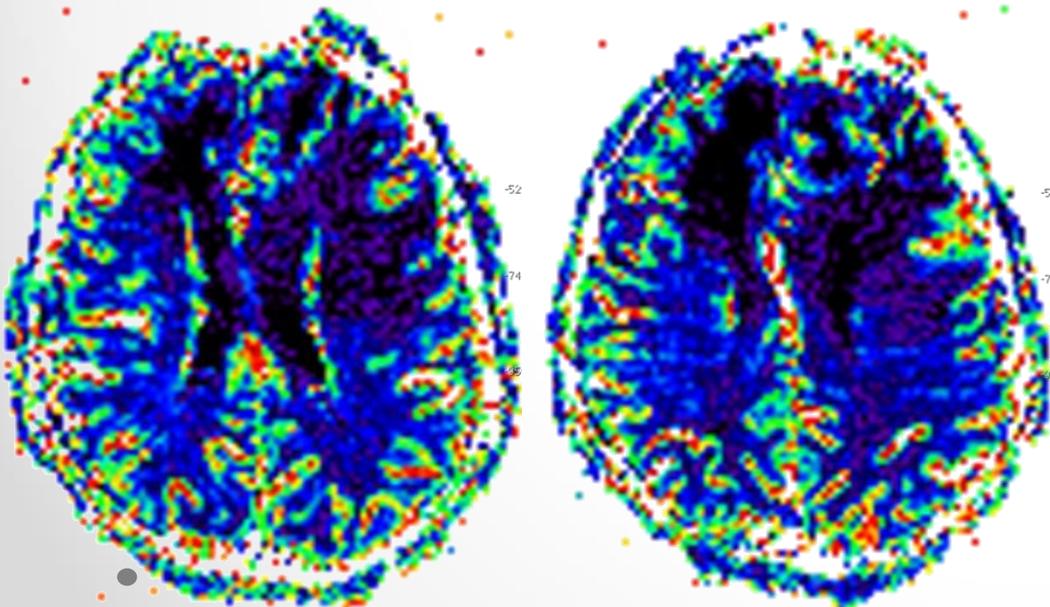
Studio RM funzionale – PWI DSC: bilancio post-terapia

RADIONECROSI

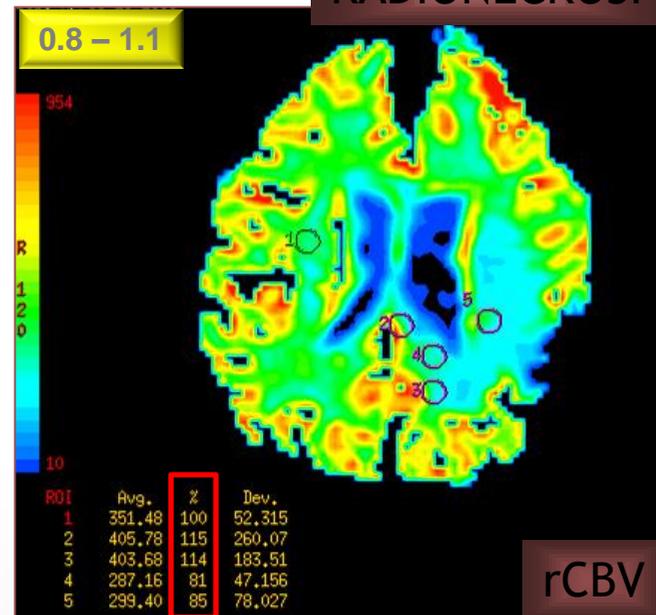
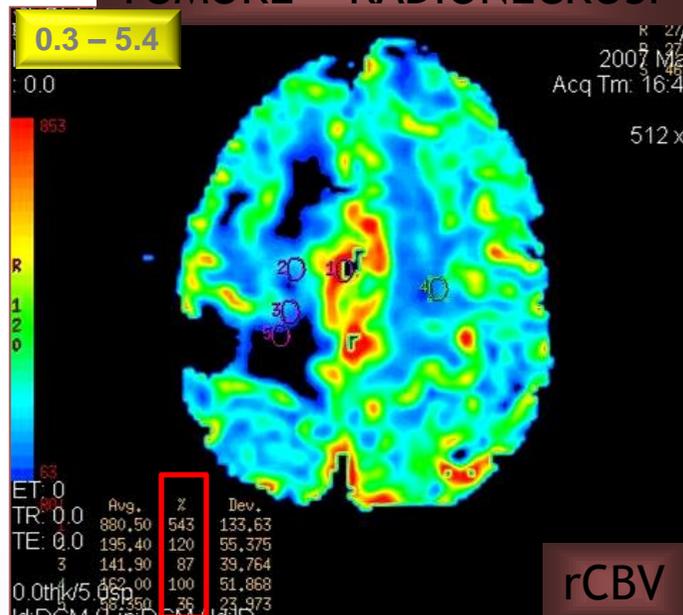
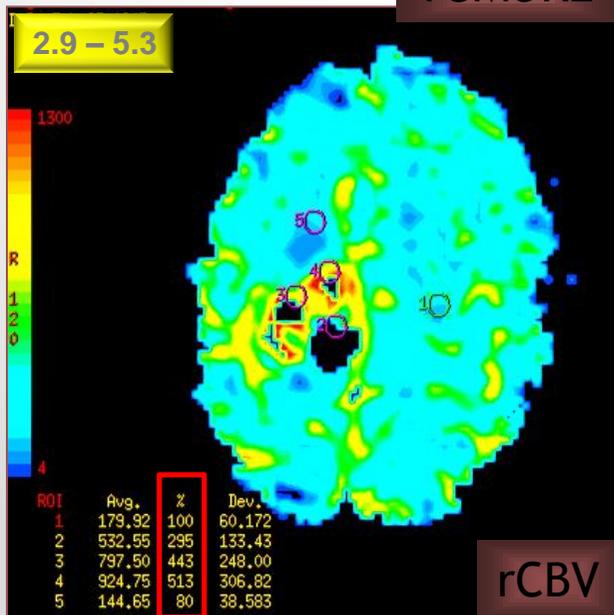
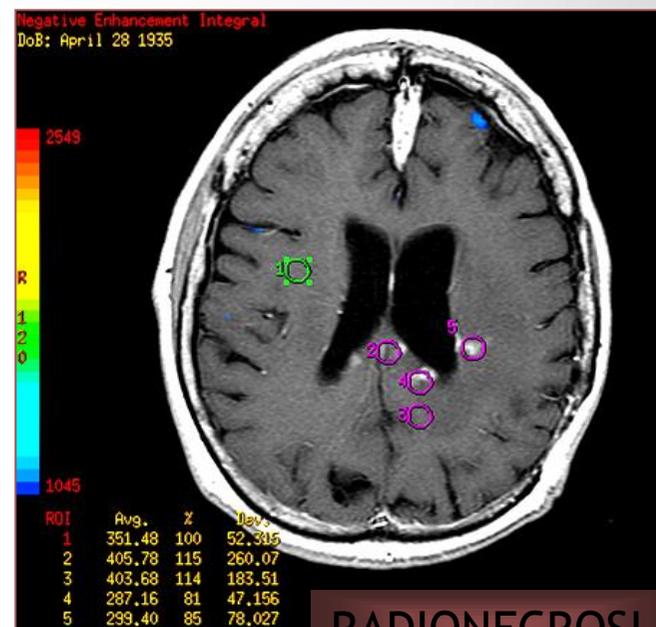
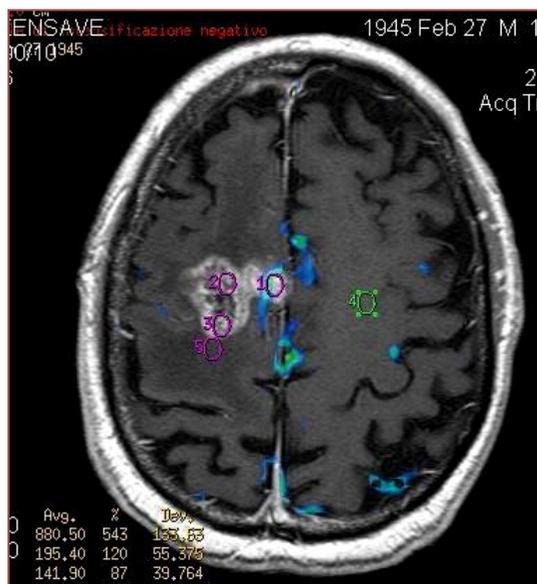
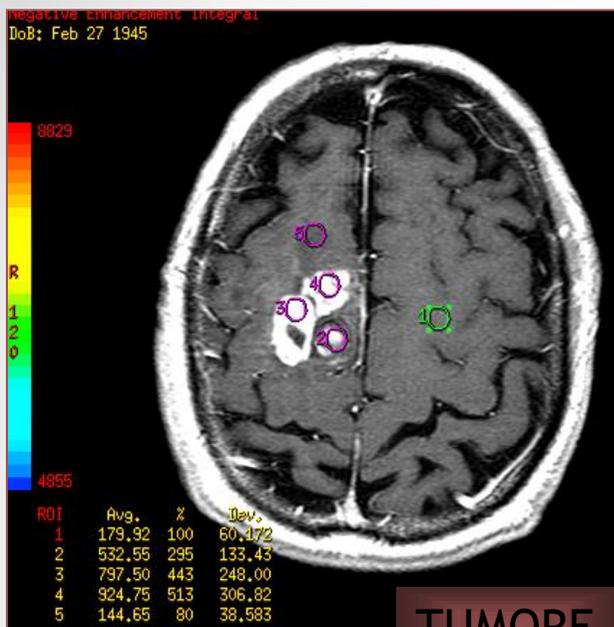
- ✓ demielinizzazione
- ✓ microcalcificazioni
- ✓ depositi emosiderina



- ✓ necrosi fibrinoide arteriole
- ✓ teleangectasie
- ✓ proliferazione gliale
- ✓ infiltrati linfocitari



Studio RM funzionale – PWI DSC: bilancio post-terapia



Studio RM funzionale – PWI DSC: bilancio post-terapia

RADIONECROSI

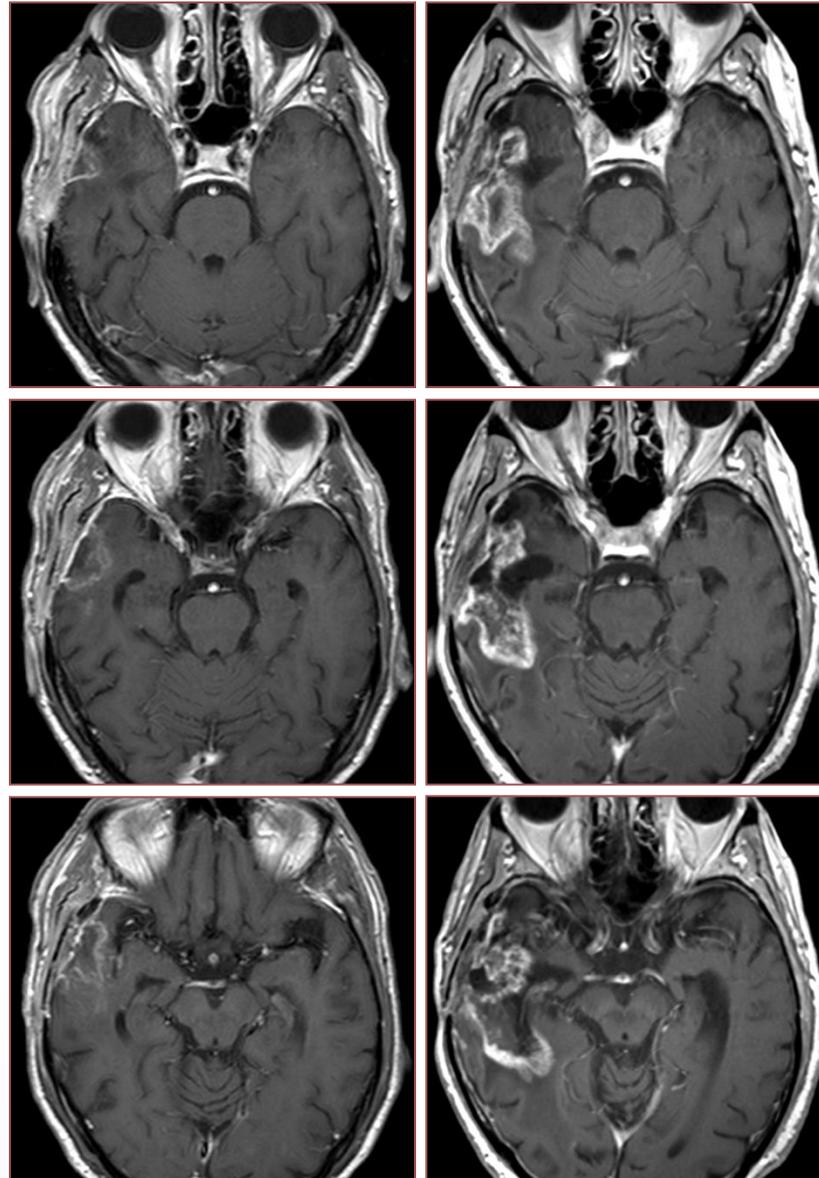
$rCBV < 0.6$



Cho/Cr
Cho/NAA



nADC



RIPRESA DI MALATTIA

$rCBV > 2.6$



Cho/Cr
Cho/NAA

cut-off 1.80
Weybright, Neuroradiology 2005

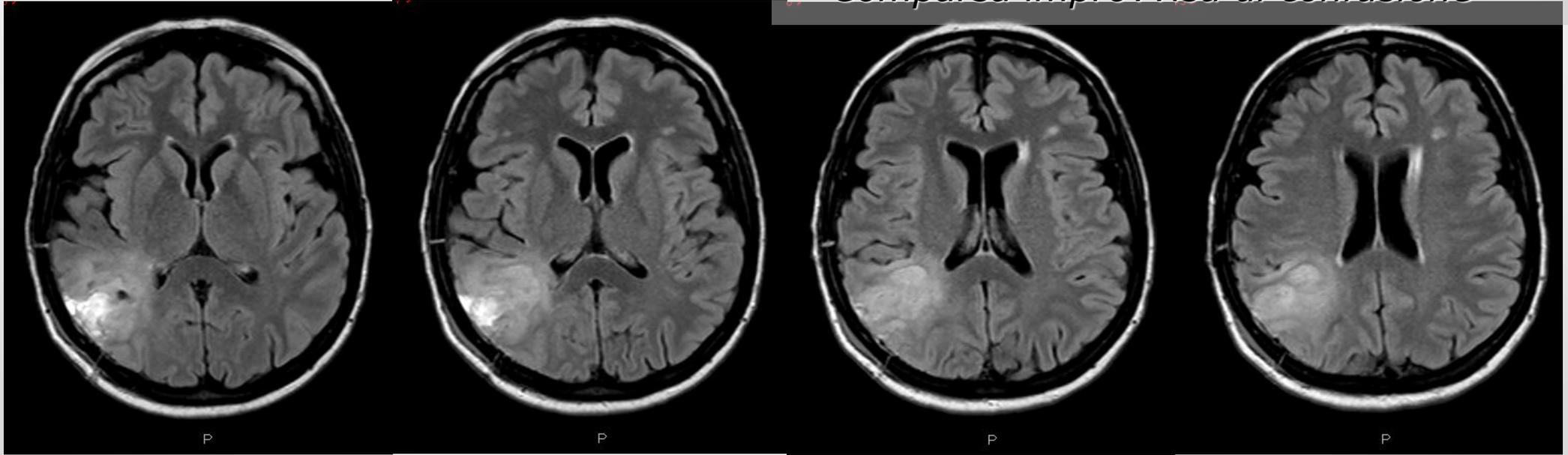


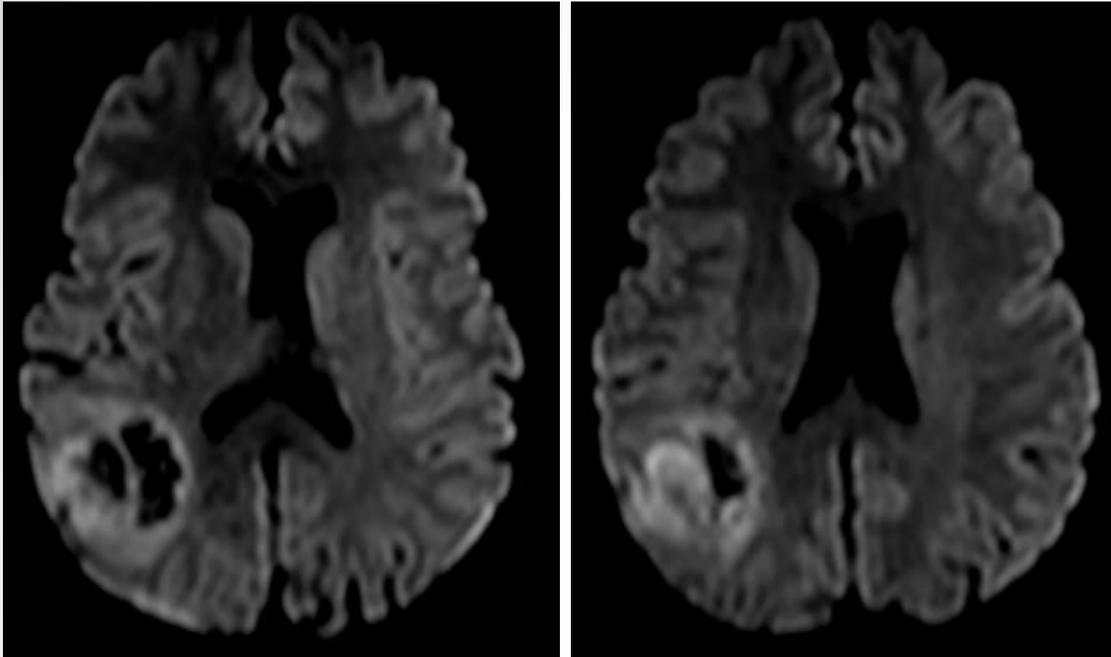
nADC

cut-off 1.62

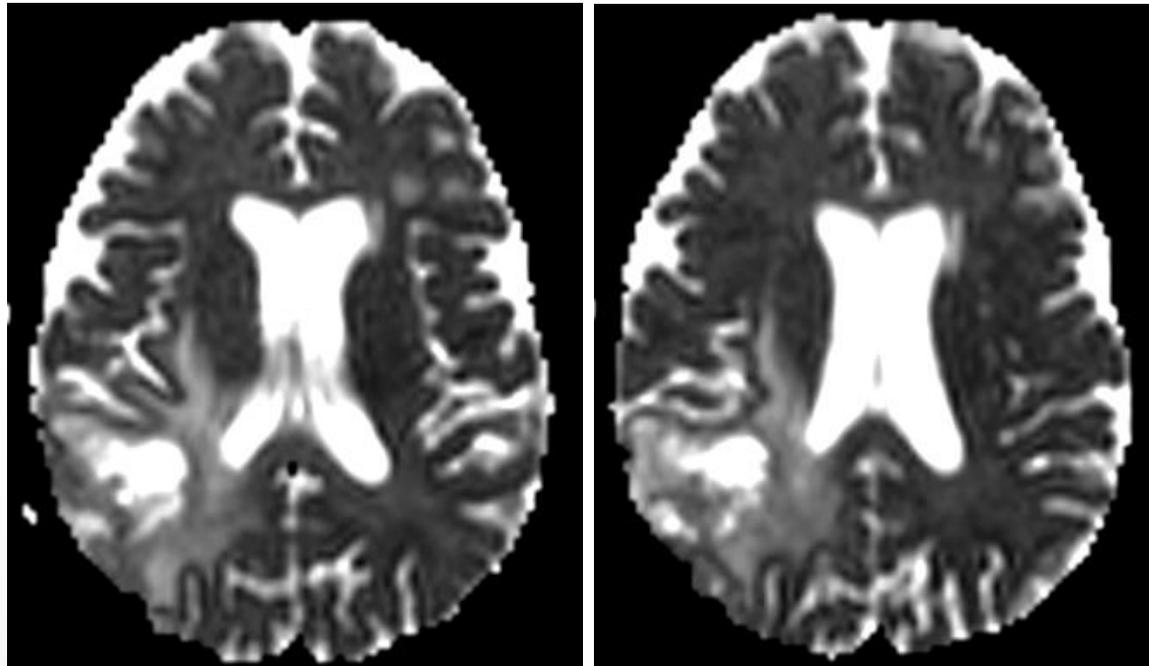


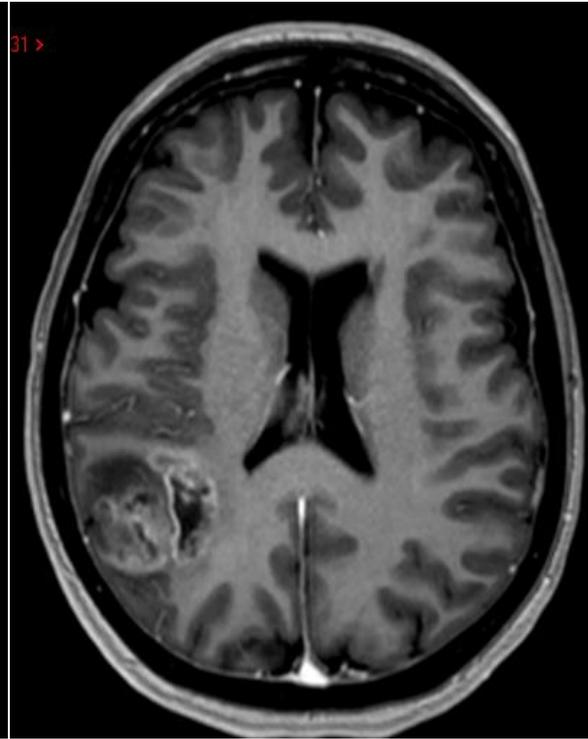
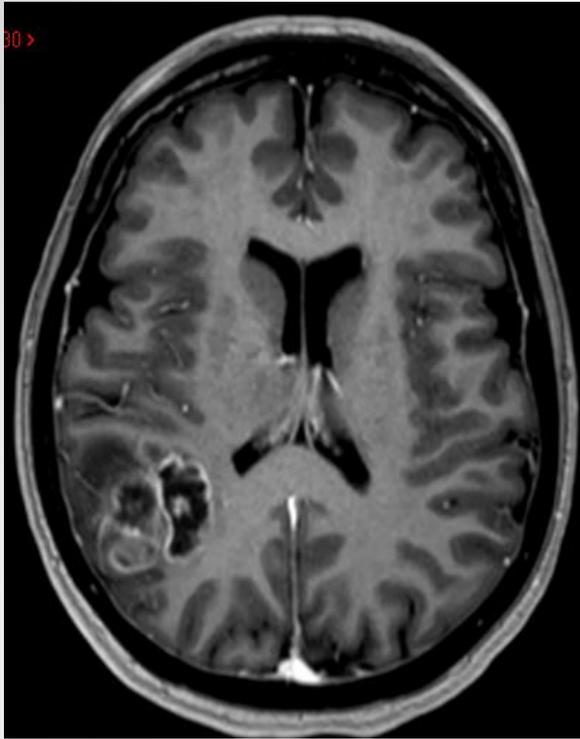
- *AE, ♀*
- *48 aa*
- *Comparsa improvvisa di confusione*



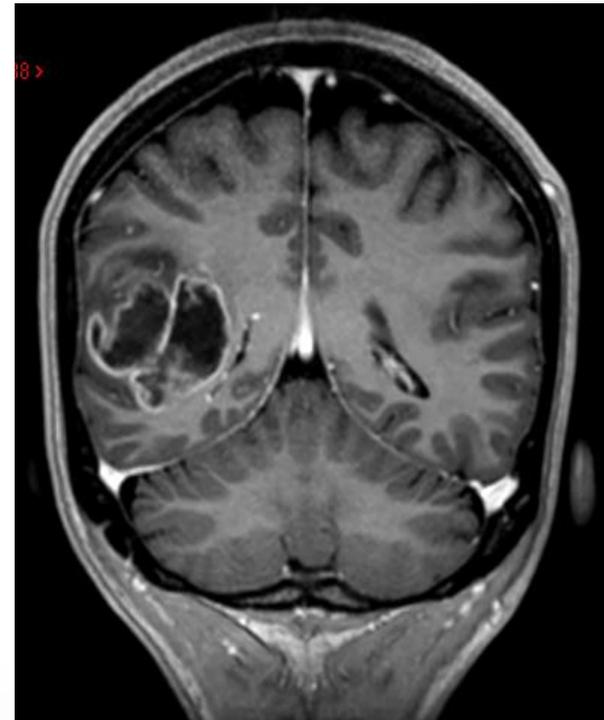
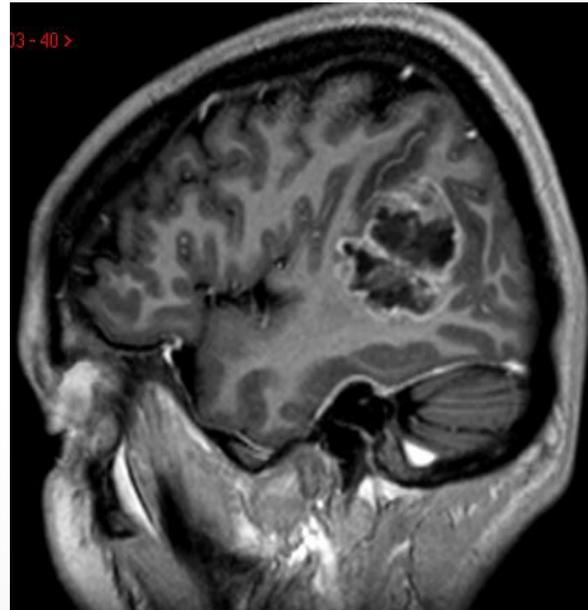


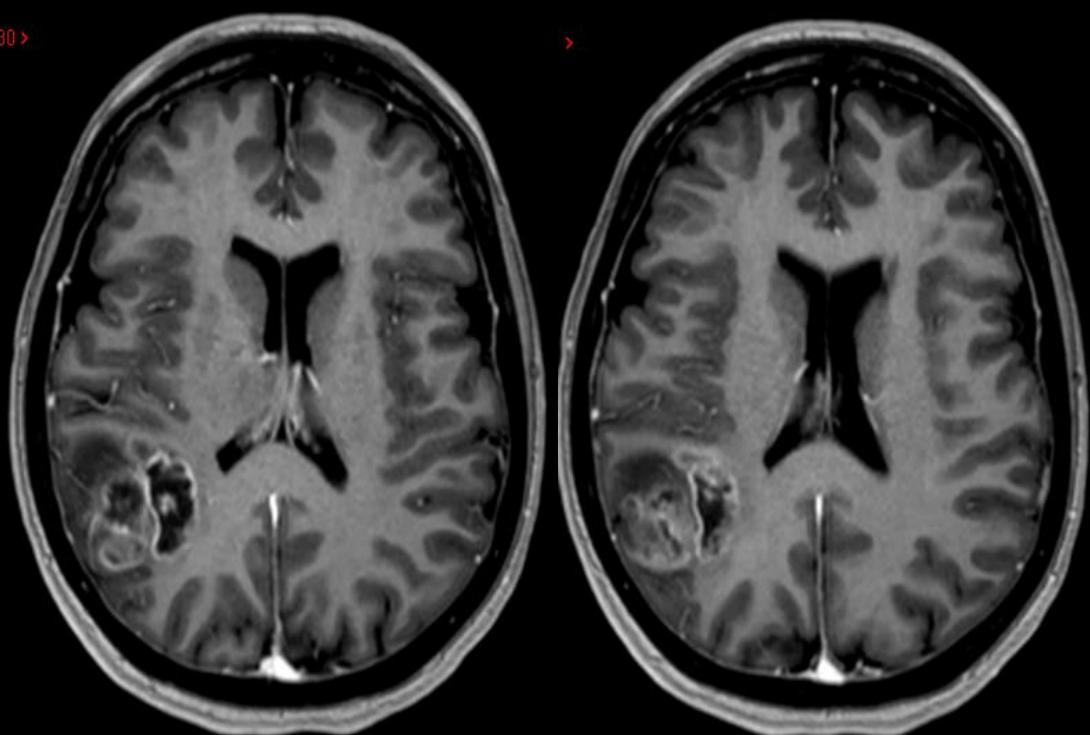
- AE, ♀
- 48 aa
- *Comparsa improvvisa di confusione*



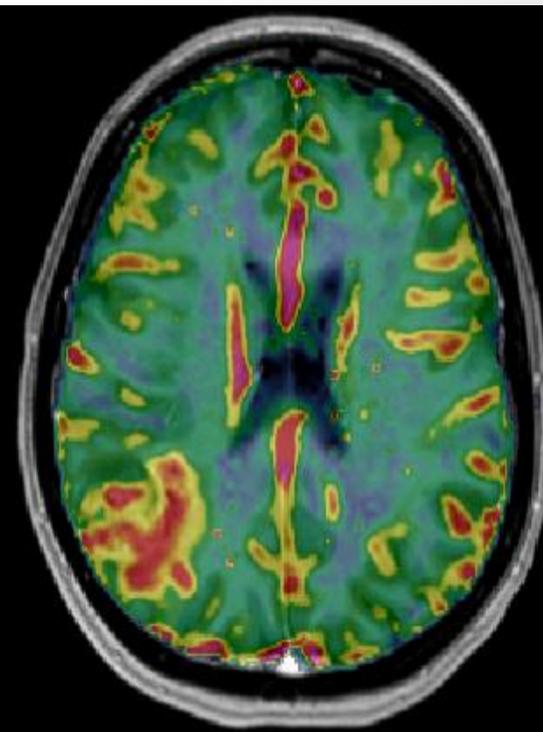
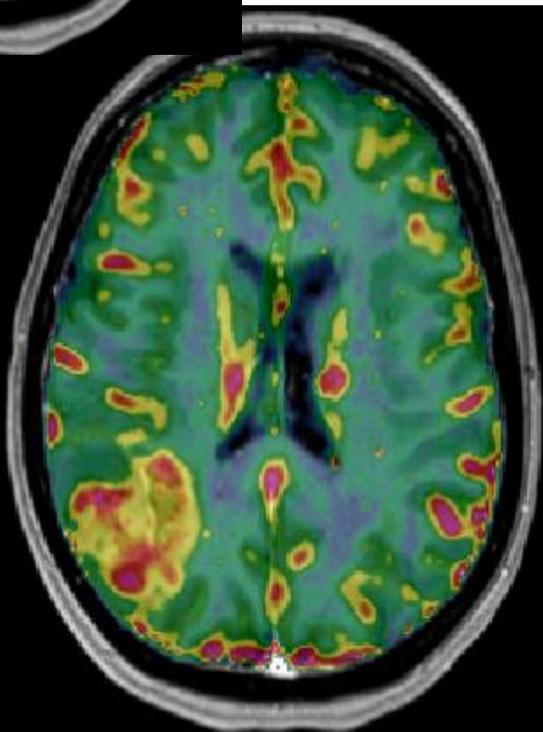
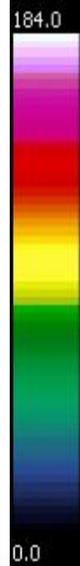


- AE, ♀
- 48 aa
- *Comparsa improvvisa di confusione*





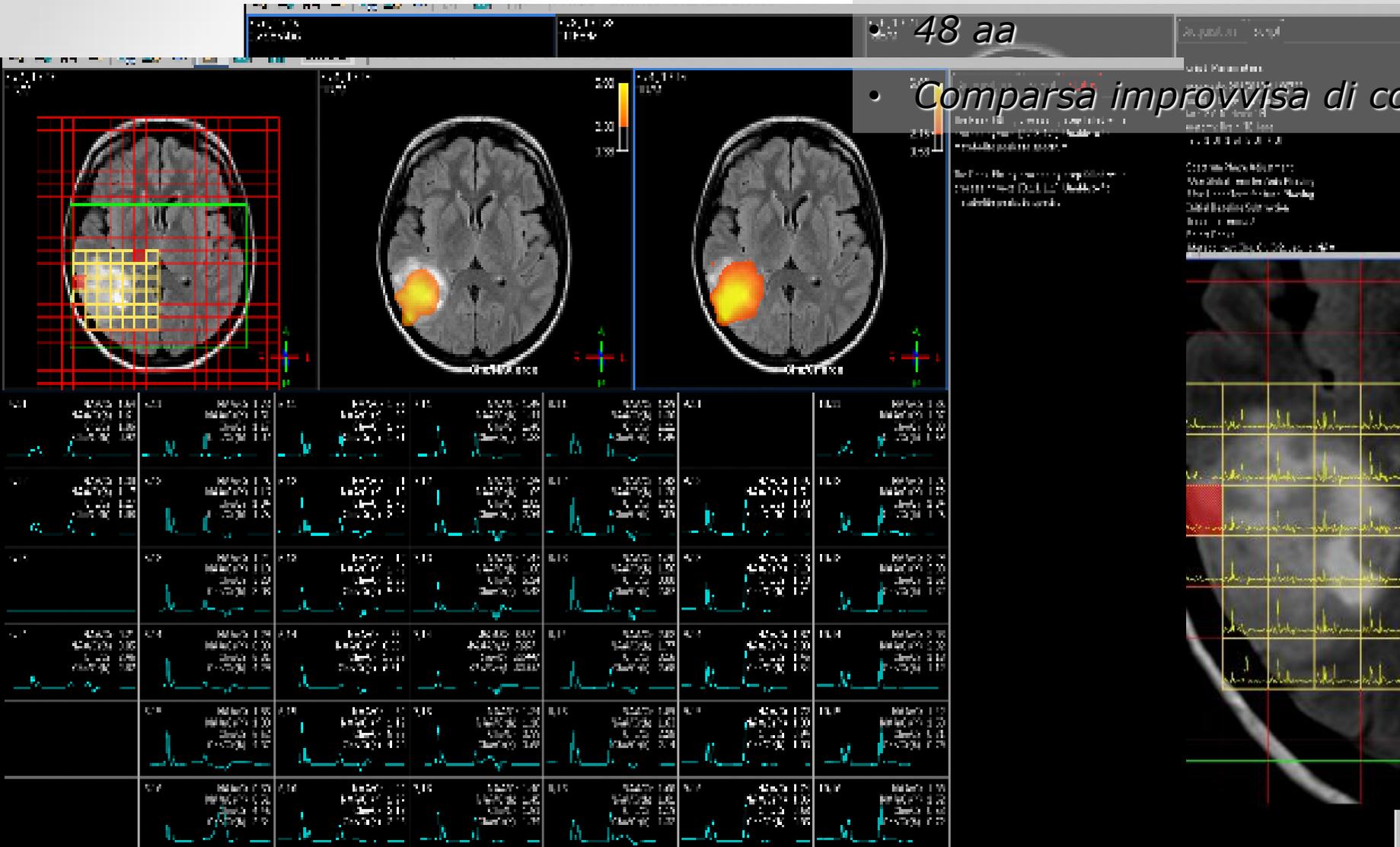
- AE, ♀
- 48 aa
- *Comparsa improvvisa di confusione*



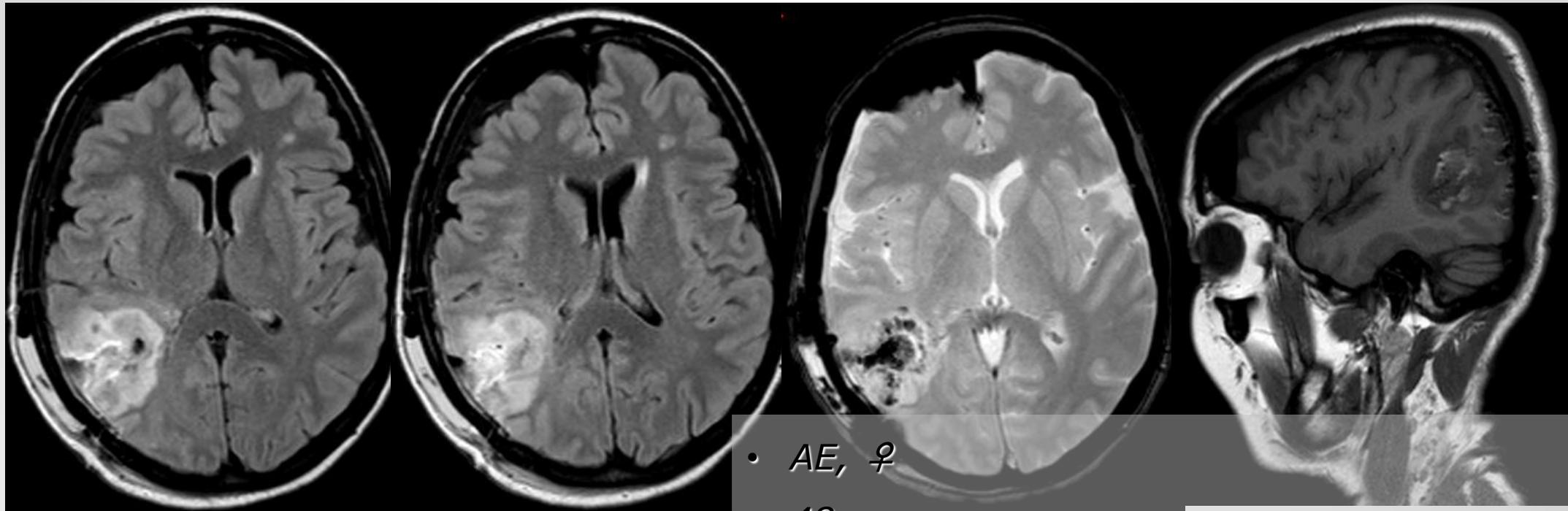
• AE, ♀

• 48 aa

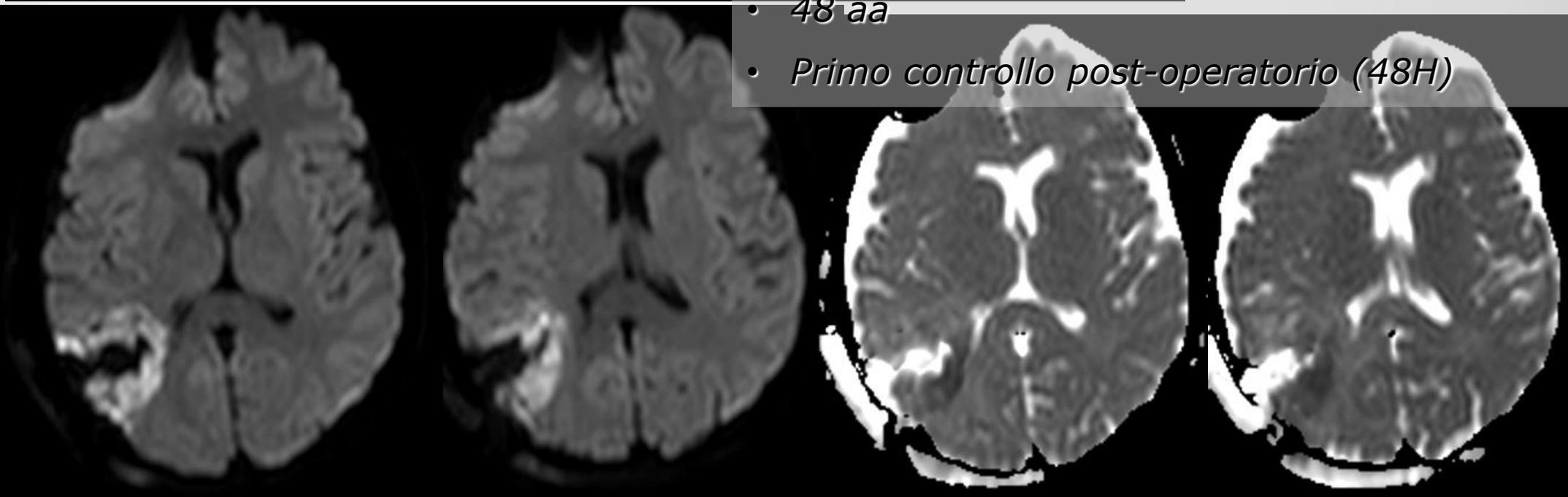
• *Comparsa improvvisa di confusione*



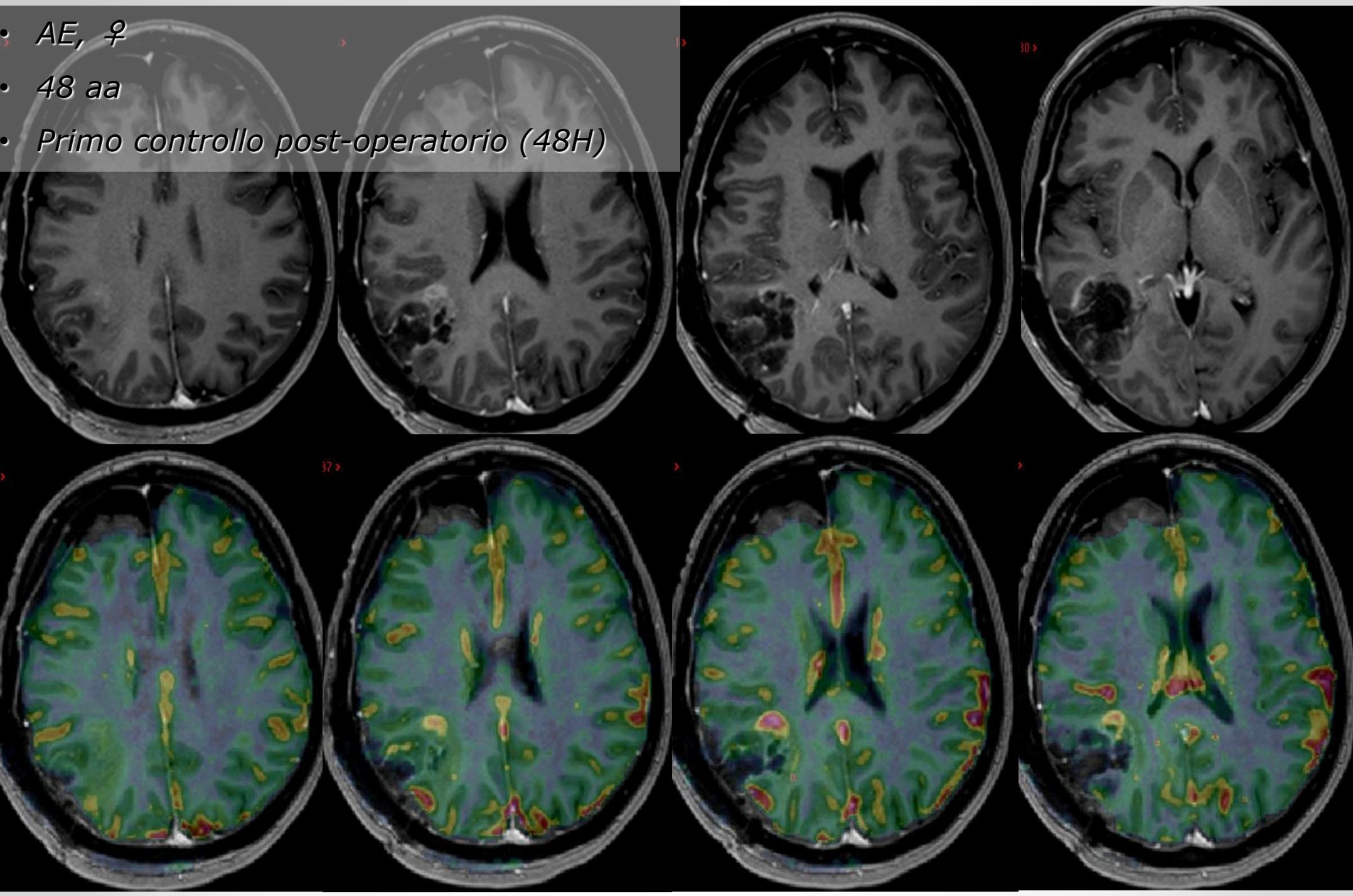
ipervisita in un'azienda di lavoro (di un'azienda)



- *AE, ♀*
- *48 aa*
- *Primo controllo post-operatorio (48H)*



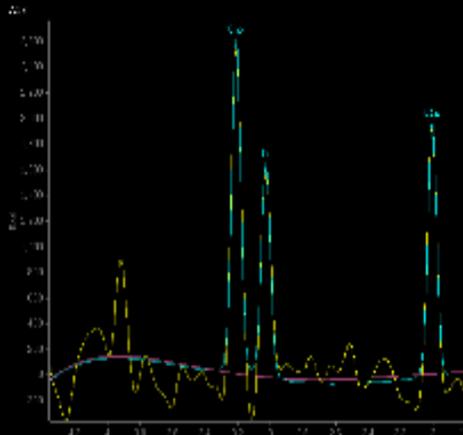
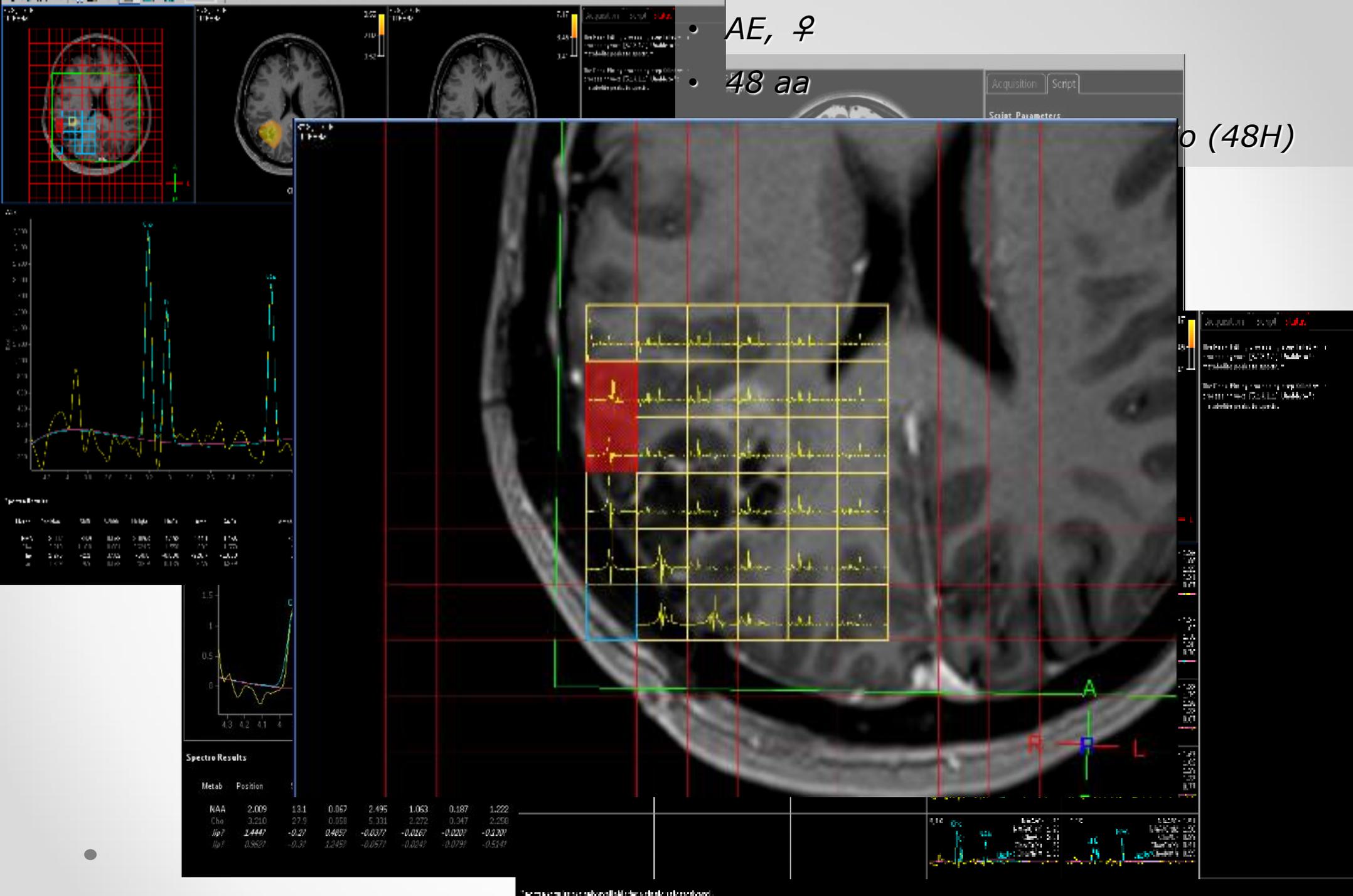
- AE, ♀
- 48 aa
- *Primo controllo post-operatorio (48H)*



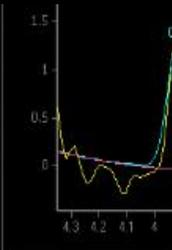
• AE, ♀

• 48 aa

o (48H)

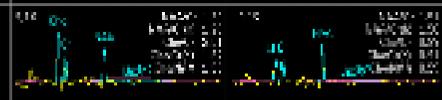


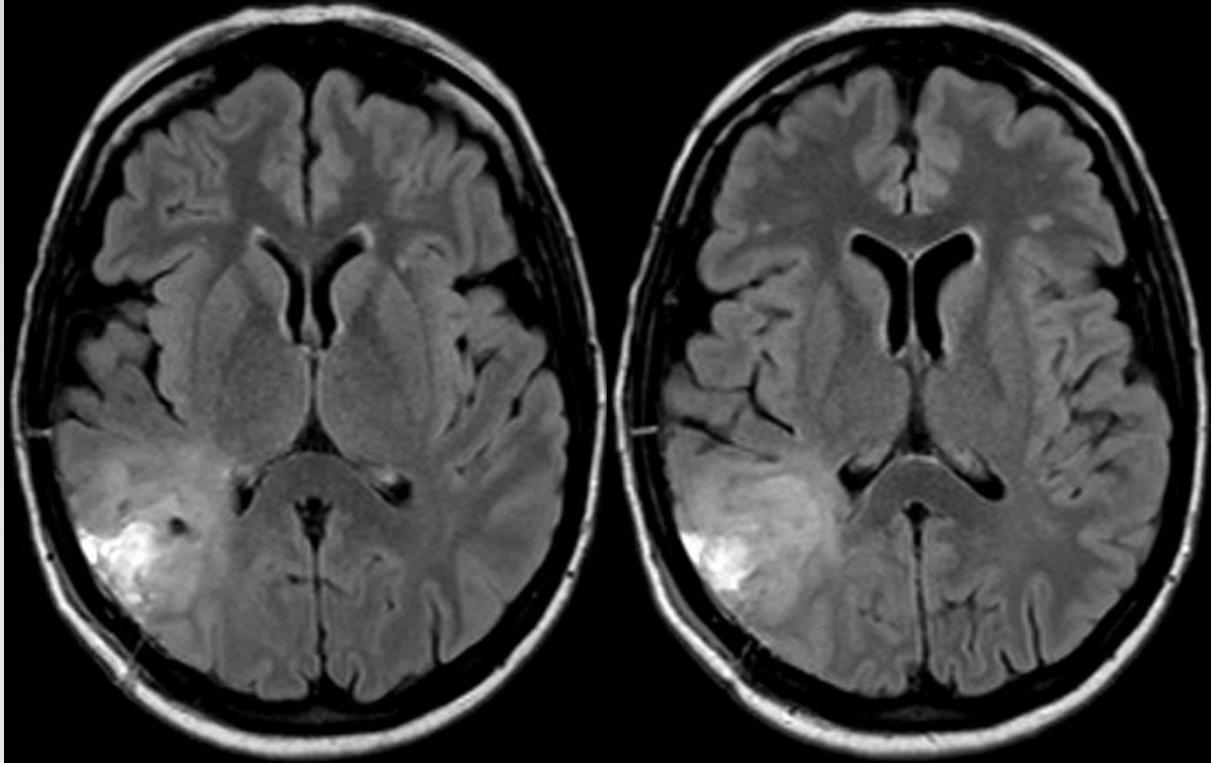
Metab	Position	SNR	FWHM	Height	Area	Area%
Cho	3.210	458	0.050	1.700	11.1	1.700
Cho	3.210	1.70	0.051	1.700	11.1	1.700
Cho	3.210	1.70	0.051	1.700	11.1	1.700
Cho	3.210	1.70	0.051	1.700	11.1	1.700



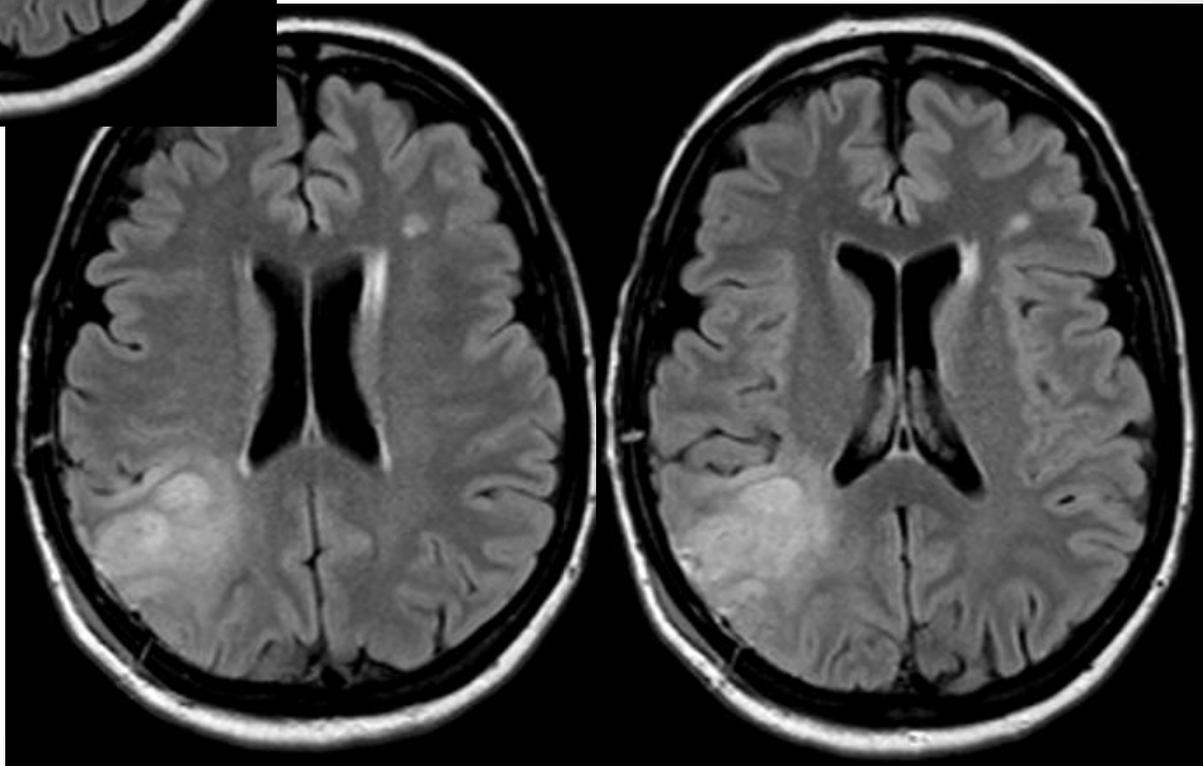
Spectro Results

Metab	Position	SNR	FWHM	Height	Area	Area%
NAA	2.009	13.1	0.067	2.495	1.063	0.187
Cho	3.210	27.9	0.058	5.331	2.272	0.347
lip7	1.4447	-0.27	0.4857	-0.0377	-0.0167	-0.0207
lip1	0.9627	-0.37	1.2457	-0.0577	-0.0247	-0.0797

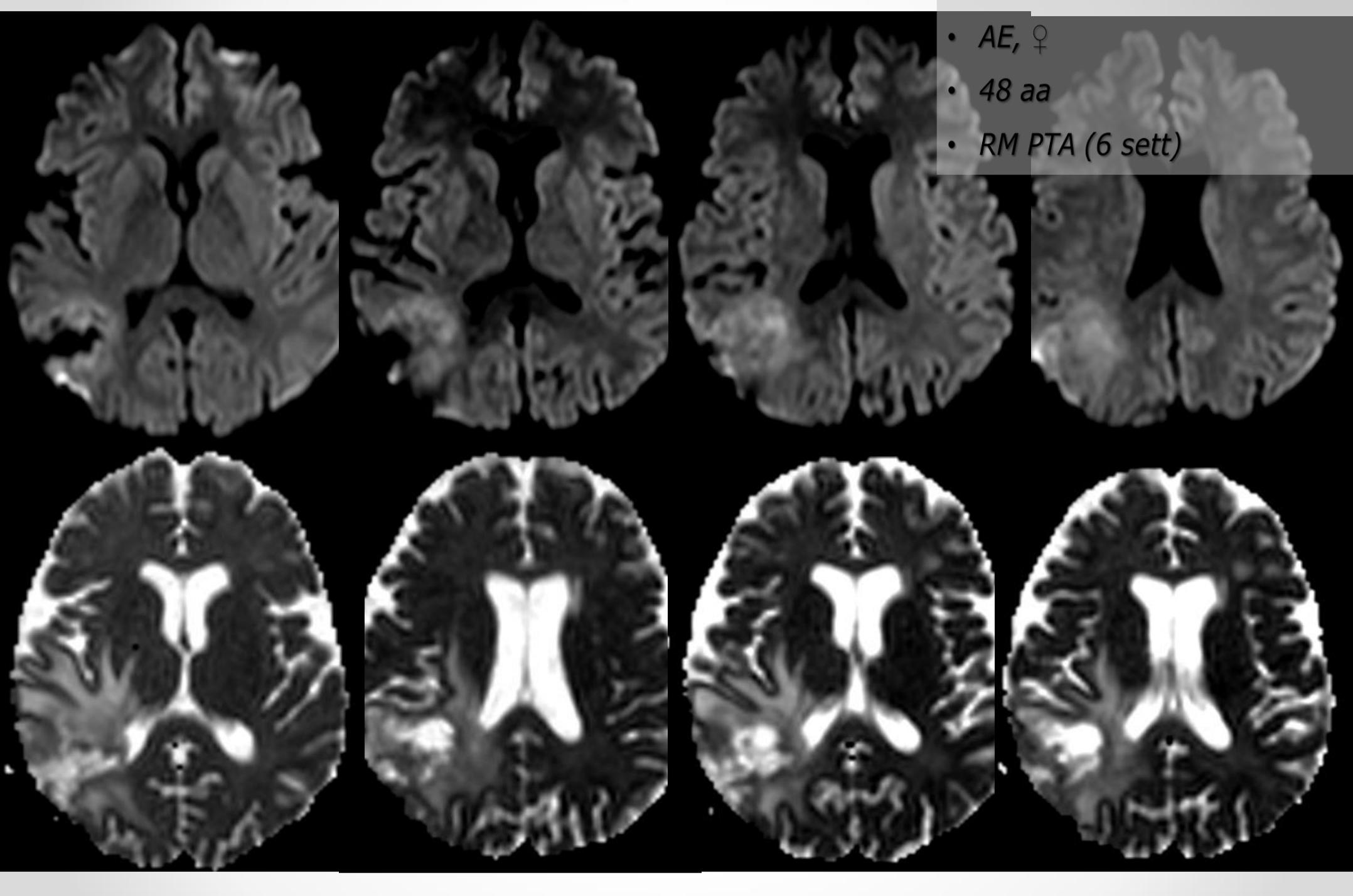




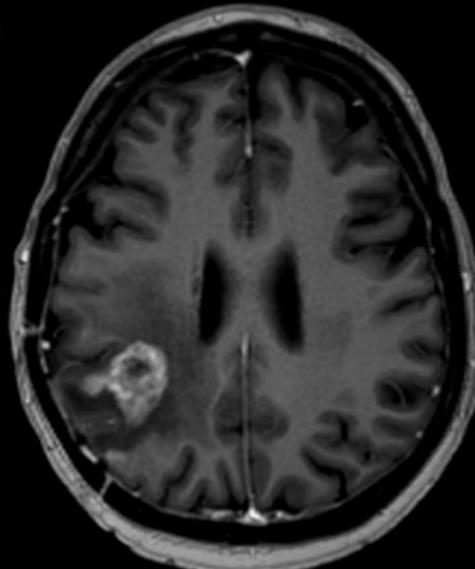
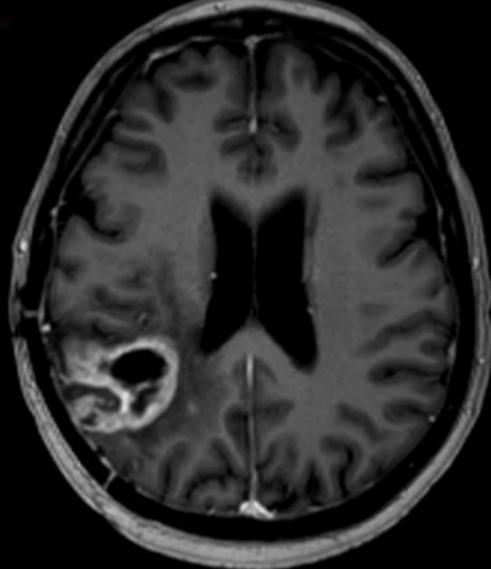
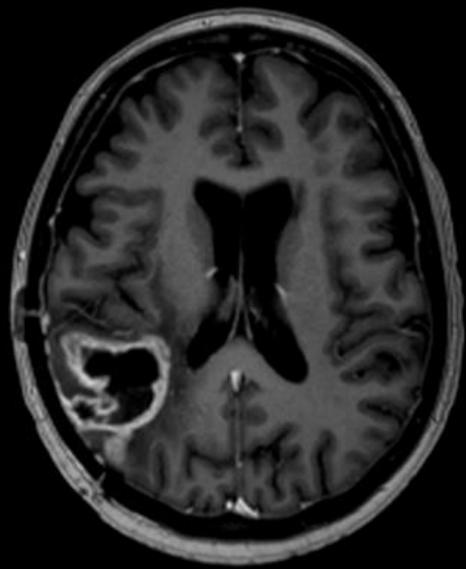
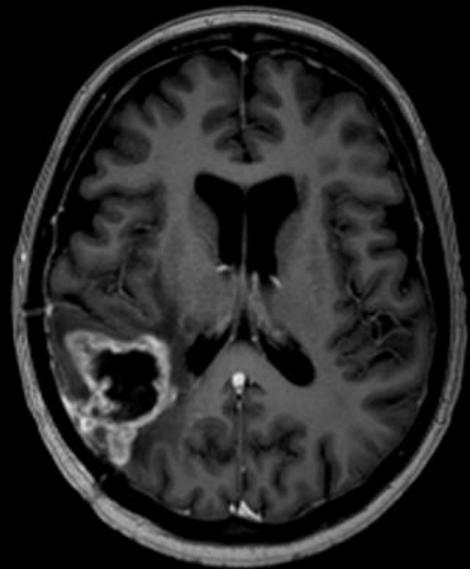
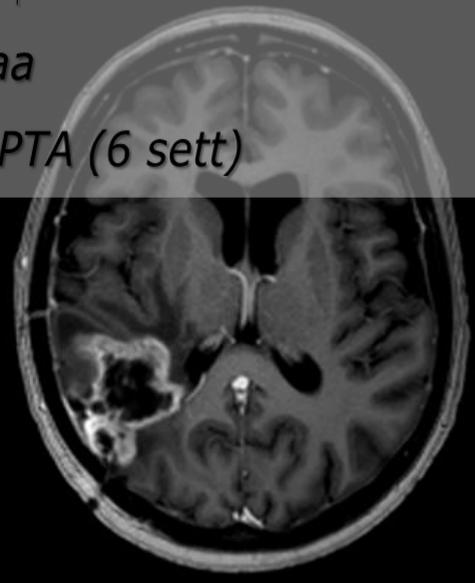
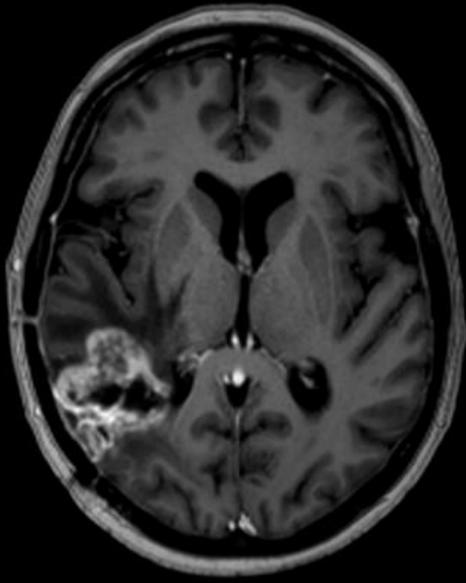
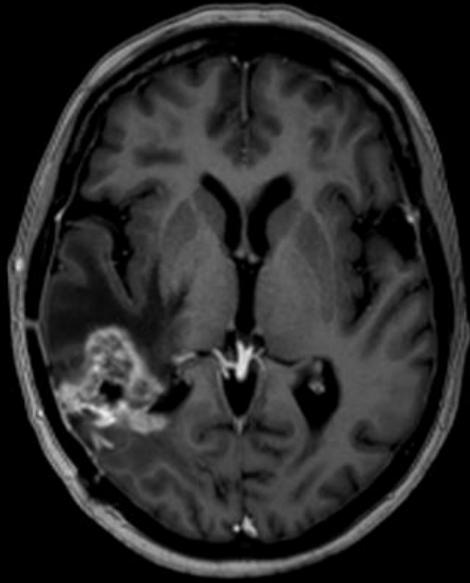
- *AE, ♀*
- *48 aa*
- *RM PTA (6 sett)*



- AE, ♀
- 48 aa
- RM PTA (6 sett)

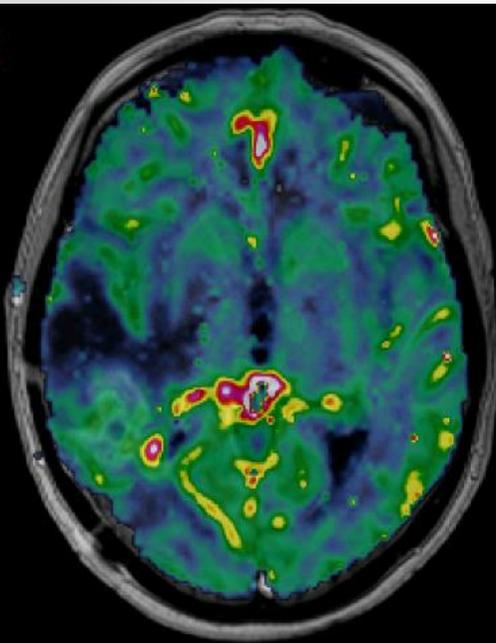


- AE, ♀
- 48 aa
- RM PTA (6 sett)

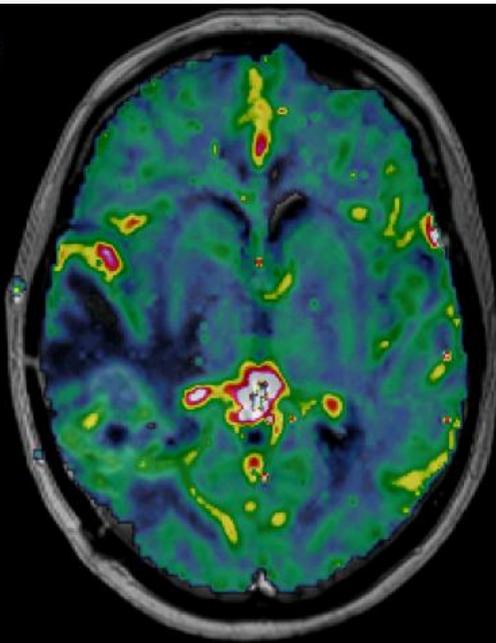


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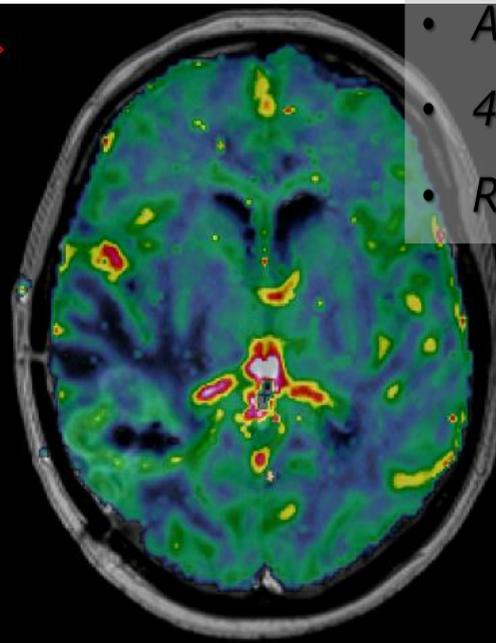
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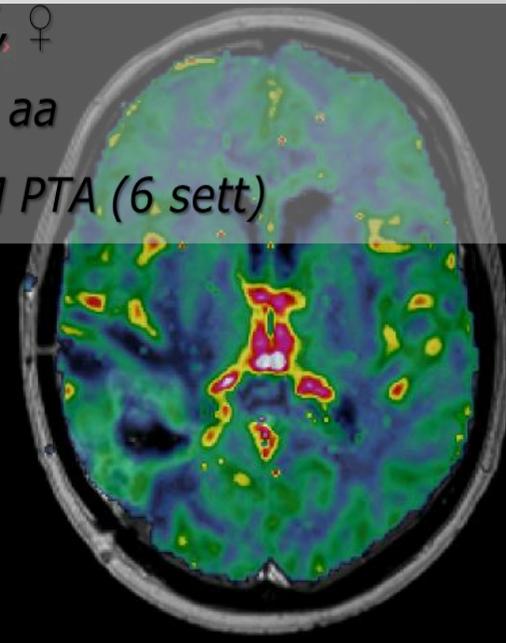
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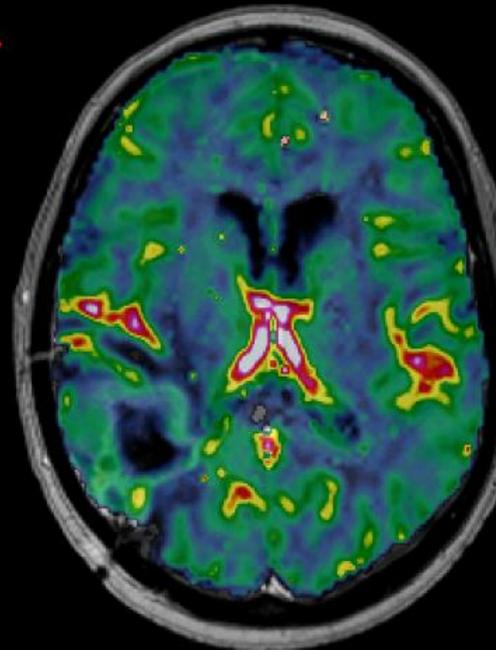
• AE, ♀

• 48 aa

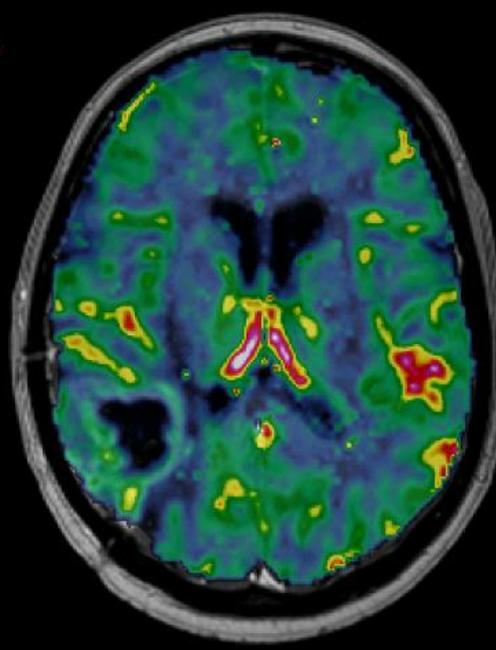
• RM PTA (6 sett)



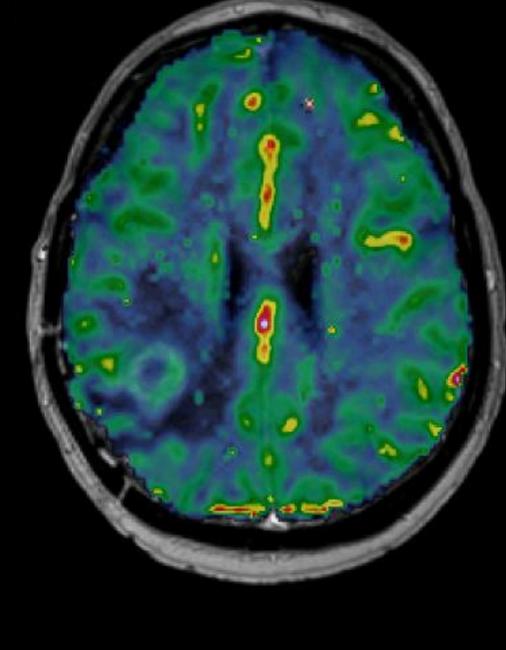
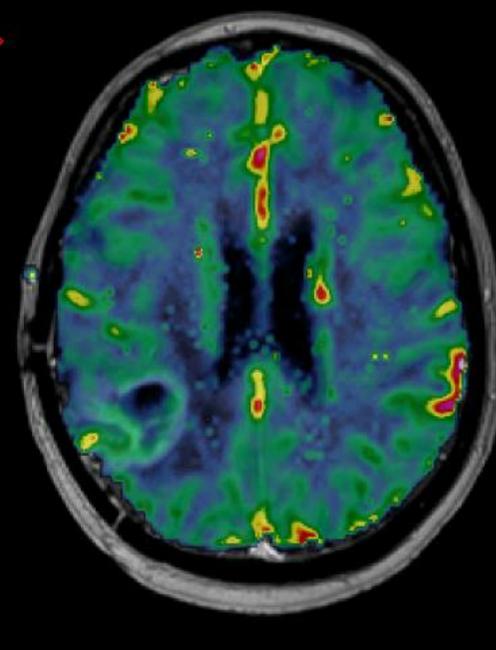
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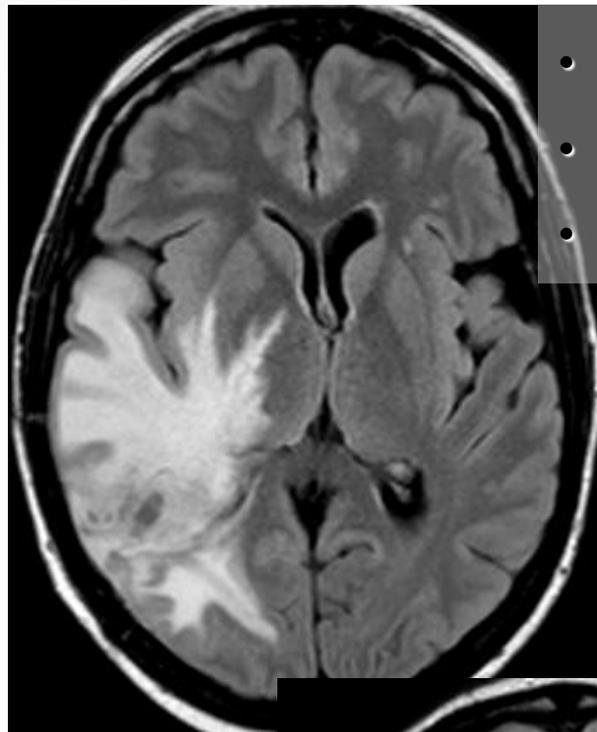
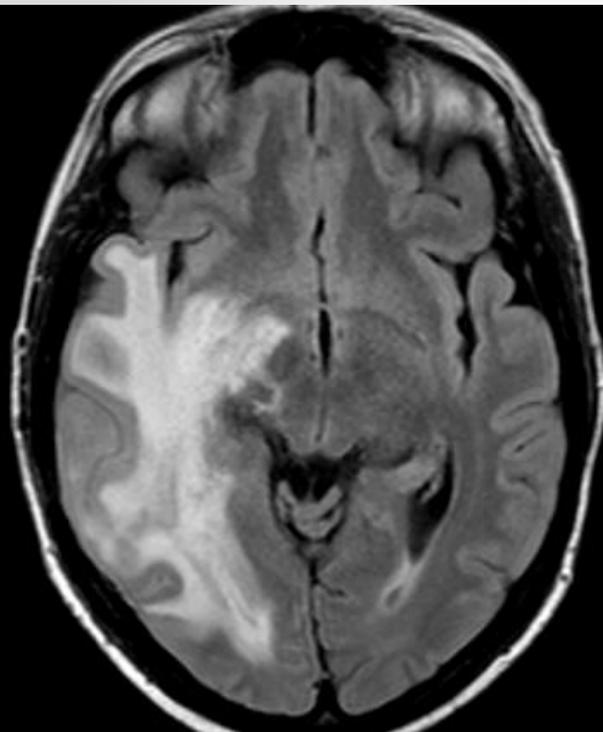


1 >

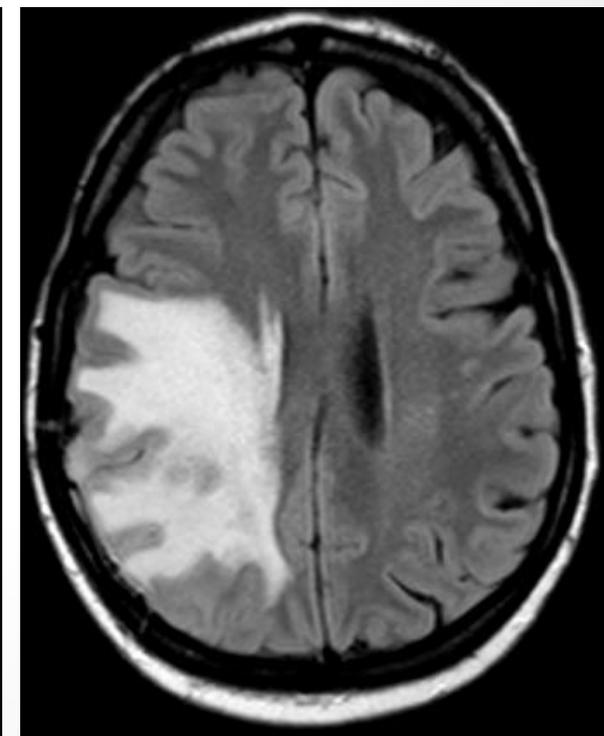
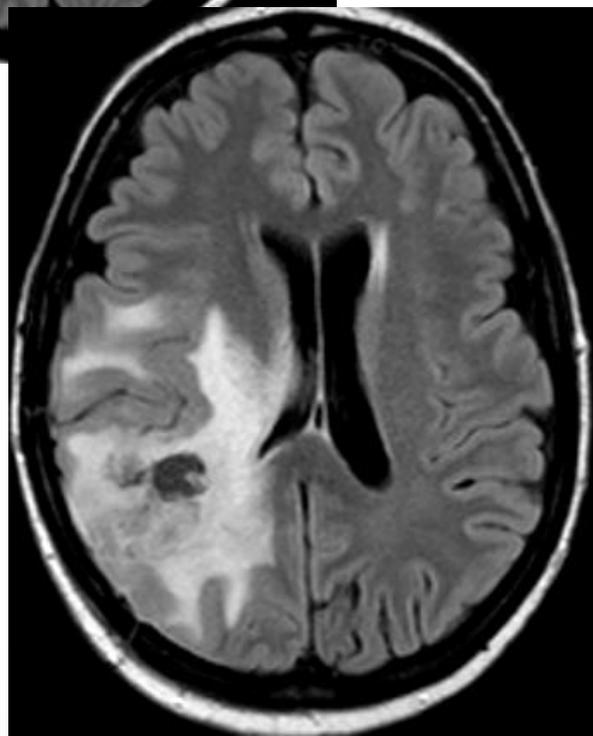


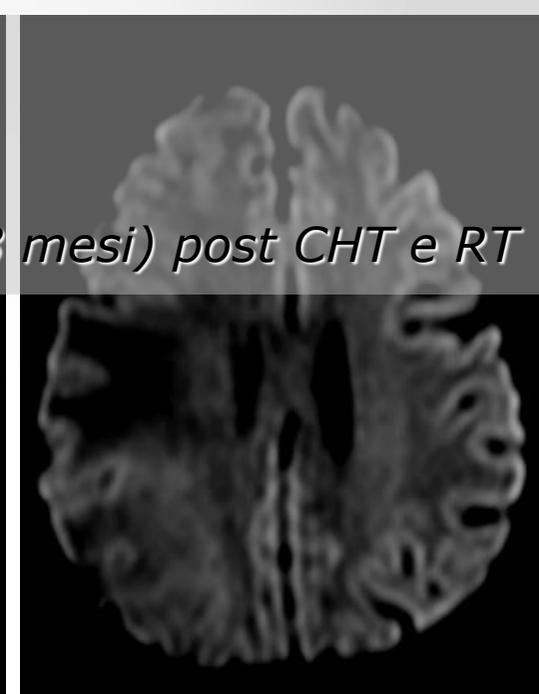
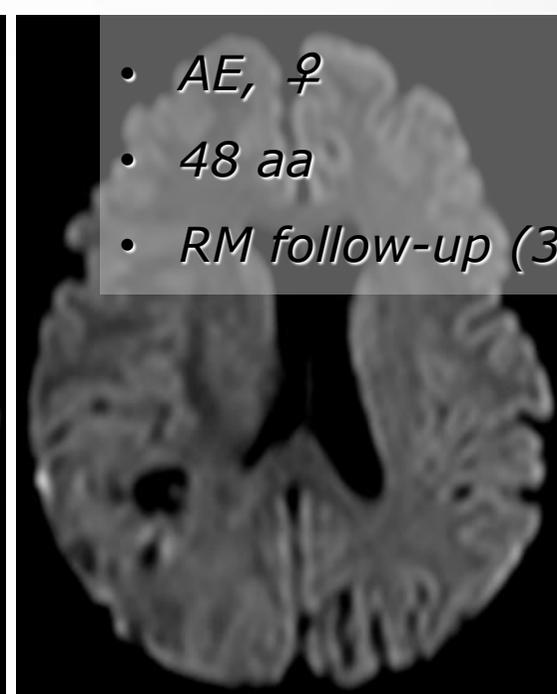
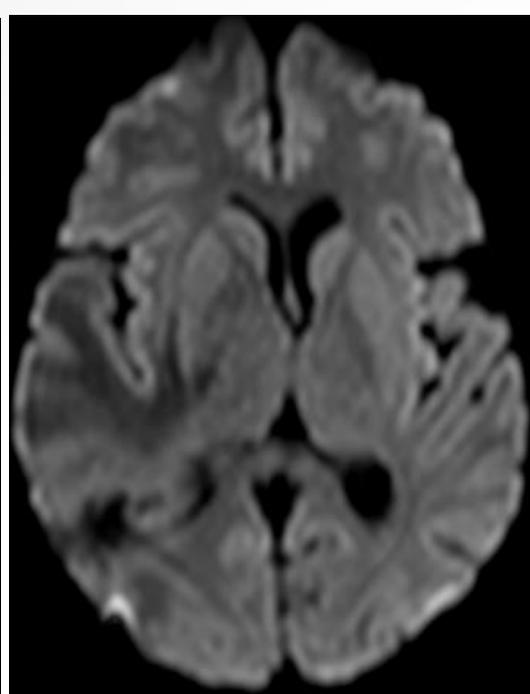
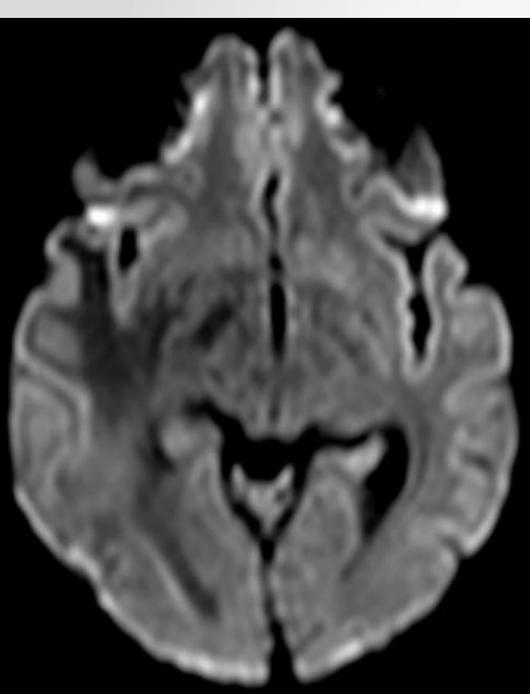
17 >



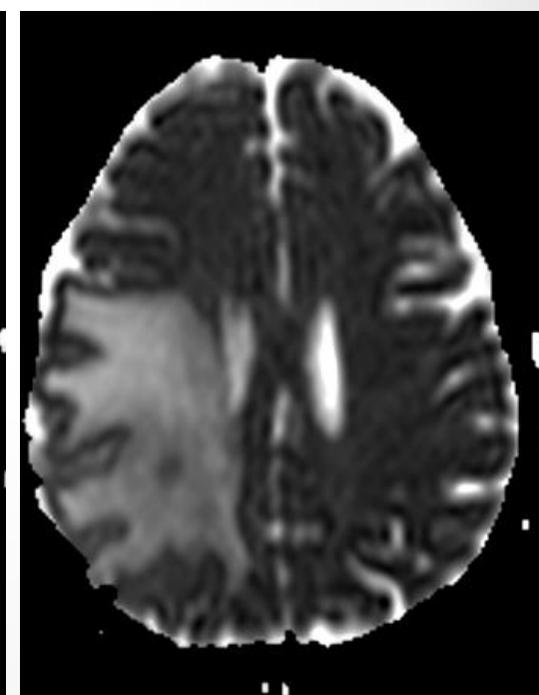
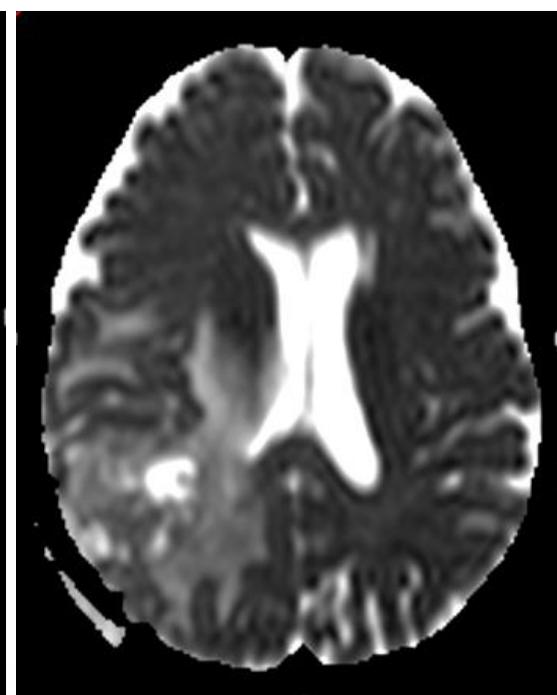
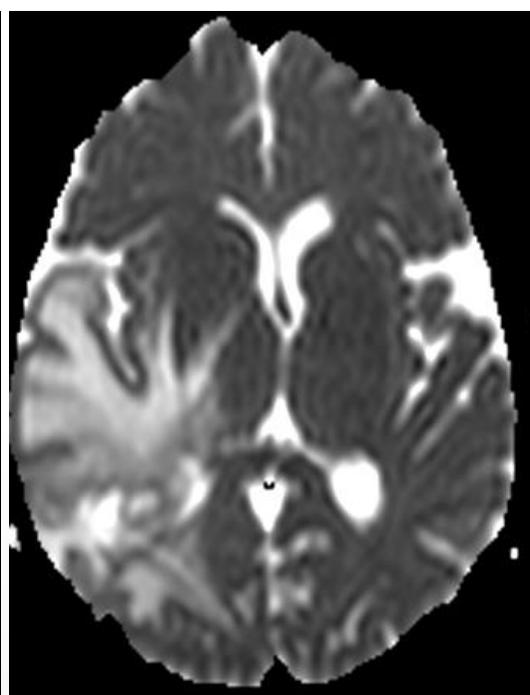
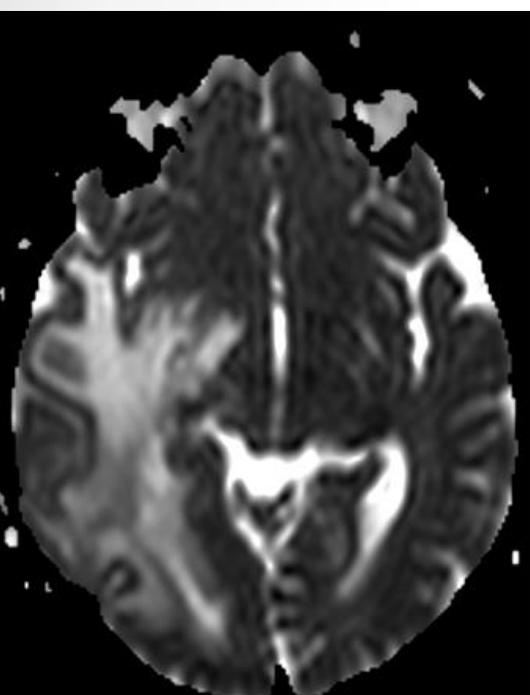


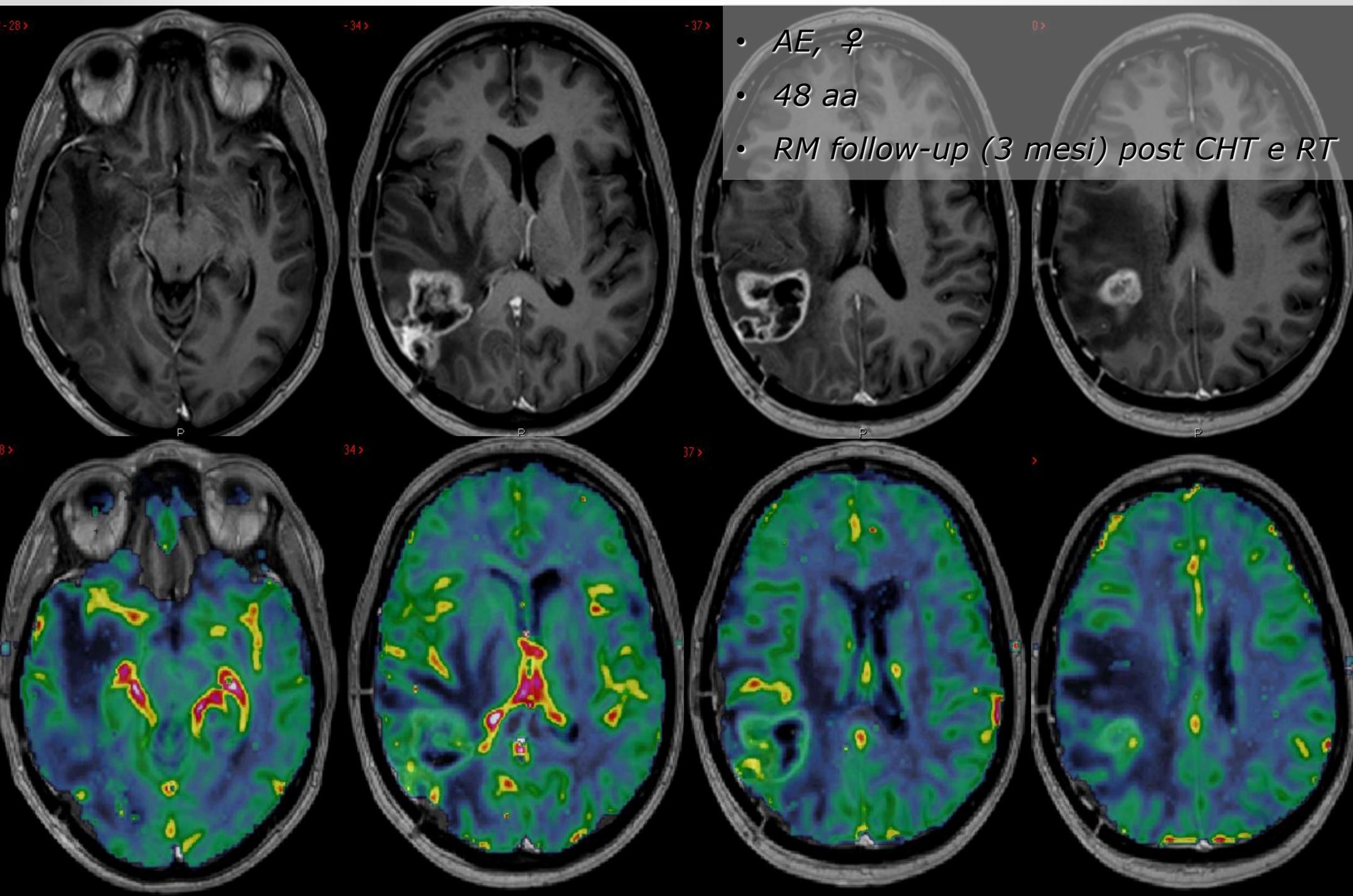
- *AE, ♀*
- *48 aa*
- *RM follow-up (3 mesi) post CHT e RT*





- *AE, ♀*
- *48 aa*
- *RM follow-up (3 mesi) post CHT e RT*





Approfondimento diagnostico – studio RM funzionale

Table 1: CNS applications of advanced MR imaging techniques

Technique	Application
DTI and fiber tractography ^{12,13}	Biopsy guidance Determination of functionally eloquent tracts and surgical plan
PWI ¹⁴⁻²⁴ DSC	Differential diagnosis: tumor vs nontumoral lesions, primary vs metastatic lesions, tumor grading, tumor complications, treatment response, pseudoprogression
DCE	Differential diagnosis: tumor vs nontumoral tissue, tumor grading, treatment response, pseudoprogression
DWI ^{25,26} ADC ^{27,28}	Differential diagnosis: tumor vs nontumoral lesions, tumor grading, treatment response Glioma grading, differentiation of high cellularity lymphoma
MRS ²⁹⁻³³	Differential diagnosis: tumor vs nontumoral lesions, primary vs metastatic lesions, treatment response
Blood oxygen level–dependent imaging ³⁴ Nuclear medicine, PET ³⁵ Volumetric imaging ³⁶	Neuronal activity, surgical guidance Biopsy guidance, treatment response, differential diagnosis: tumor recurrence vs radionecrosis Not widely available and implementable

Table 3: Standard protocol for brain tumor imaging based on expert panel discussion following the framework of the ACRIN 6686 component of the RTOG 0825 protocol⁷³

Standardized MR imaging protocol

3-Plane localizer/scout (in order of acquisition)

T1-weighted precontrast (spin-echo)

T2-weighted axial

FLAIR (optional to perform after contrast)

T1 map (quantitation) for DCE MR imaging—3D gradient-echo T1 or 2D TSE/FSE T1^a

DWI and/or DTI (can extract DWI data trace/ADC from DTI)^a

T2* DSC MR imaging (after presaturation DCE MR imaging sequence)^a

T1-weighted postcontrast (spin-echo)

Functional language, auditory, visual, motor testing, and MRS^a

Can do FLAIR before DSC MR imaging

SWI, gradient-echo, additional optional sequences^a

General parameter recommendations

Section thickness not greater than 5 mm

Delay is recommended, which can be built in by performing DWI and/or DTI before acquiring T1 sequences. Another option is to perform FLAIR (or even T2) before T1 sequences, which may give additional sensitivity for leptomeningeal disease⁷⁴

Target duration \leq 30 minutes (maximum, 1.5–2.0 hr)

Classificazione WHO 2007

Table 1 The 2007 WHO Classification of Tumours of the Central Nervous System. Reprinted from Ref. 35

TUMOURS OF NEUROEPITHELIAL TISSUE

Astrocytic tumours

Pilocytic astrocytoma	9421/1 ¹
Pilomyxoid astrocytoma	9425/3*
Subependymal giant cell astrocytoma	9384/1
Pleomorphic xanthoastrocytoma	9424/3
Diffuse astrocytoma	9400/3
Fibrillary astrocytoma	9420/3
Gemistocytic astrocytoma	9411/3
Protoplasmic astrocytoma	9410/3
Anaplastic astrocytoma	9401/3
Glioblastoma	9440/3
Giant cell glioblastoma	9441/3
Gliosarcoma	9442/3
Gliomatosis cerebri	9381/3

Oligodendroglial tumours

Oligodendroglioma	9450/3
Anaplastic oligodendroglioma	9451/3

Oligoastrocytic tumours

Oligoastrocytoma	9382/3
Anaplastic oligoastrocytoma	9382/3

Ependymal tumours

Subependymoma	9383/1
Myxopapillary ependymoma	9394/1
Ependymoma	9391/3
Cellular	9391/3
Papillary	9393/3
Clear cell	9391/3
Tanycytic	9391/3
Anaplastic ependymoma	9392/3

Choroid plexus tumours

Choroid plexus papilloma	9390/0
Atypical choroid plexus papilloma	9390/1*
Choroid plexus carcinoma	9390/3

Other neuroepithelial tumours

Astroblastoma	9430/3
Chordoid glioma of the third ventricle	9444/1
Angiocentric glioma	9431/1*

¹ Morphology code of the International Classification of Diseases for Oncology (ICD-O) (614A) and the Systematized Nomenclature of Medicine (<http://snomed.org>). Behaviour is coded /0 for benign tumours, /3 for malignant tumours and /1 for borderline or uncertain behaviour.

* The italicised numbers are provisional codes proposed for the 4th edition of ICD-O. While they are expected to be incorporated into the next ICD-O edition, they currently remain subject to change.

Neuronal and mixed neuronal-glia tumours

Table 1 The 2007 WHO Classification of Tumours of the Central Nervous System

TUMOURS OF NEUROEPITHELIAL TISSUE

Astrocytic tumours

Pilocytic astrocytoma	9421/1 ¹
Pilomyxoid astrocytoma	9425/3*
Subependymal giant cell astrocytoma	9384/1
Pleomorphic xanthoastrocytoma	9424/3
Diffuse astrocytoma	9400/3
Fibrillary astrocytoma	9420/3
Gemistocytic astrocytoma	9411/3
Protoplasmic astrocytoma	9410/3
Anaplastic astrocytoma	9401/3
Glioblastoma	9440/3
Giant cell glioblastoma	9441/3
Gliosarcoma	9442/3
Gliomatosis cerebri	9381/3

Oligodendroglial tumours

Oligodendroglioma	9450/3
Anaplastic oligodendroglioma	9451/3

Oligoastrocytic tumours

Oligoastrocytoma	9382/3
Anaplastic oligoastrocytoma	9382/3

Perineurioma

Perineurioma, NOS	9571/0
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Table 1 The 2007 WHO Classification of Tumours of the Central Nervous System

TUMOURS OF NEUROEPITHELIAL TISSUE

Pilocytic astrocytoma	9421/1 ¹
Pilomyxoid astrocytoma	9425/3*
Subependymal giant cell astrocytoma	9384/1
Pleomorphic xanthoastrocytoma	9424/3
Diffuse astrocytoma	9400/3
Fibrillary astrocytoma	9420/3
Gemistocytic astrocytoma	9411/3
Protoplasmic astrocytoma	9410/3
Anaplastic astrocytoma	9401/3
Glioblastoma	9440/3
Giant cell glioblastoma	9441/3
Gliosarcoma	9442/3
Gliomatosis cerebri	9381/3

Oligodendroglial tumours	
Oligodendroglioma	9450/3
Anaplastic oligodendroglioma	9451/3

Oligoastrocytic tumours	
Oligoastrocytoma	9382/3
Anaplastic oligoastrocytoma	9382/3

Osteochondroma	9210/0
Haemangioma	9120/0
Epithelioid haemangioendothelioma	9133/1

Haemangiopericytoma	9150/1
Anaplastic haemangiopericytoma	9150/3
Angiosarcoma	9120/3
Kaposi sarcoma	9140/3
Ewing sarcoma - PNET	9364/3

Primary melanocytic lesions

Diffuse melanocytosis	8728/0
Melanocytoma	8728/1
Malignant melanoma	8720/3
Meningeal melanomatosis	8728/3

Other neoplasms related to the meninges

Haemangioblastoma	9161/1
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LYMPHOMAS AND HAEMATOPOIETIC NEOPLASMS

Malignant lymphomas	9590/3
Plasmacytoma	9731/3
Granulocytic sarcoma	9930/3

GERM CELL TUMOURS

Germinoma	9064/3
Embryonal carcinoma	9070/3
Yolk sac tumour	9071/3
Choriocarcinoma	9100/3
Teratoma	9080/1
Mature	9080/0
Immature	9080/3
Teratoma with malignant transformation	9084/3
Mixed germ cell tumour	9085/3

TUMOURS OF THE SELLAR REGION

Craniopharyngioma	9350/1
Adamantinomatous	9351/1
Papillary	9352/1
Granular cell tumour	9582/0
Pituicytoma	9432/1*
Spindle cell oncocytoma of the adenohypophysis	8291/0*

METASTATIC TUMOURS

Conclusioni

- La Classificazione aggiornata (2007 World Health Organization) dei tumori encefalici attribuisce ad ogni tipo di lesione un nome (basato sul tipo cellulare e su criteri istologici), grading (aggressività), ed un codice per stabilire se la massa è benigna, maligna, o borderline
- Critiche sono state sollevate ma permangono problemi di classificazione e grading, che riflettono sia la complessità delle lesioni neoplastiche sia le sfide dell'interpretazione istologica (come errori di campionamento e di variabilità inter- ed intraosservatore)



Conclusioni

- Future revisioni della Classificazione World Health Organization dovrebbero includere markers molecolari e di imaging per aiutare nella classificazione dei gliomi.
- MR imaging— in particolare attraverso l'uso delle tecniche avanzate—può fornire informazioni aggiuntive sul grading delle lesioni rilevanti per l'outcome.