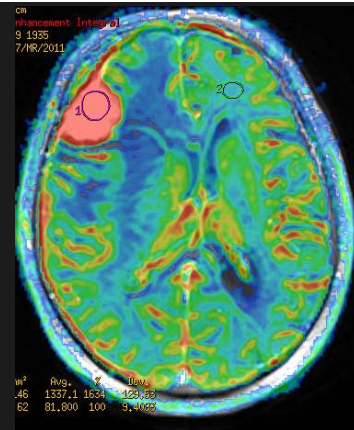




WMU



AKADEMICKI
SZPITAL KLINICZNY
Im. Jana Mikulicza-Radeckiego
we Wrocławiu



Perfuzja MR mózgu w mojej codziennej praktyce klinicznej

dr hab. Anna Zimny
Profesor UMW

Zakład Radiologii Ogólnej, Zabiegowej i Neuroradiologii
Uniwersytet Medyczny we Wrocławiu

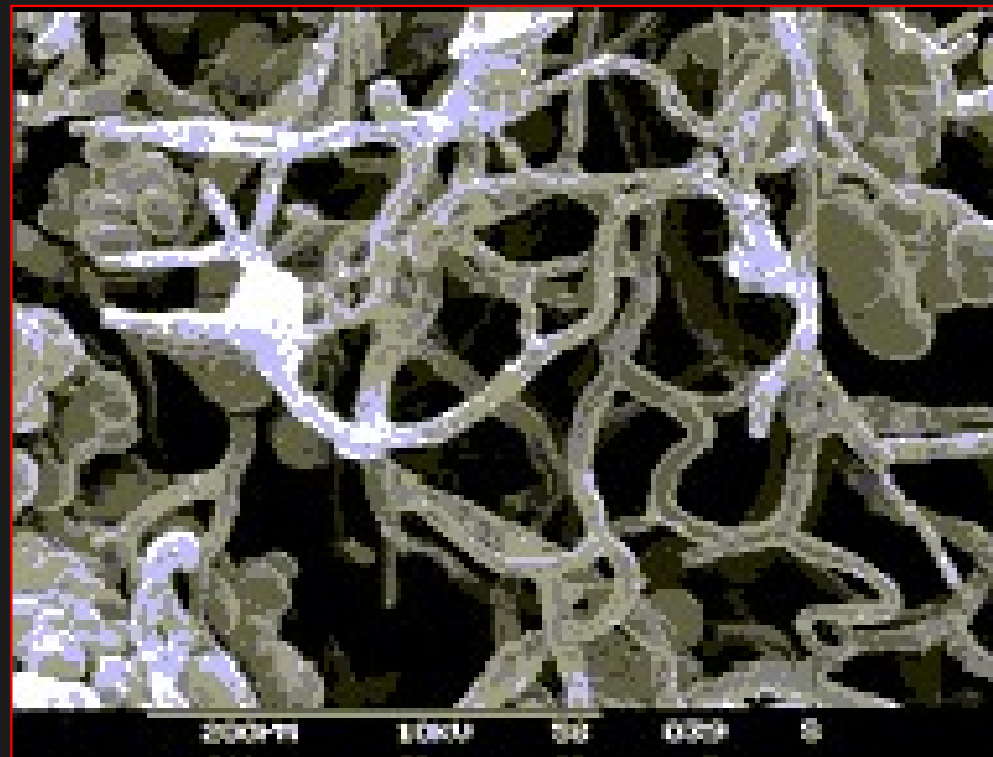
Jachranka 2022

Plan prezentacji

- Rodzaje badań perfuzyjnych w MR (DSC)
- Zastosowanie kliniczne
- Przypadki kliniczne
- Co nowego w perfuzji DSC?
- Quiz

Perfuzja MR

in vivo nieinwazyjna ocena mikrokrazenia mózgowego
na poziomie kapilarnym



Techniki perfuzyjne MR

- T2/T2* DSC – Dynamic Susceptibility Contrast MR perfusion
- DCE – Dynamic Contrast Enhanced MR perfusion
- ASL – Arterial Spin Labeling MR perfusion

T2/T2*DSC

- Aparat MR 1.5 T lub 3T
- Strzykawka automatyczna

Podanie kontrastu przez strzykawkę
Popychane bolusem soli (20 ml)

dawka: 0.2 mmol/kg gdy T2 SE EPI,
0.1 mmol/kg gdy T2* GE EPI
prędkość: > 3 mL/s, zazwyczaj 5 mL/s

Skanowanie (< 2 minuty, rozdzielczość czasowa 1-2 s):

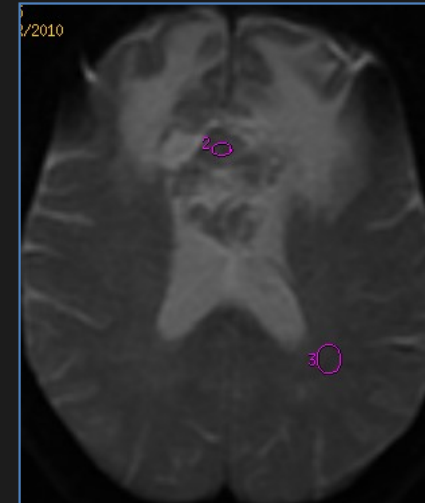
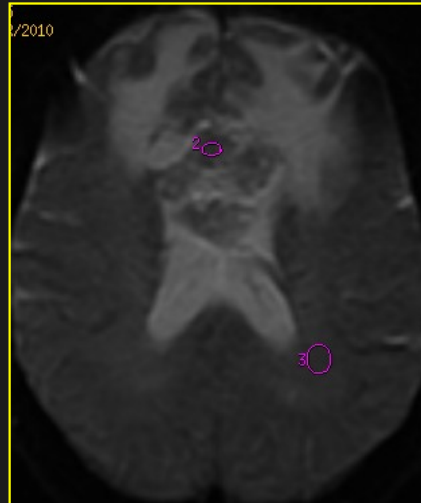
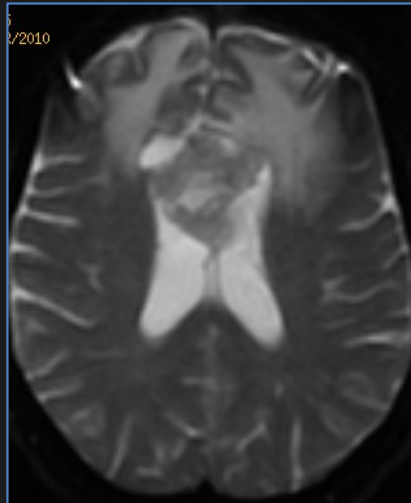
Przed, w trakcie i po pierwszym przejściu bolusa kontrastu
bolus dociera do mózgu po ok. 10-12 s

Zakres badania: cały mózg

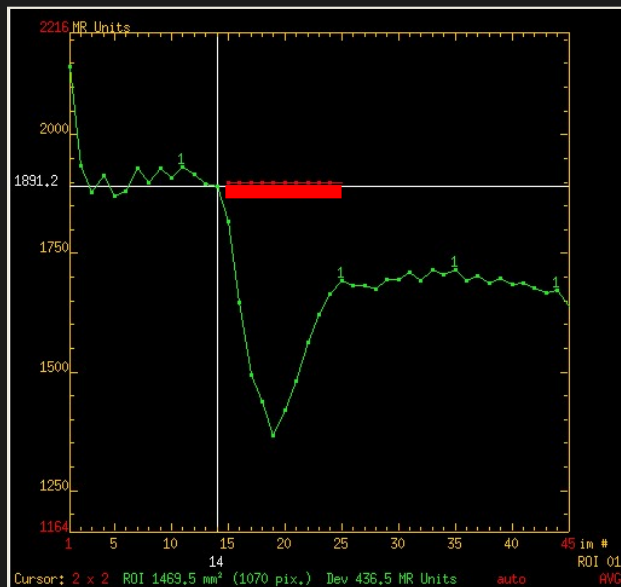
Grubość warstwy: 5-8 mm,



Pierwsze przejście środka kontrastowego



spadek sygnału na obrazach T2/T2*

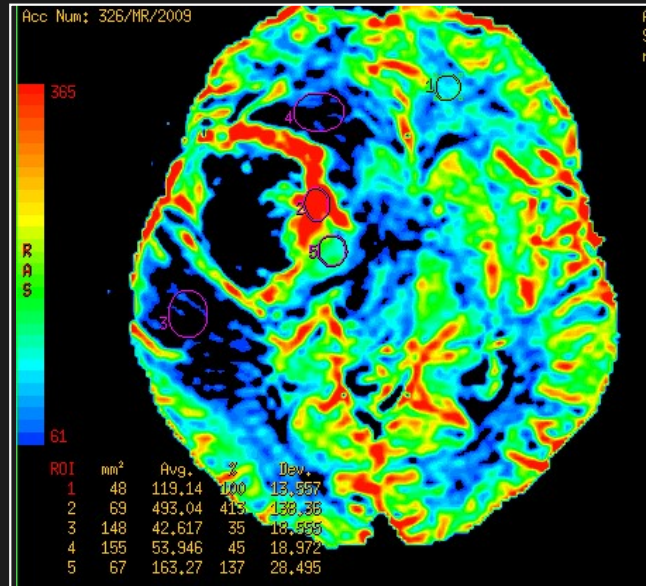


Krzywa perfuzyjna

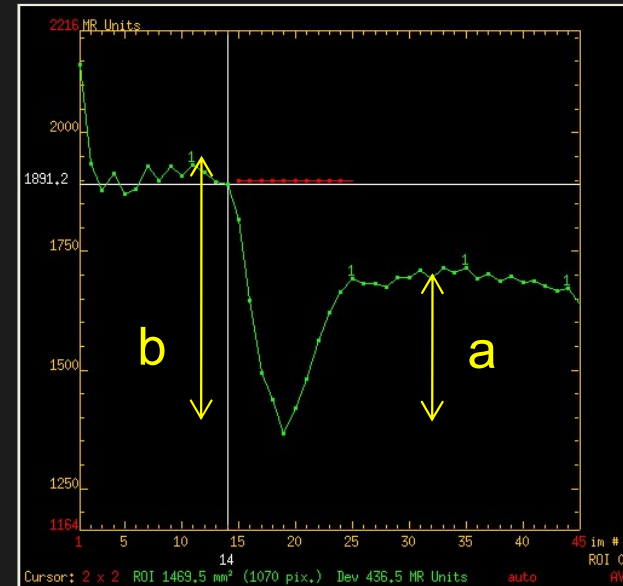
Krzywa intensywności sygnału

Postprocessing - DSC

Mapy perfuzyjne



Krzywa perfuzyjna



linia
bazowa

CBV – cerebral blood volume

CBF – cerebral blood flow

MTT – mean transit time $MTT = CBV / CBF$

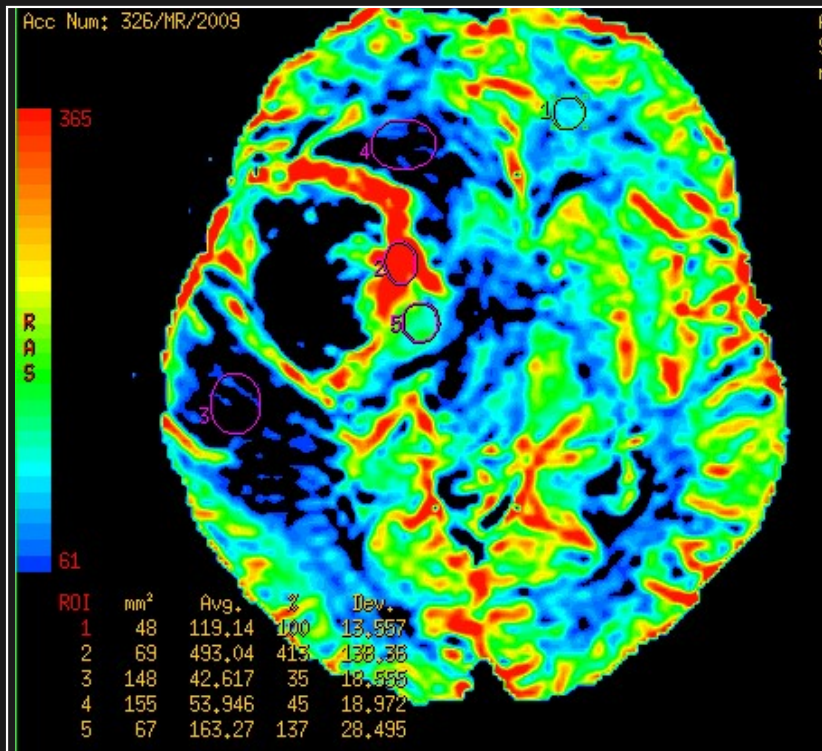
TTP – time to peak

PH – peak height (b) \approx CBF

PSR – percentage of signal recovery (b/a)

DSC - wynik

metoda półilościowa,
parametry muszą być porównane do wartości z przeciwnej półkuli,
zazwyczaj do prawidłowo wyglądającej istoty białej (nawm)
(rCBV, rCBF, rPSR etc)



$$rCBV = CBV \text{ ze zmiany} / CBV \text{ nawm}$$

mapa CBV

Zastosowanie kliniczne

- Guzy mózgu
- Zmiany naczyniowe
- Zmiany zapalne (infekcyjne i nieinfekcyjne)
- Zmiany demielinizacyjne

Guzy

wewnątrzczaszowe

- glejaki
- przerzuty
- chłoniak pierwotny

zewnątrzczaszowe

- oponiaki
- nerwiaki

Glejaki

Najważniejsze parametry: rCBV, max. rCBV

- marker neoangiogenezy, koreluje z gęstością kapilar
- koreluje ze stopniem złośliwości guza

↑ rCBV

oznacza

↑ złośliwości

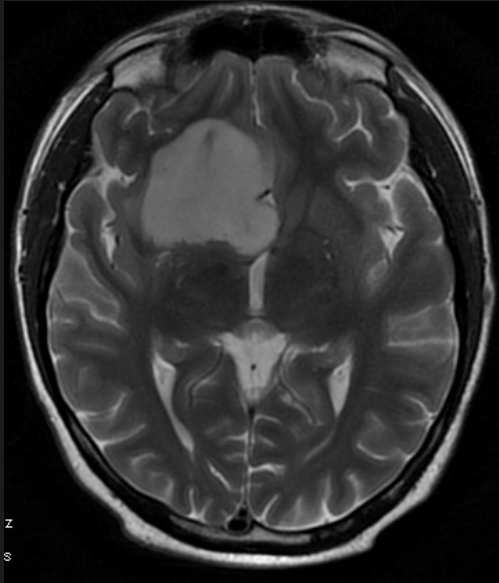
low grade

< **1.75** >

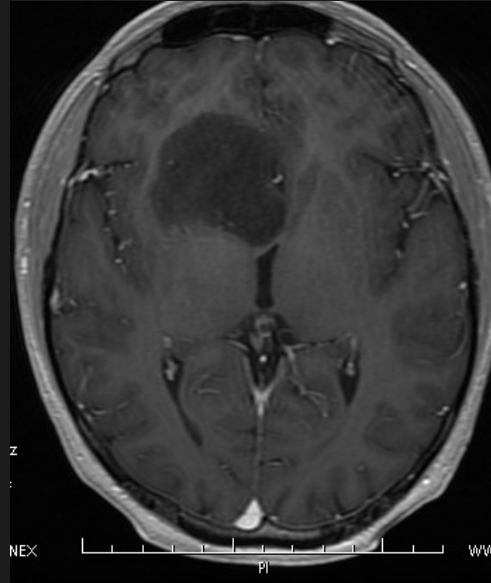
high grade

Low grade glioma

T2

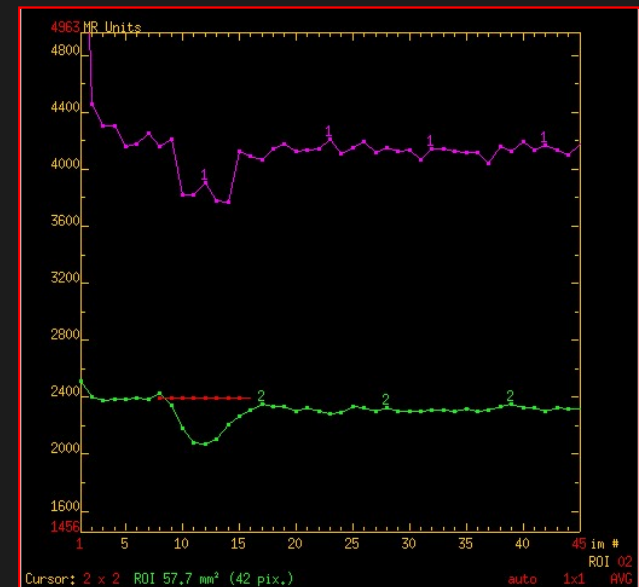
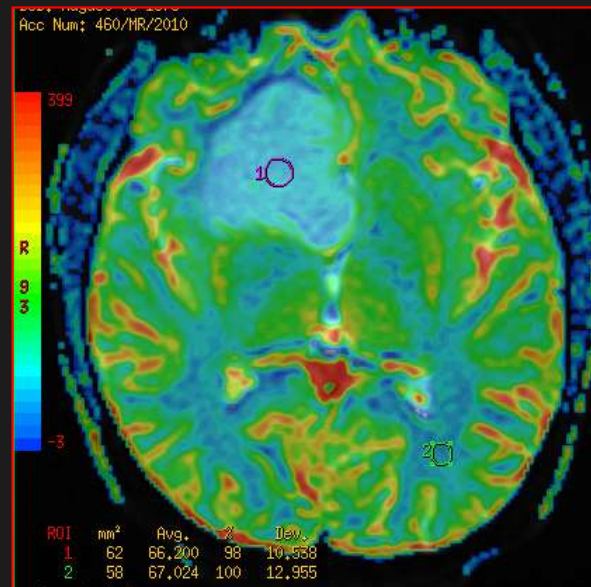


T1+C

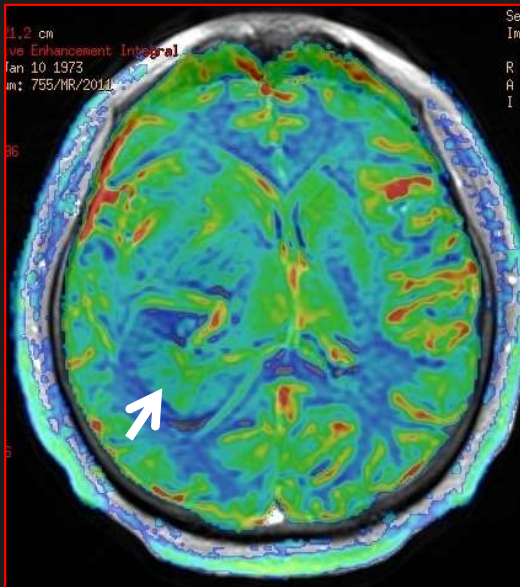
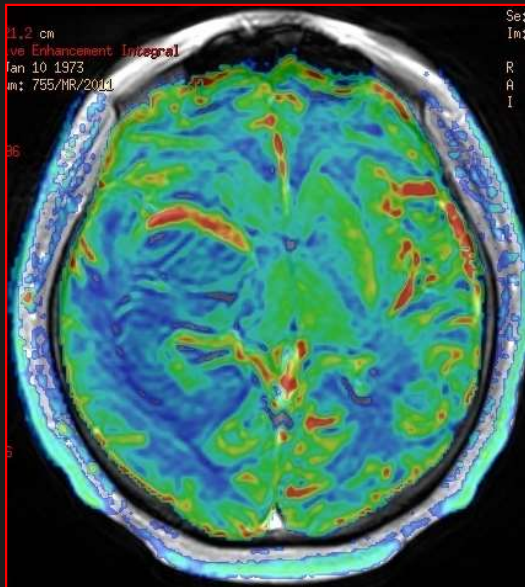
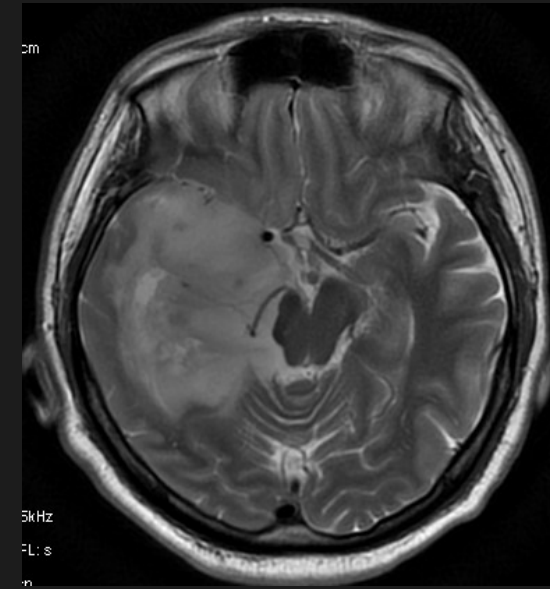
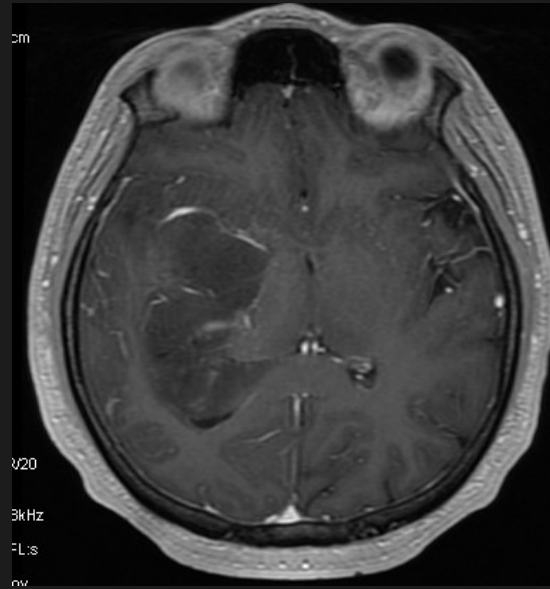
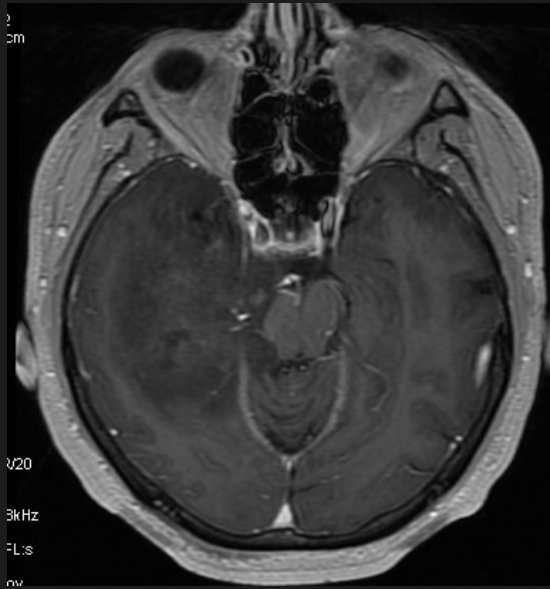


Diffuse astrocytoma
WHO 2

rCBV = 0.9



WHO 2/3 astrocytoma

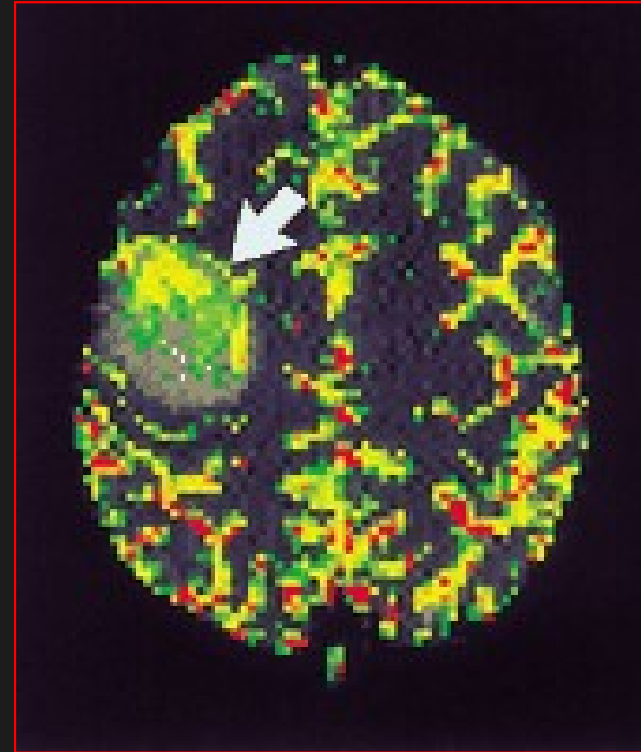
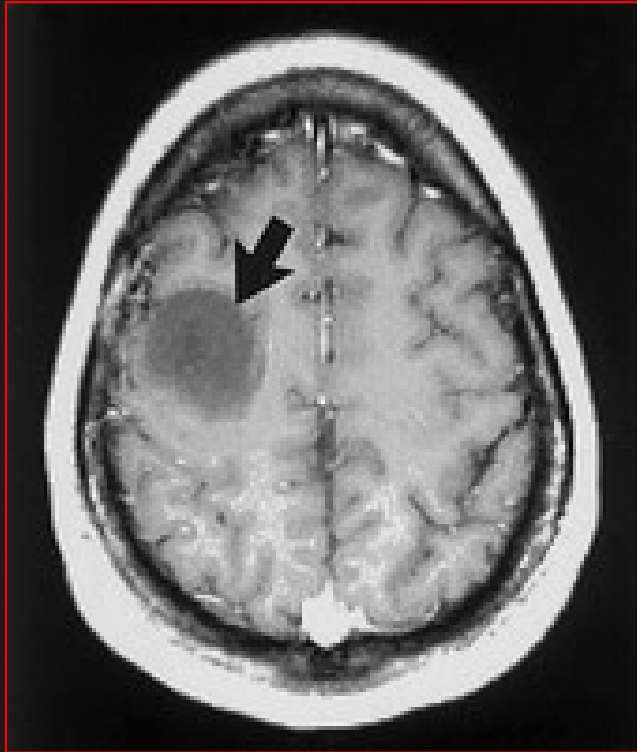


obszar hiperperfuzji (strzałki)
rCBV 2.1
wzrost złośliwości (WHO 3)

miejsce biopsji !!!

Anaplastic astrocytoma
progresja z WHO 2 do 3

LGG czy HGG ??

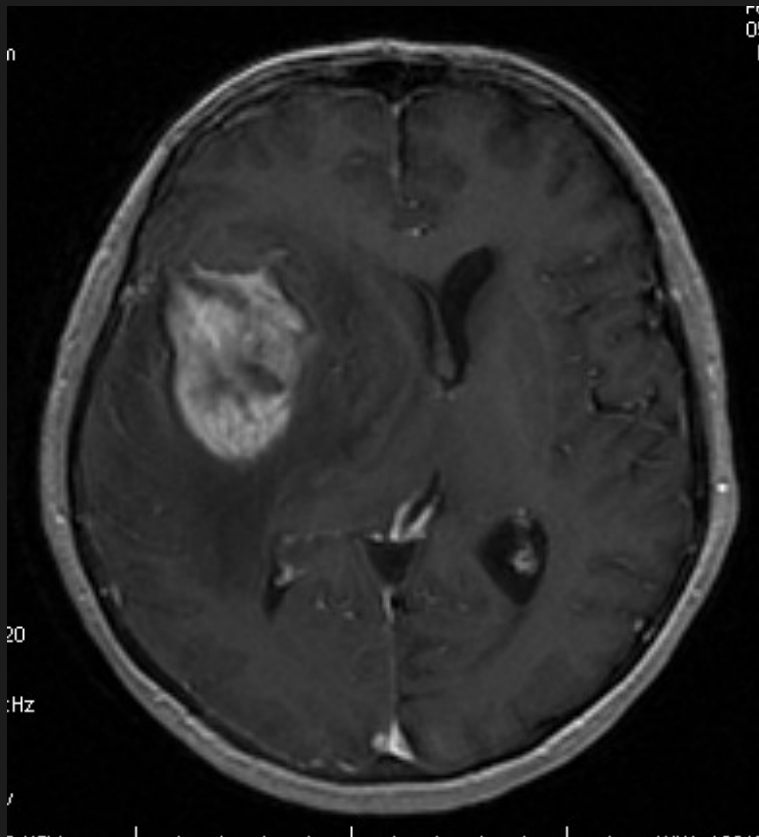


guz nie ulegający wzmocnieniu kontrastowemu sugeruje astrocytoma WHO 2,
biopsja z obszaru o podwyższonym rCBV - gwiazdziak anaplastyczny WHO 3,
brak wzmocnienia nie oznacza braku neoangiogenezy
30% HGG nie ulega wzmocnieniu po podaniu środka kontrastowego

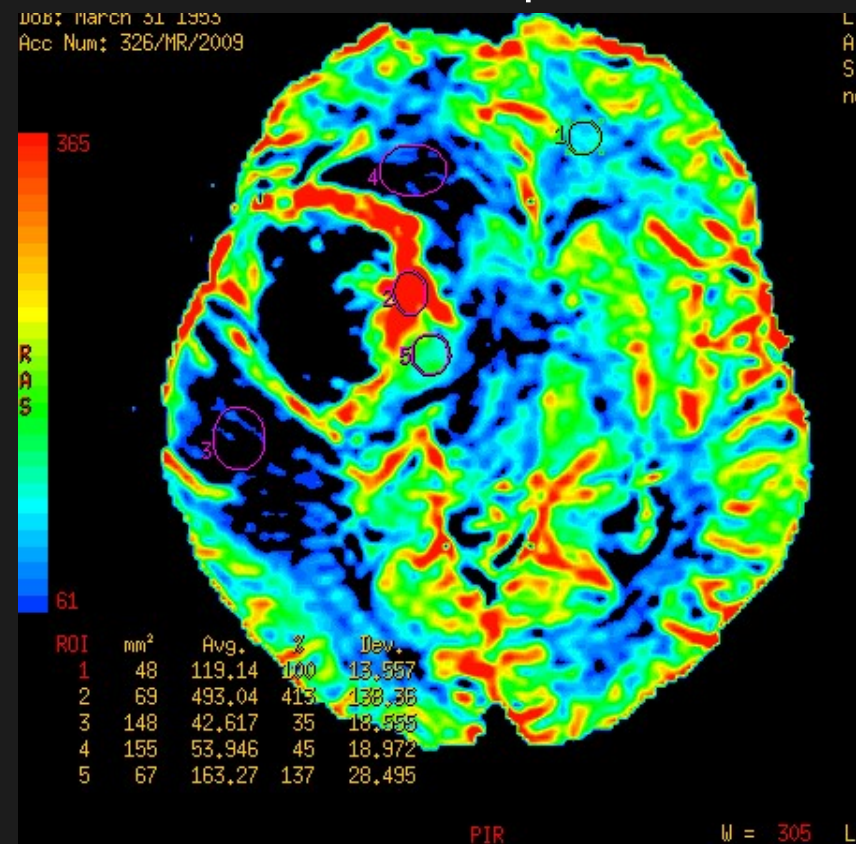
Cha S. et al. Intracranial mass lesions: dynamic contrast-enhanced susceptibility weighted echo-planar perfusion MR imaging. RSN 2002;223:11-29.

Glioblastoma - GBM

T1 + C



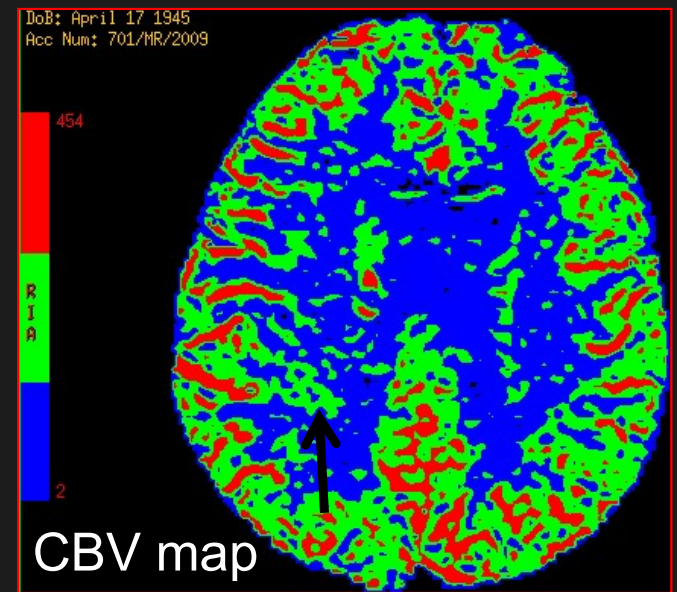
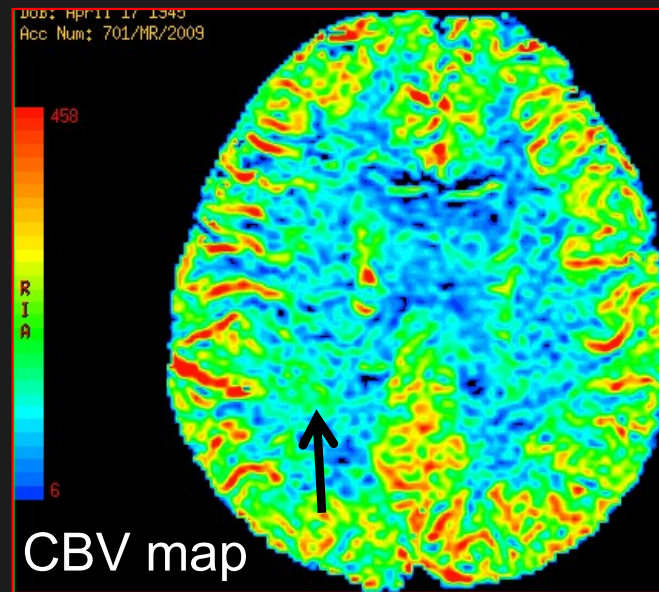
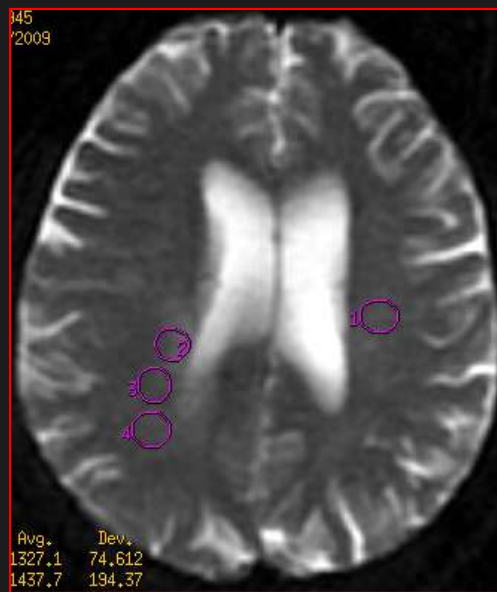
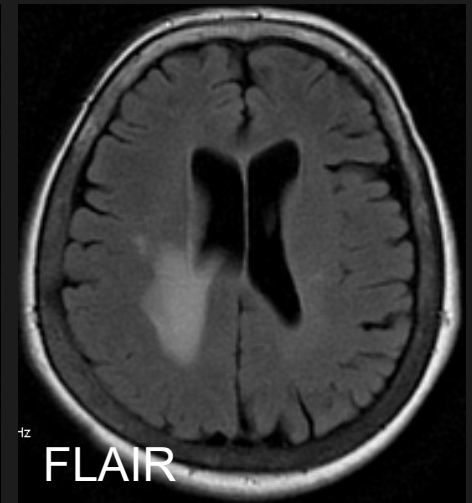
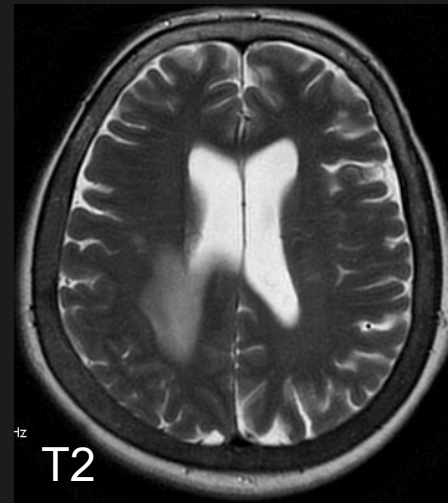
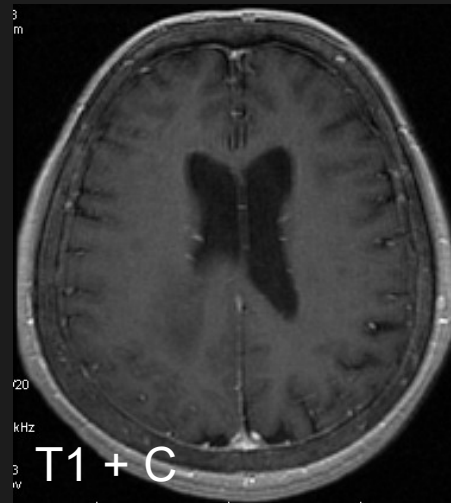
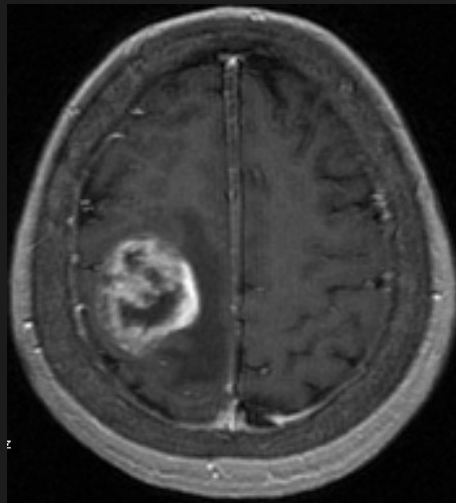
CBV map



Wysokie wartości rCBV w bogato komórkowej części guza

HGG – infiltracja nowotworowa

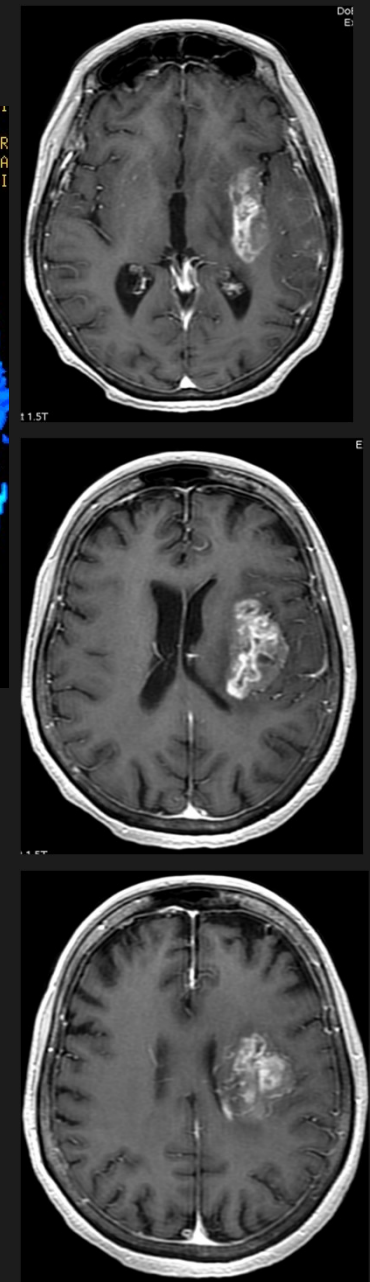
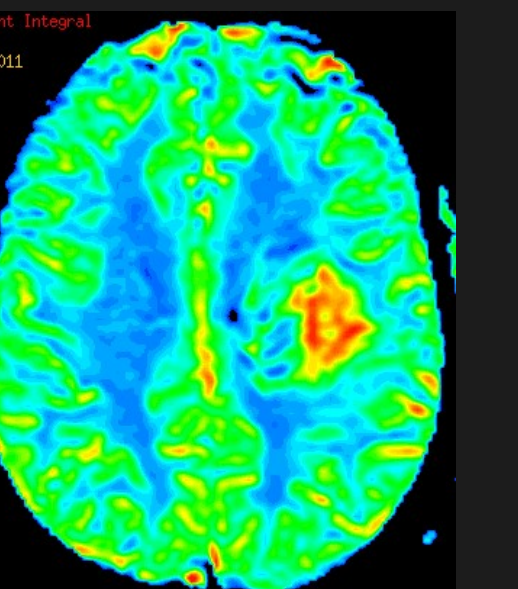
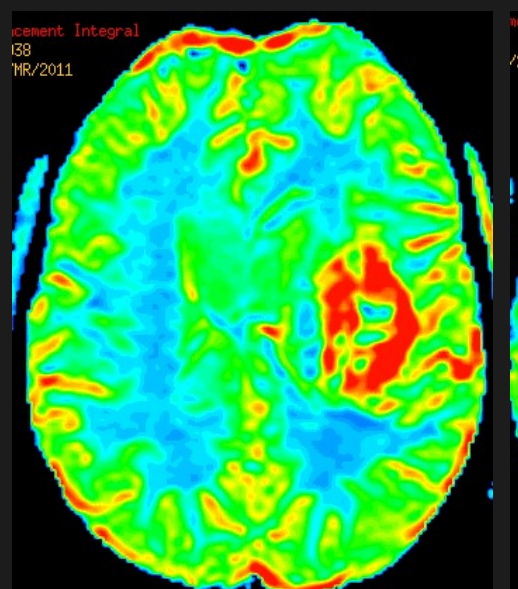
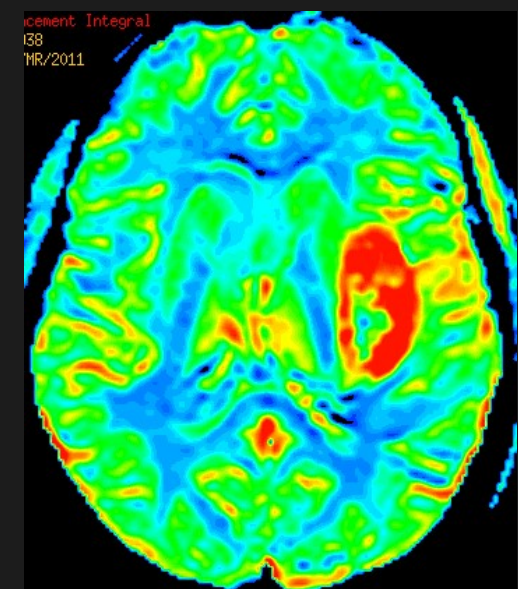
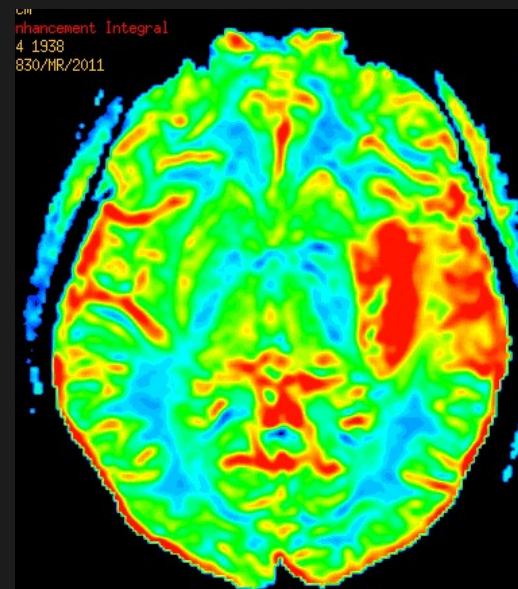
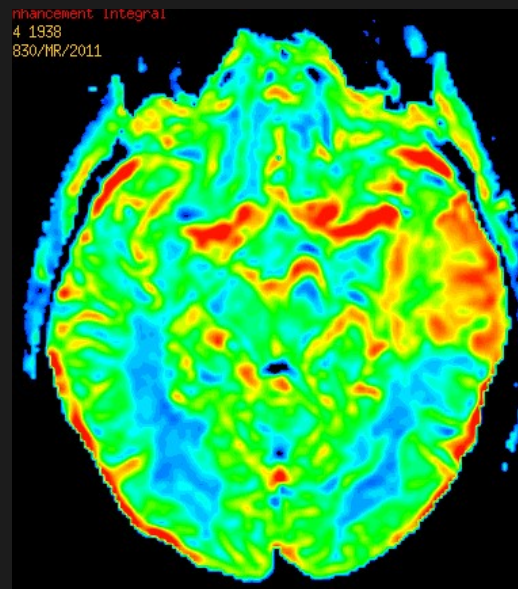
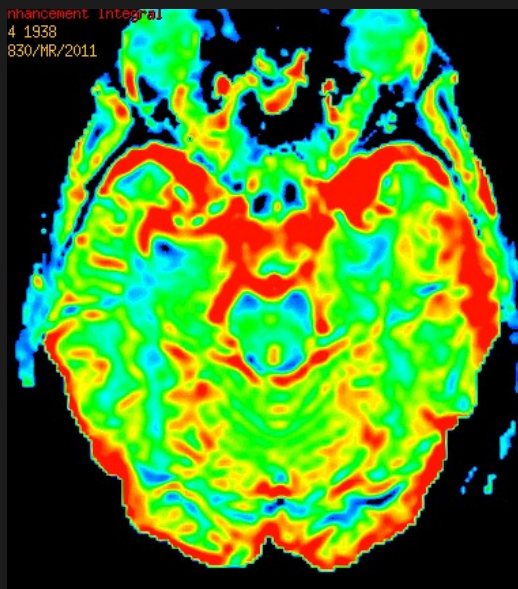
GBM



$$rCBV = 1.8$$

Rozległość nacieku npl

Glioblastoma



Wyjątki !!!

- Oligodendroglioma (skąpodrzewiak)
- Astrocytoma pilocyticum
- LGG z wysokimi wartościami rCBV !!

WHO 2 oligodendroglioma

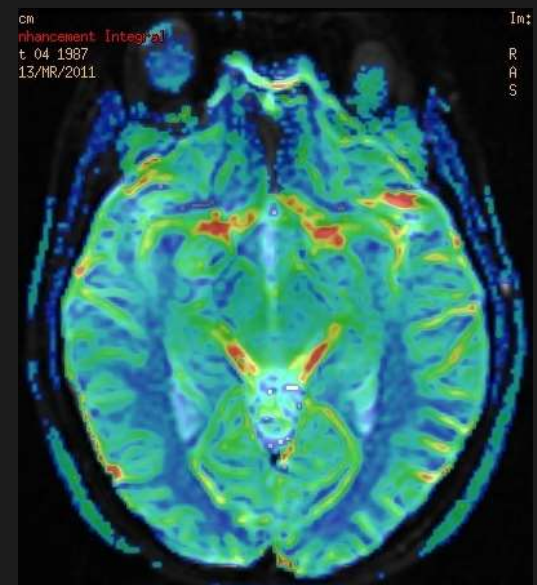
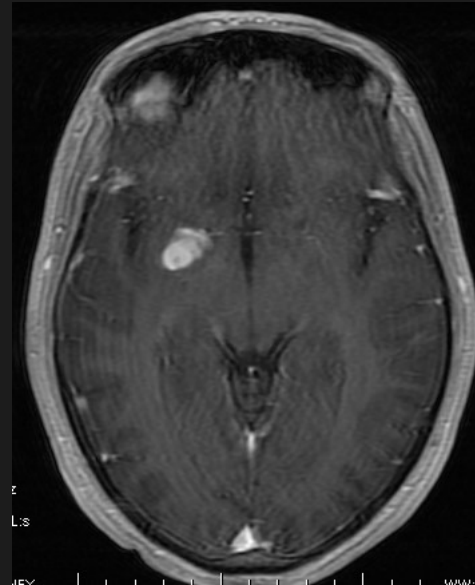
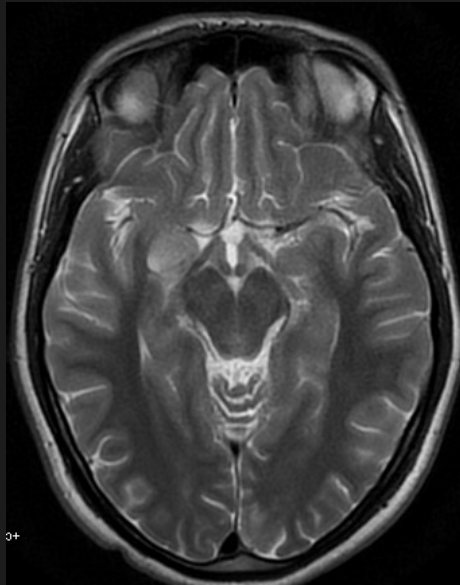
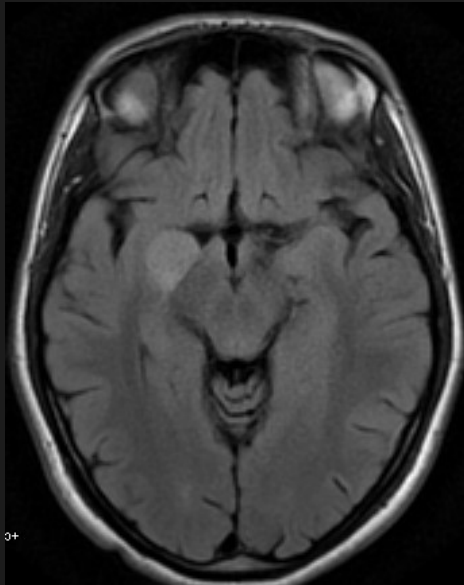


Lokalizacja korowa

Zwapnienia w T K

Silne wzmocnienie kontrastowe

Hiperperfuzja (rCBV = 2.5)



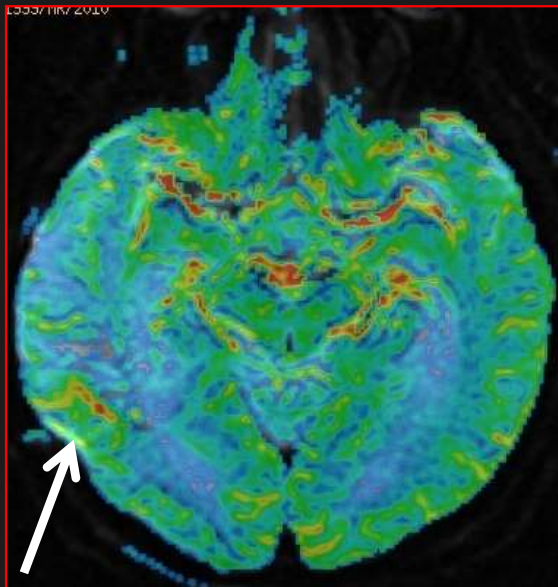
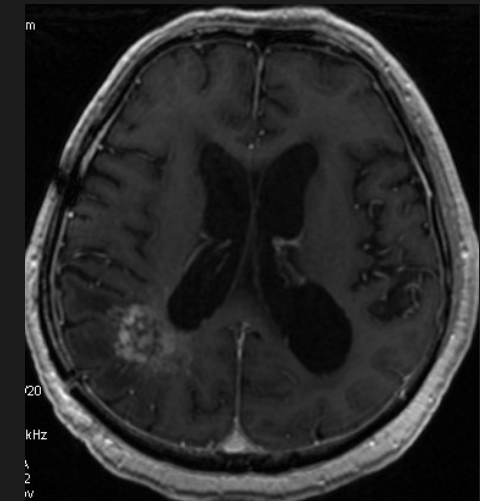
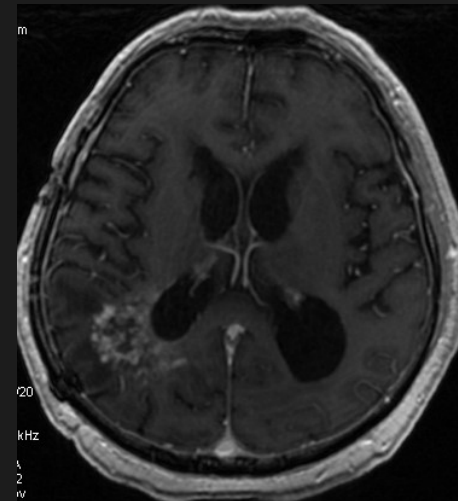
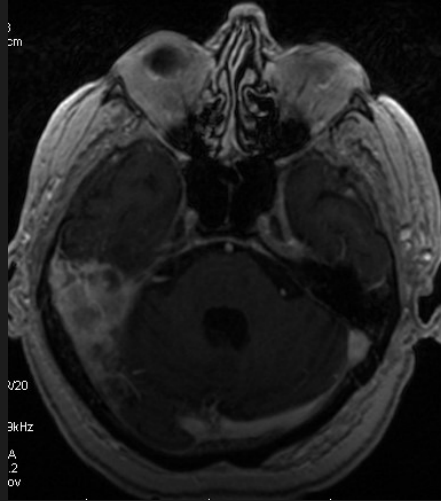
Rola perfuzji w gwiąździakach

- Różnicowanie z innymi zmianami ogniskowymi w mózgu
- Stopniowanie guza (określanie złośliwości)
- Ocena rozległości nacieku
- Planowanie biopsji
- Follow-up w trakcie i po leczeniu

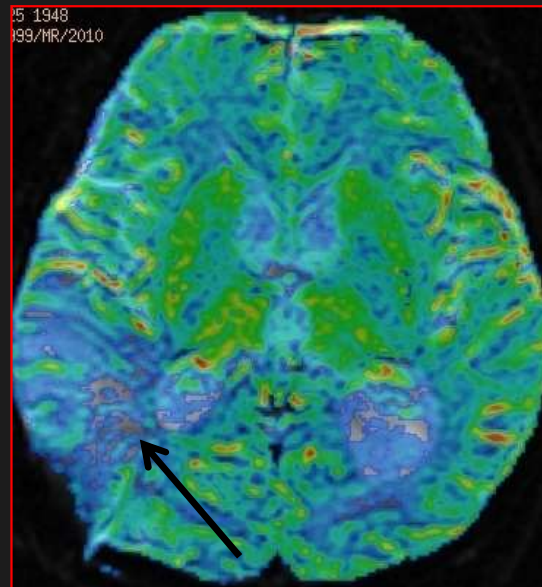
Wznowa npl i radioneekroza

GBM

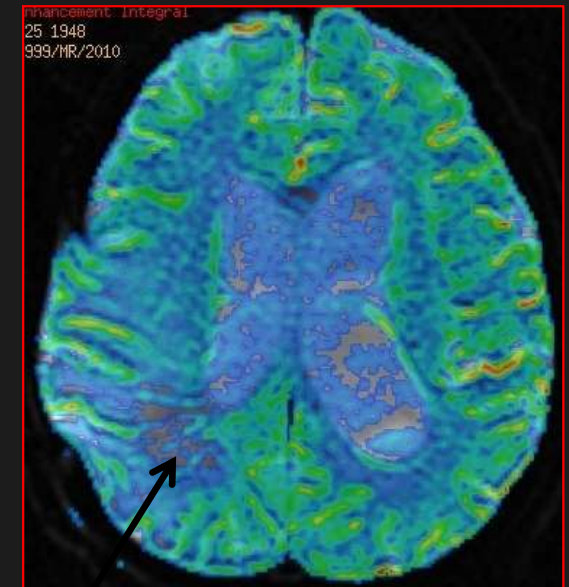
6 miesięcy
po
radio- i
chemioterapii



Wznowa npl (wzrost rCBV)



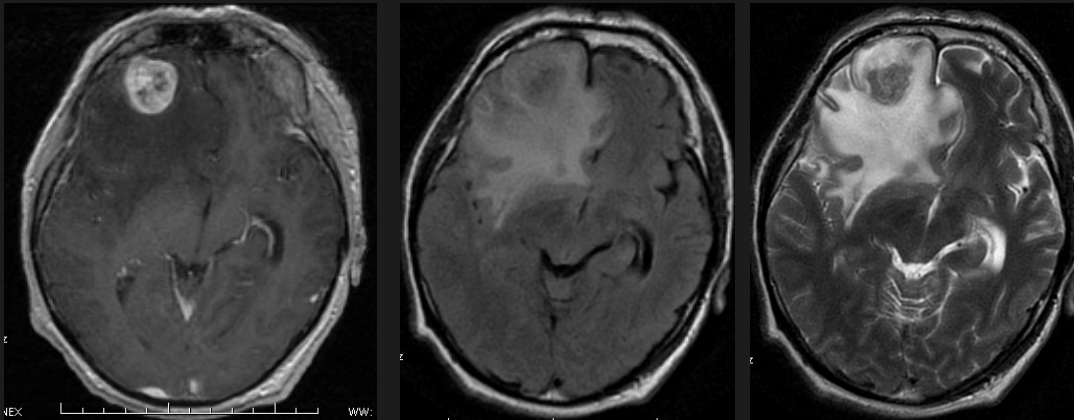
martwica popromienna (niskie rCBV)



Przerzuty

Guz – hiperperfuzja (neoangiogeneza), wysokie rCBV

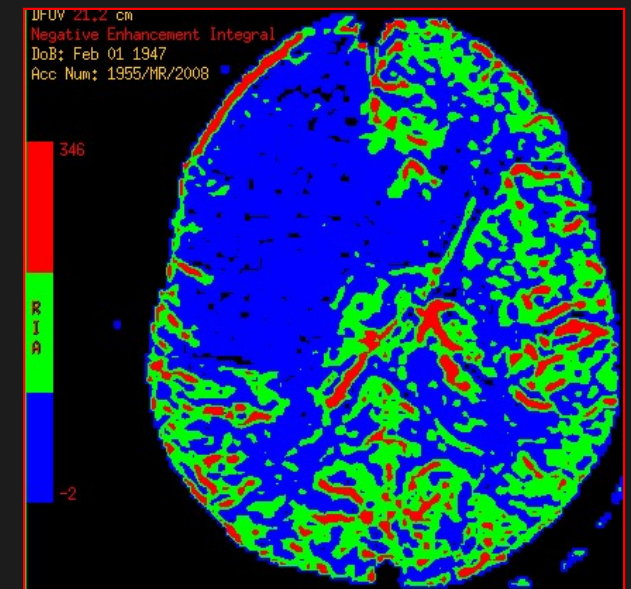
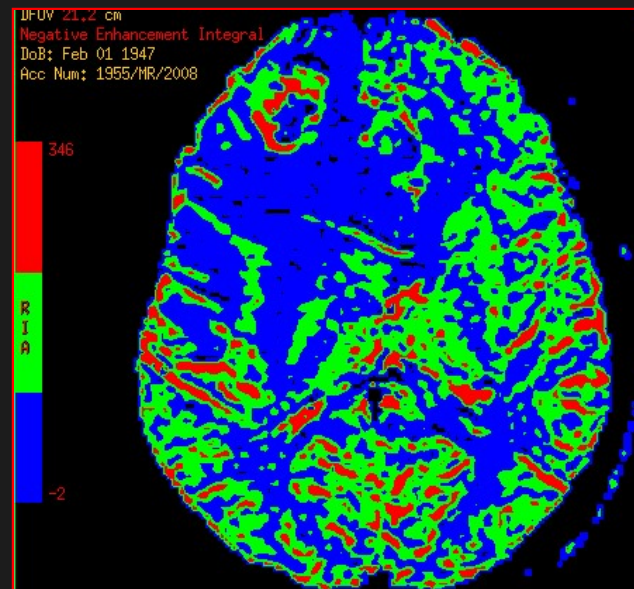
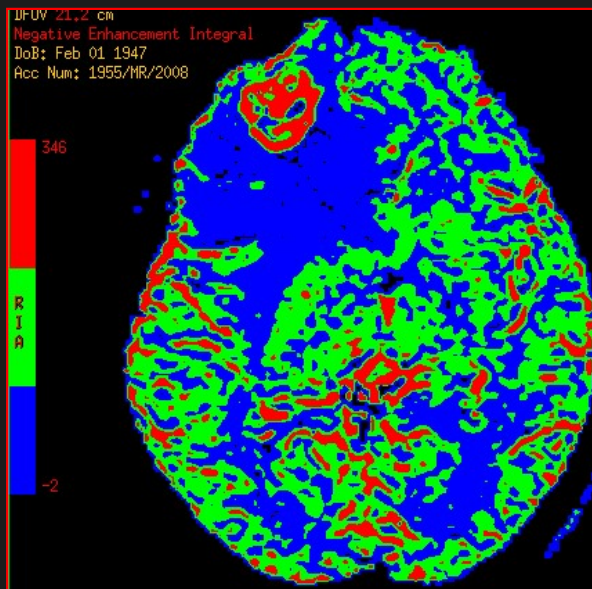
Obrzęk – brak infiltracji npl, czysty obrzęk wazogeny, niskie rCBV (poniżej 1.0)



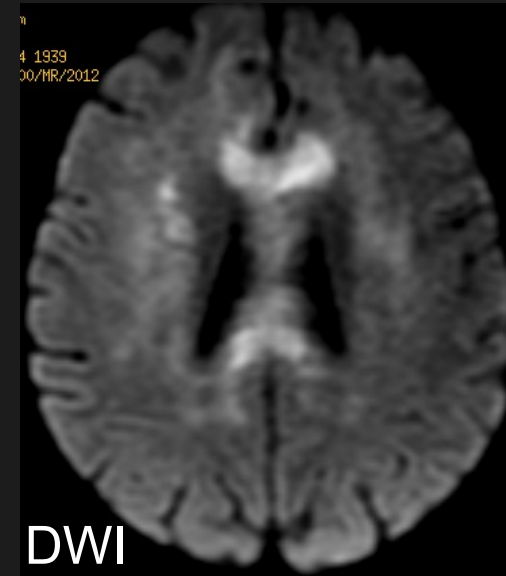
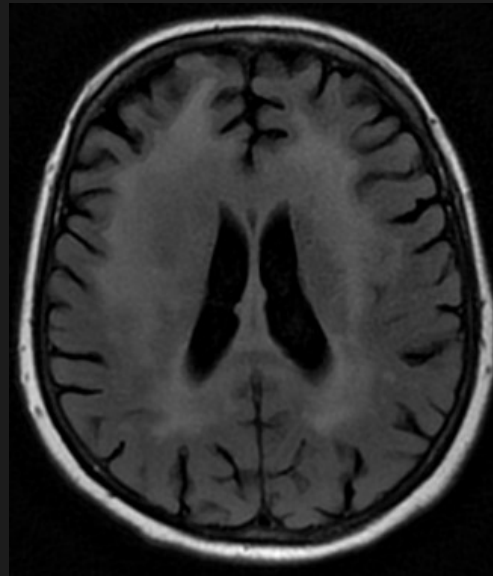
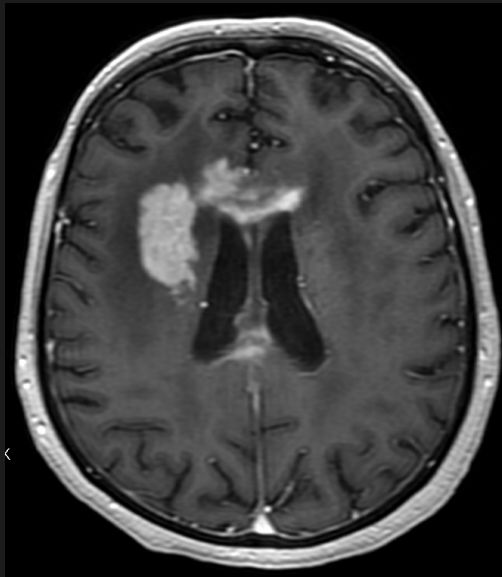
w obrzęku

śr. rCBV = 0.55

brak obszarów hiperperfuzji



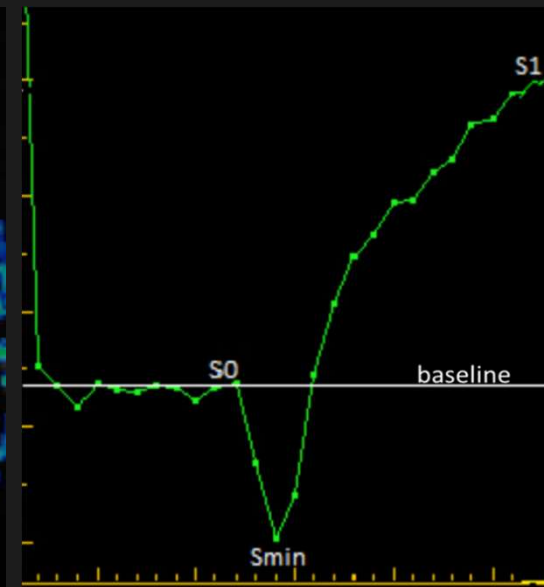
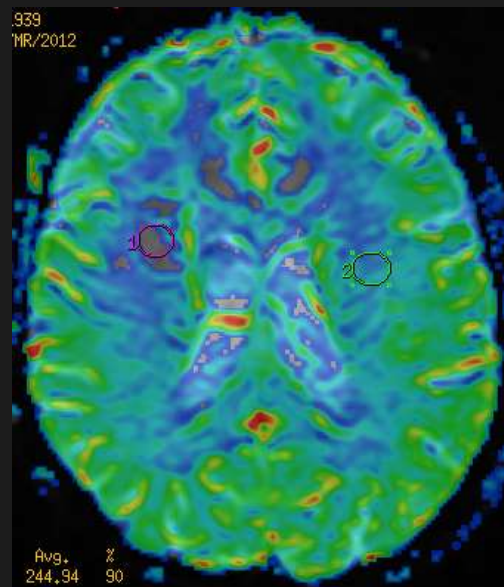
Pierwotny chłoniak mózgu



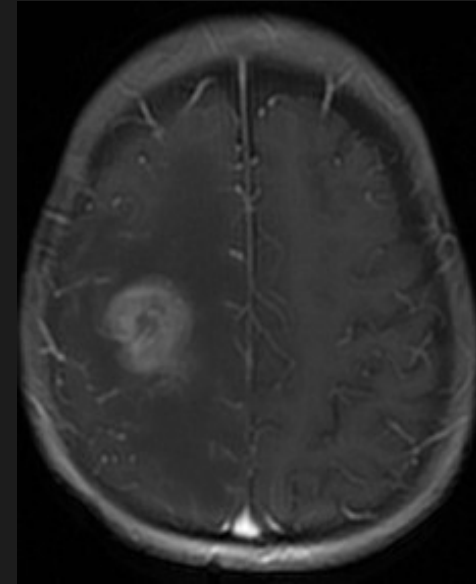
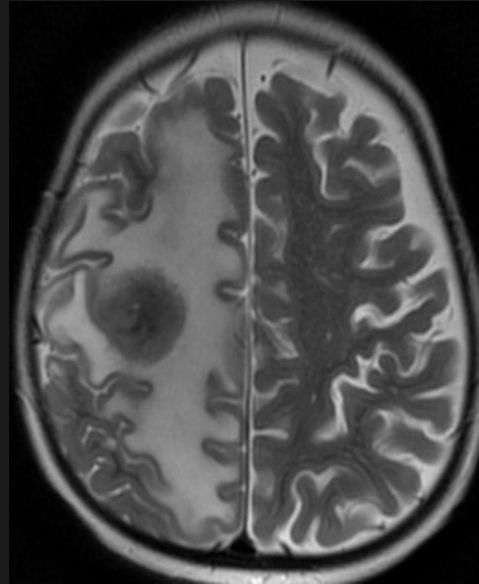
niskie rCBV
rzadko powyżej 2.2

istotnie niższe niż
HGG i meta

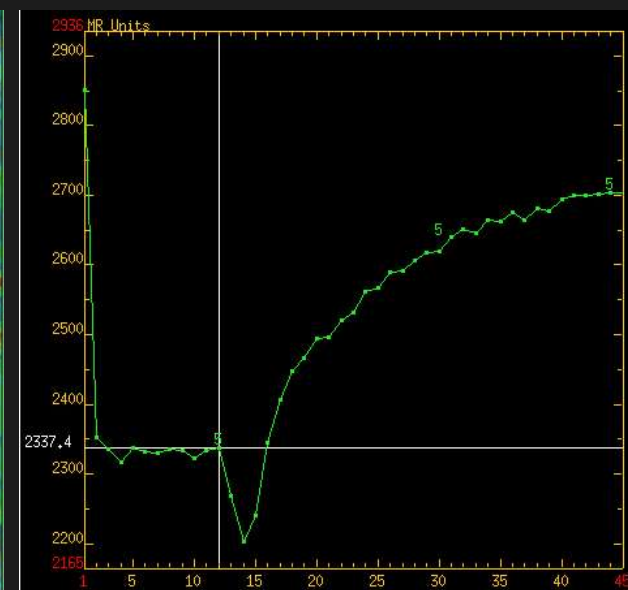
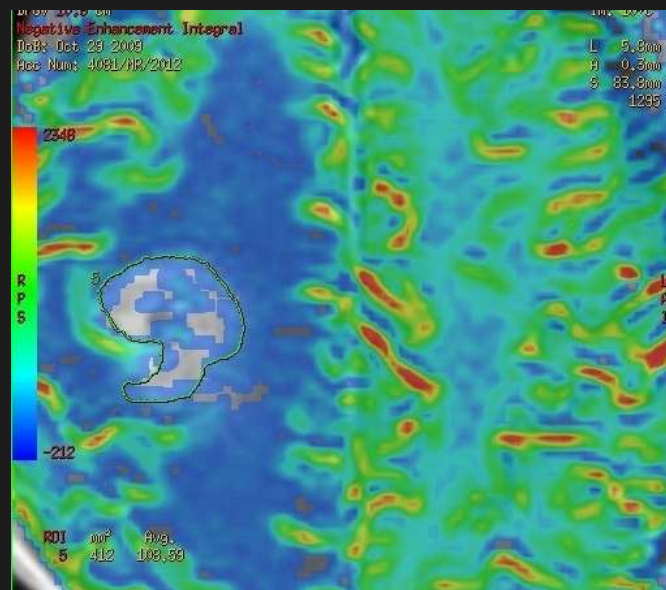
typowa krzywa perfuzyjna
przekraczająca linię bazową



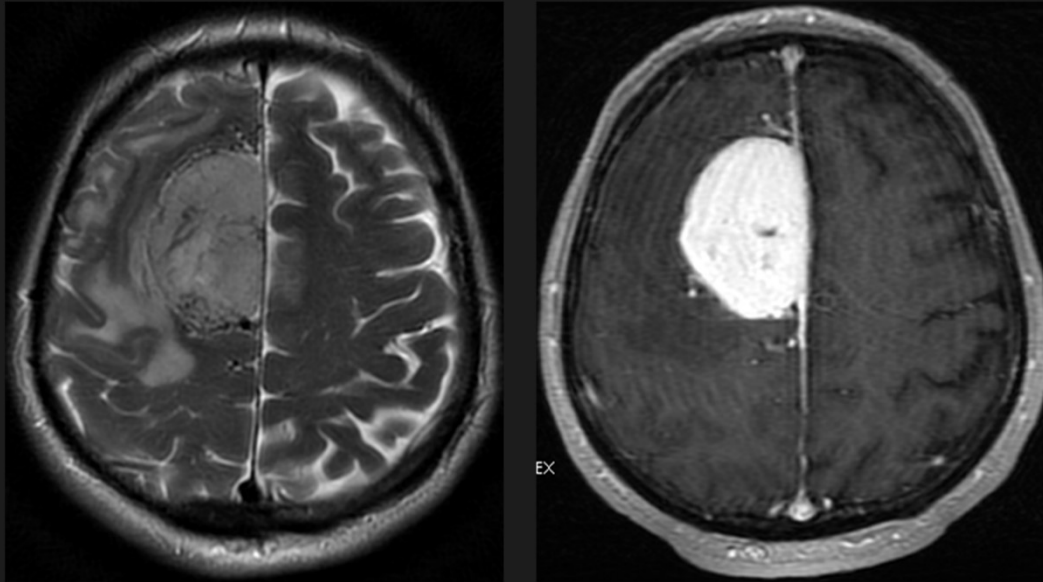
Pierwotny chłoniak mózgu



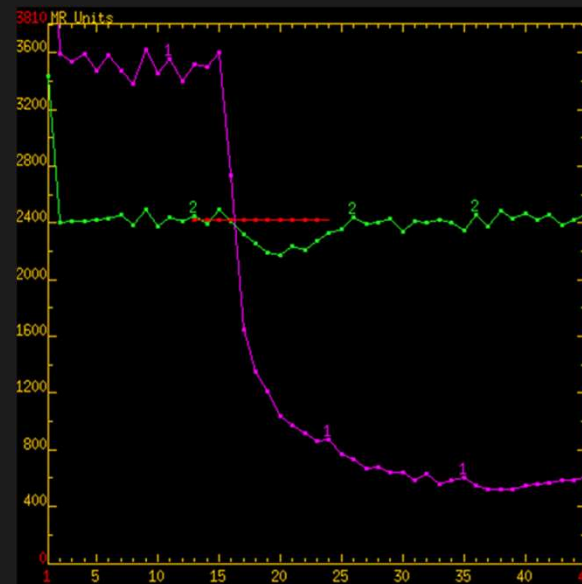
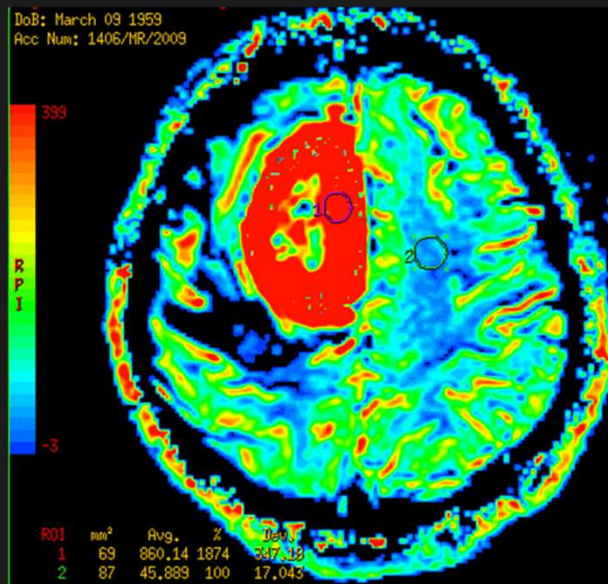
M, 3 lata,
imunosupresja
po 2 przeszczepach
szpiku



Oponiak



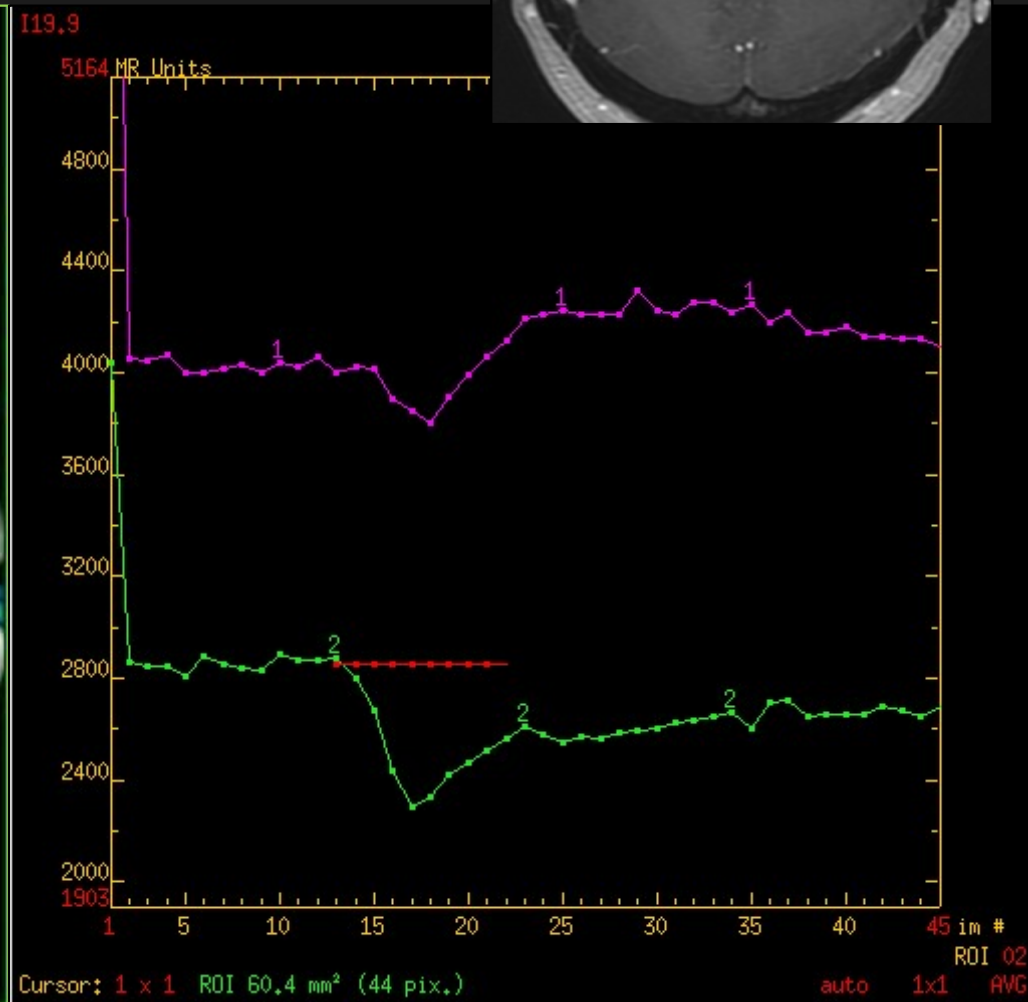
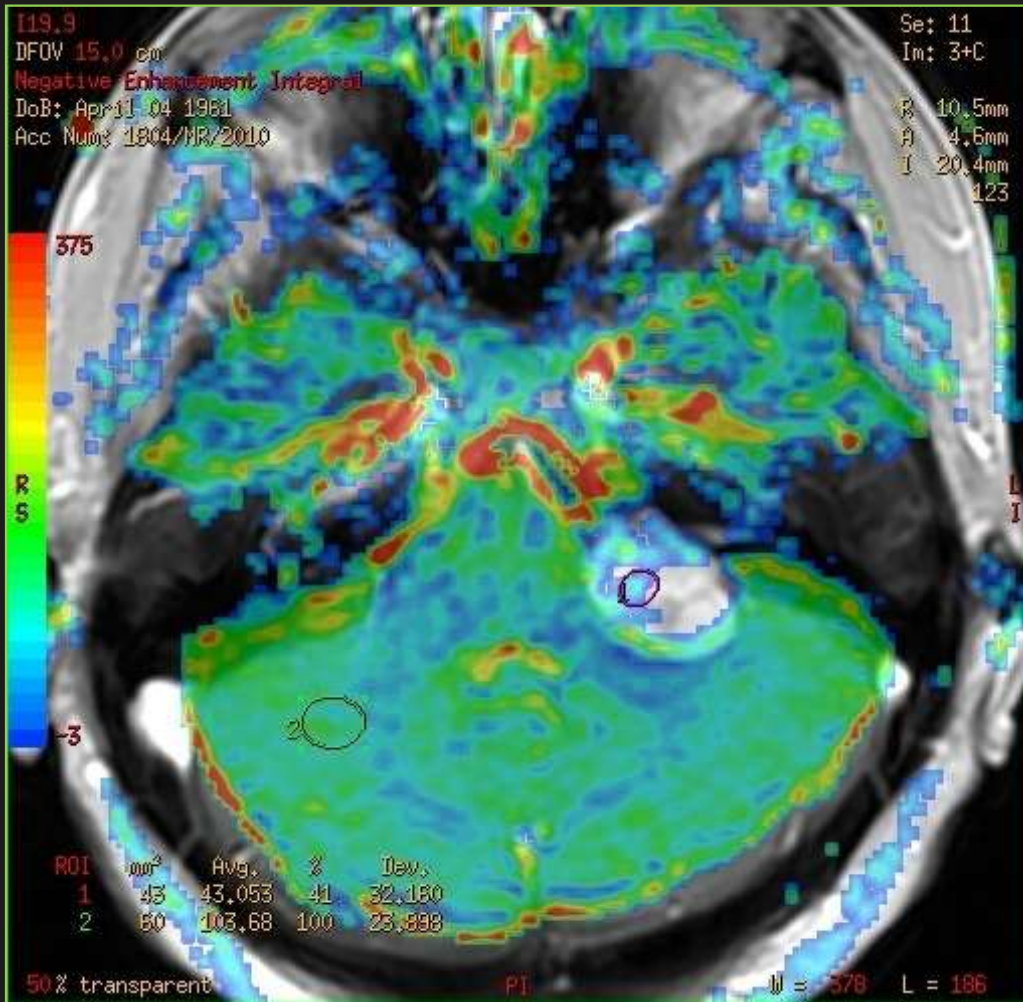
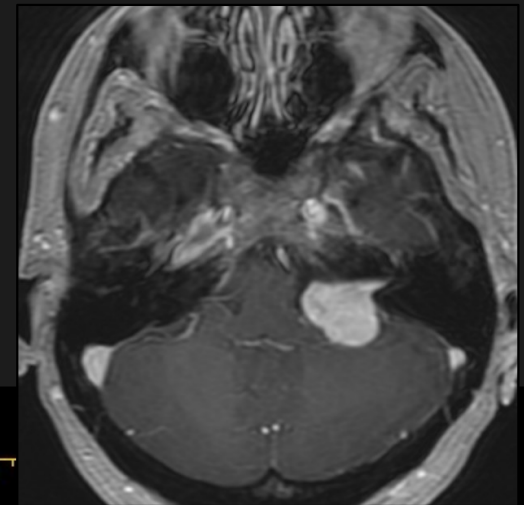
wysokie rCBV
z powodu neowaskularyzacji
i braku BBB,
nie oznacza złośliwości



typowa krzywa perfuzyjna
z niewielkim powrotem
do linii bazowej

Schwannoma

Niskie rCBV, krzywa z powrotem ponad linię bazową



rCBV= 0.4

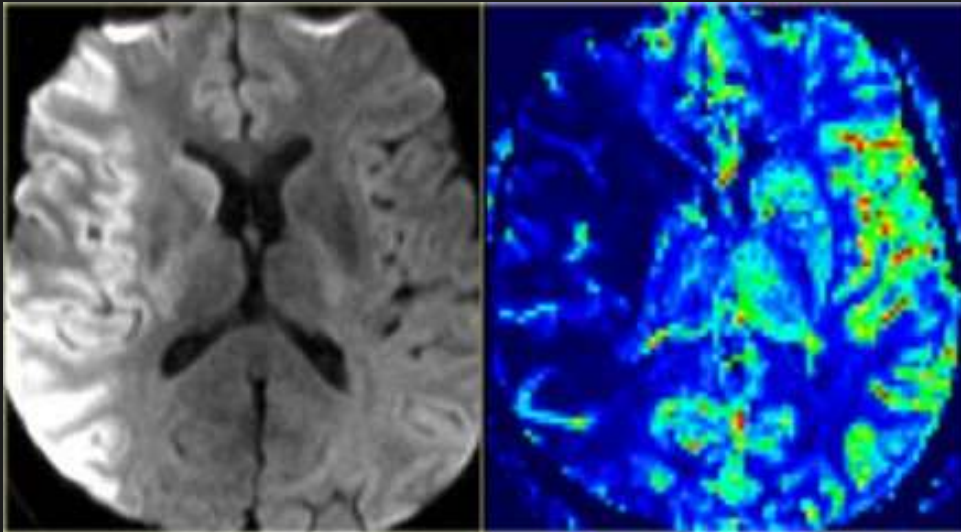
Zastosowanie kliniczne

- Guzy mózgu
- Zmiany naczyniowe
- Zmiany zapalne (infekcyjne i nieinfekcyjne)
- Zmiany demielinizacyjne

Udar niedokrwienny

diffusion

perfusion



martwica, nieodwracalne uszkodzenie

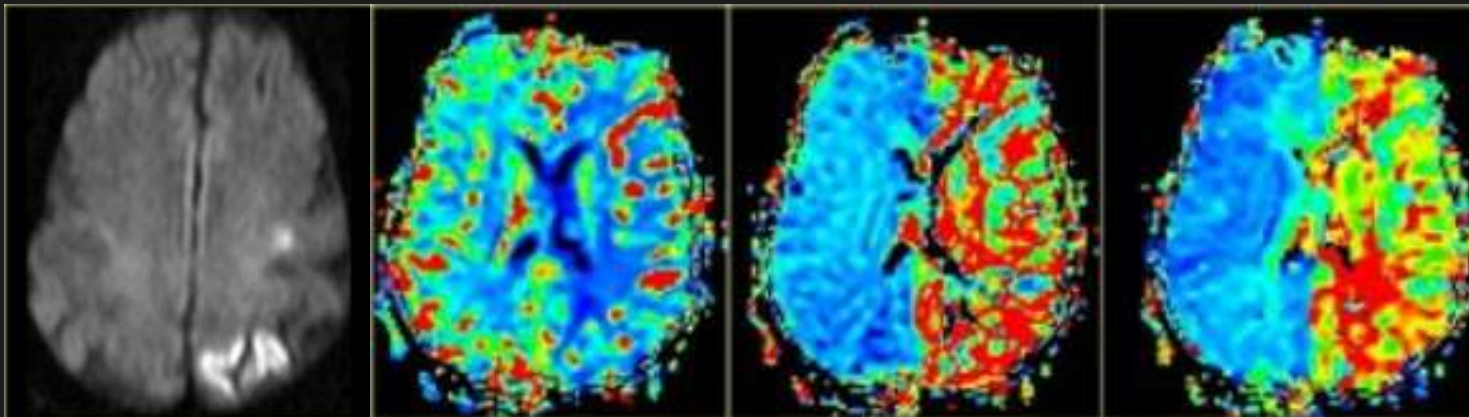
↑MTT, ↓CBF, ↓CBV

diffusion

CBF

CBV

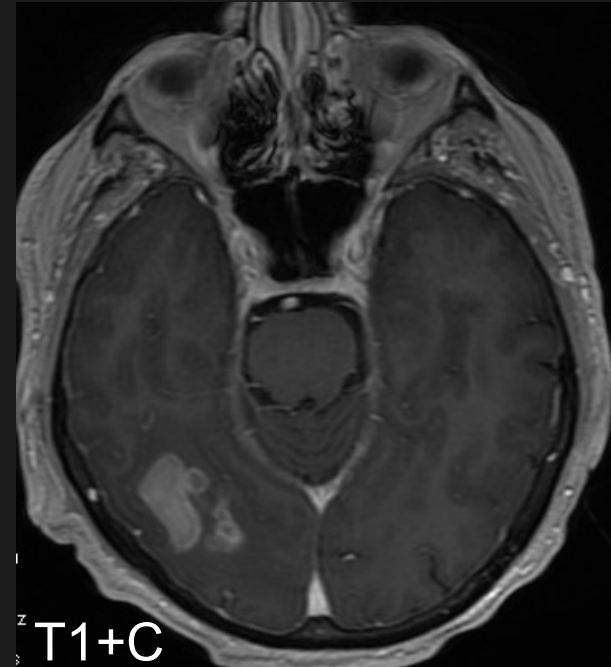
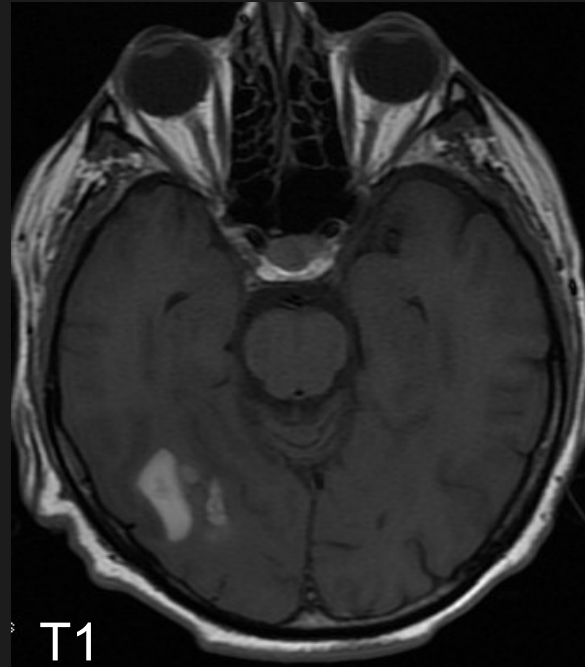
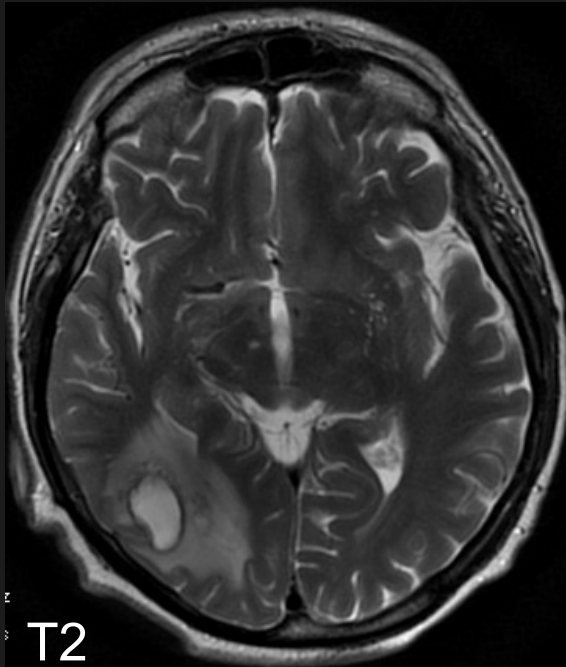
MTT



uszkodzenie
potencjalnie
odwracalne
(penumbra)

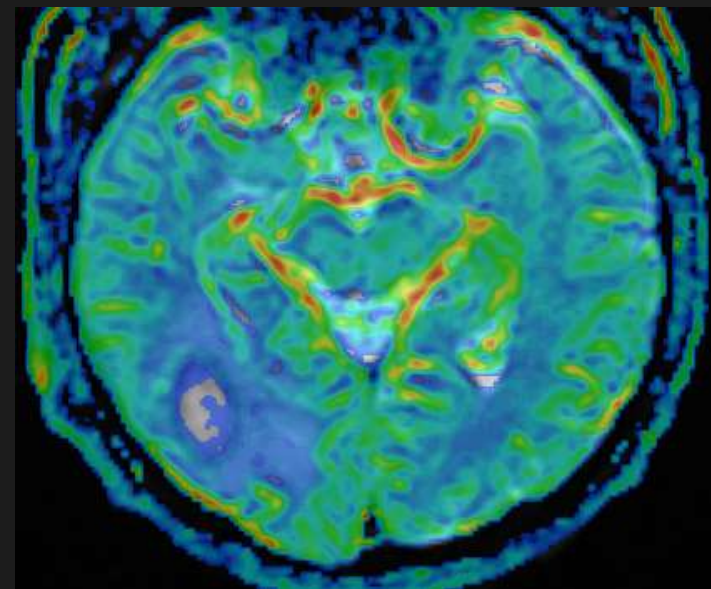
↑MTT, ↓CBF,
↑CBV

Krwiak śródmózgowy



wzmocnienie kontrastowe
torebki

niska perfuzja

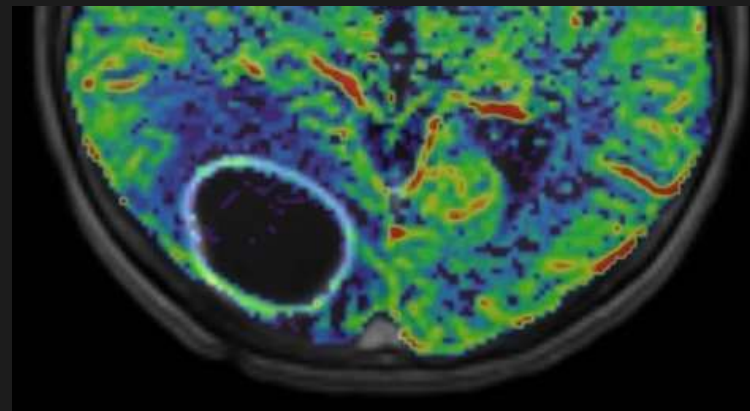
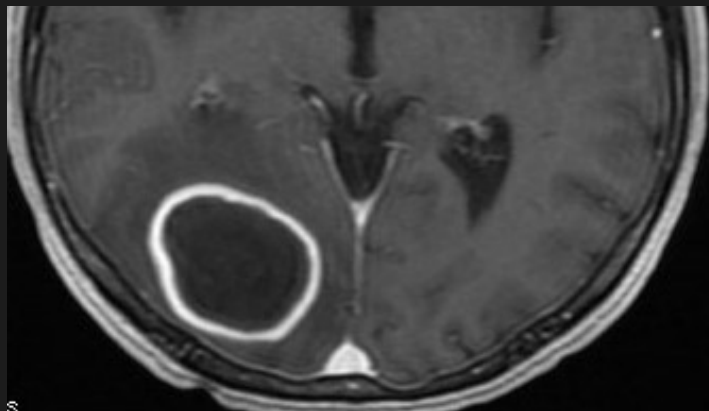
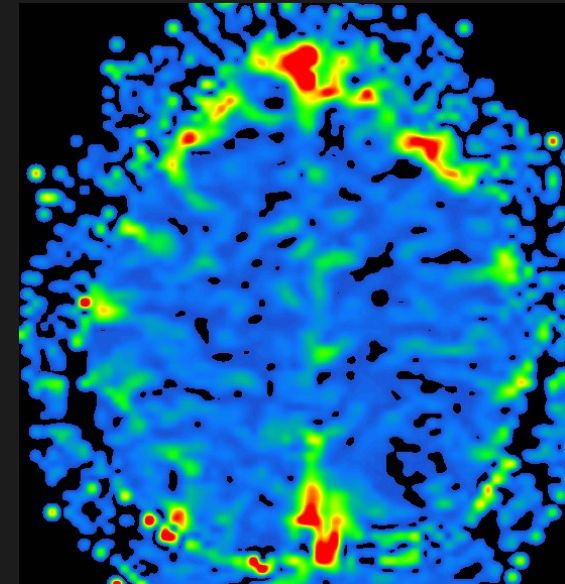
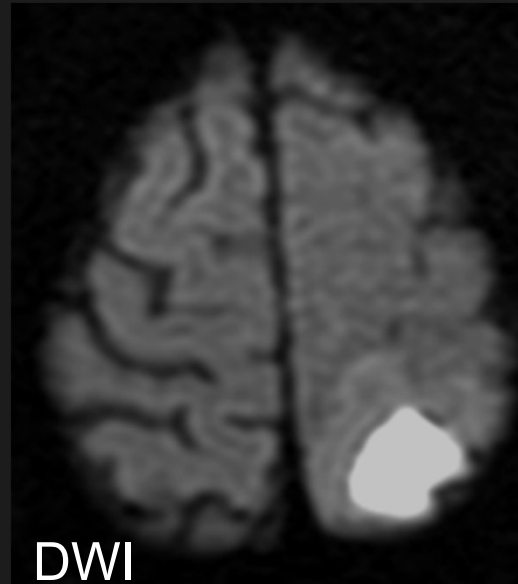
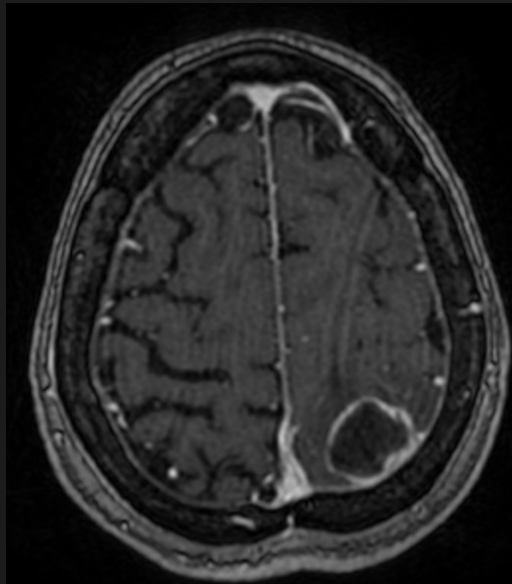


Zastosowanie kliniczne

- Guzy mózgu
- Zmiany naczyniowe
- Zmiany zapalne (infekcyjne i nieinfekcyjne)
- Zmiany demielinizacyjne

Ropień bakteryjny

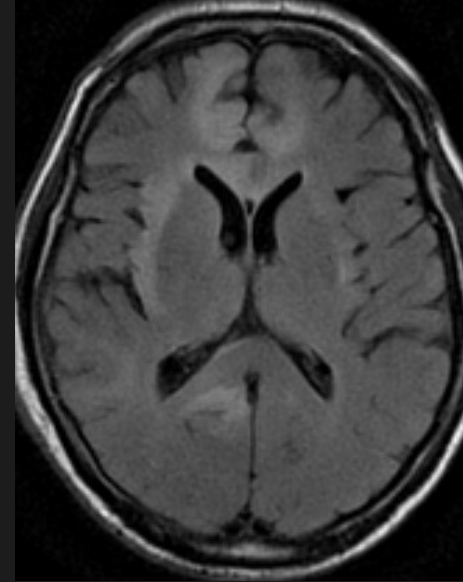
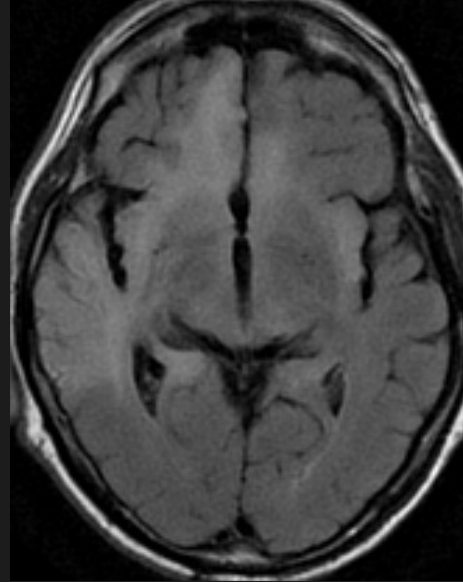
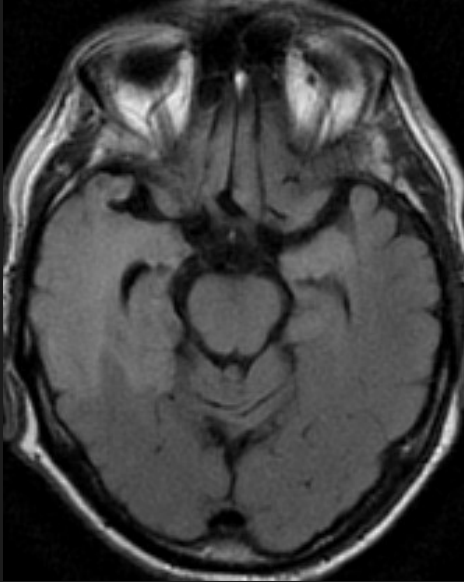
niskie rCBV w obrębie torebki – brak neoangiogenezy



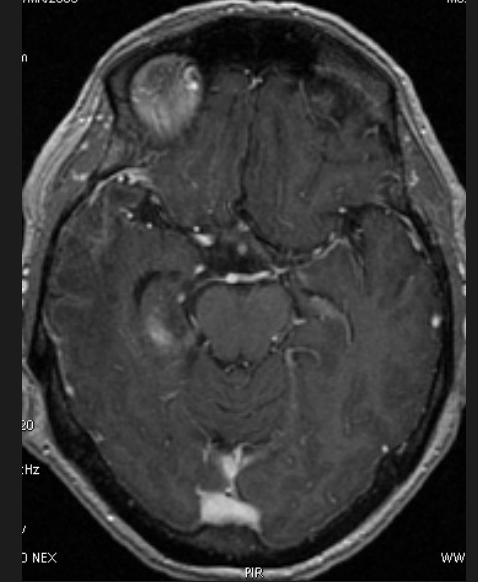
niewielka hiperperfuzja w obrębie torebki spowodowana dyskretną neowaskularyzacją lub uciskiem/stłoczeniem okolicznych naczyń

Herpes encephalitis

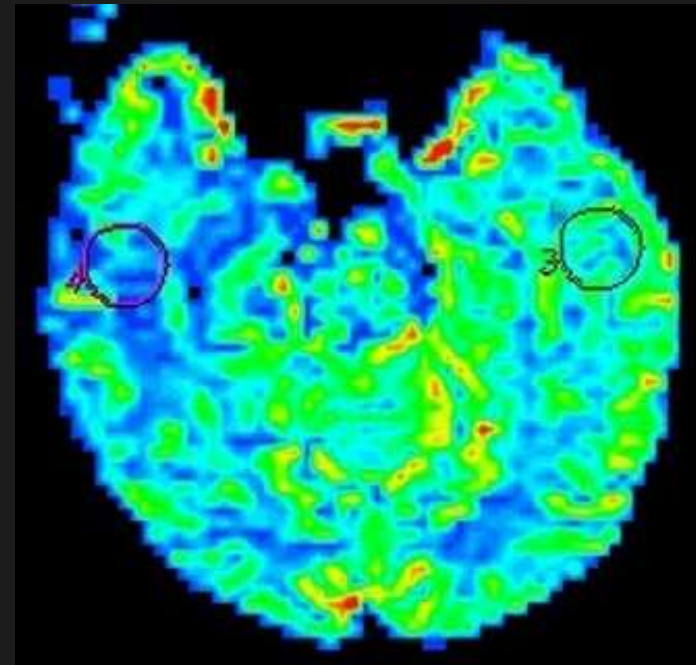
FLAIR



T1 + C



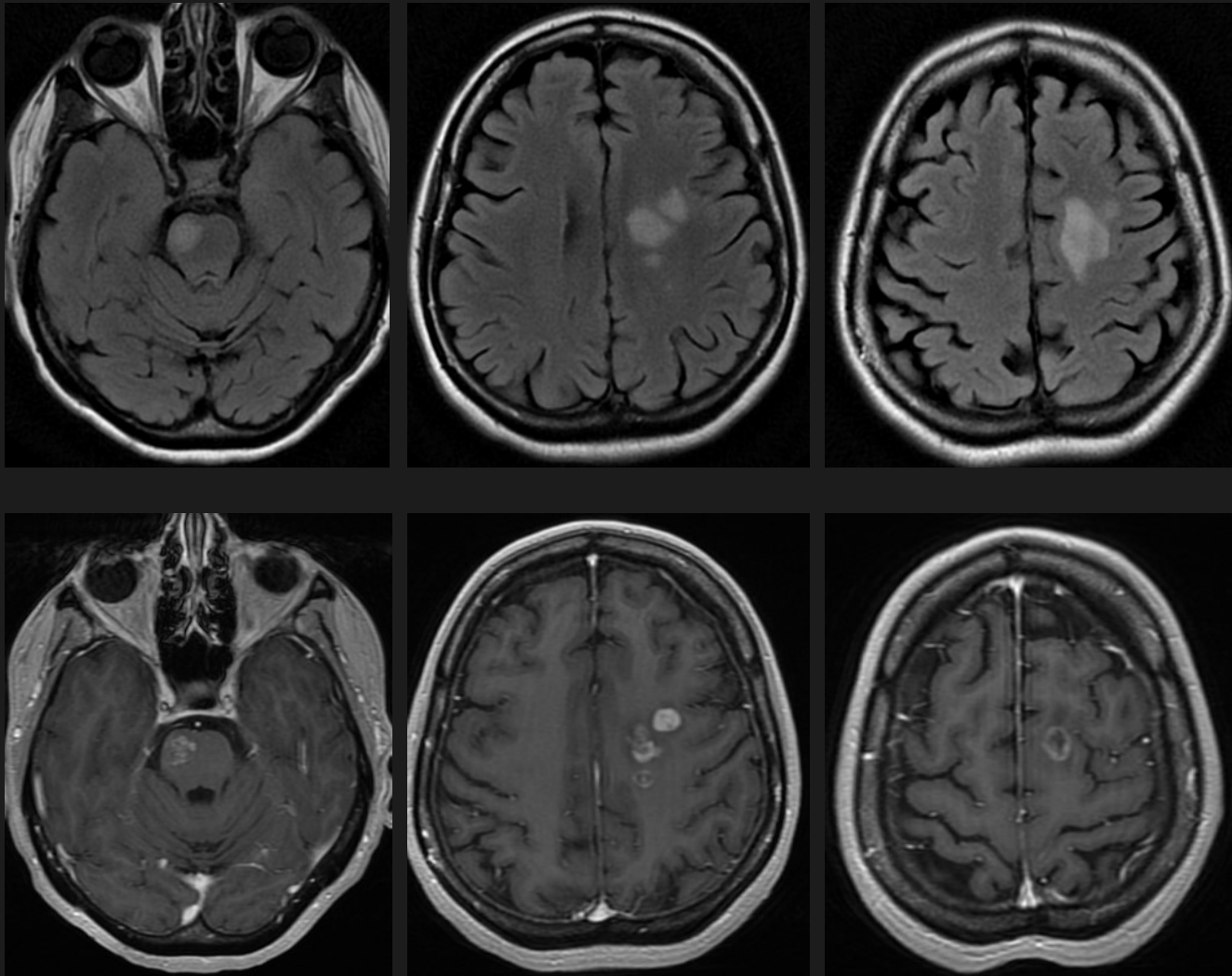
hipoperfuzja
niskie wartości rCBV
brak neoangiogenezy



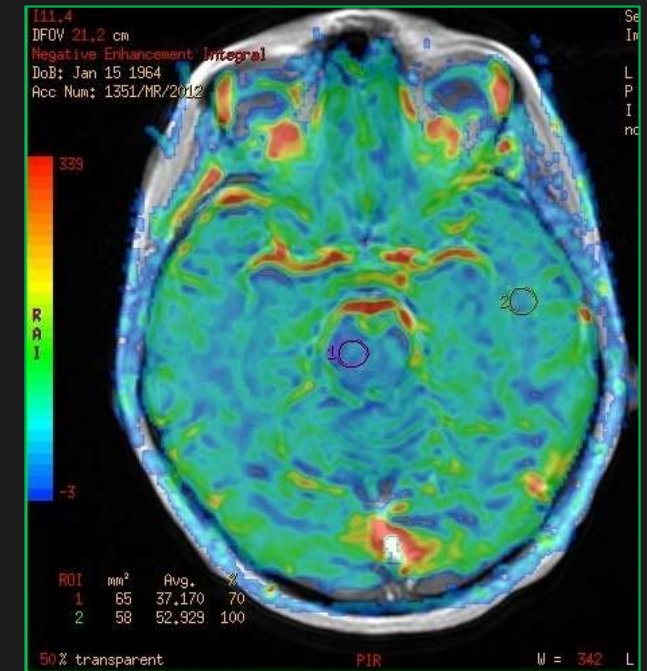
Zastosowanie kliniczne

- Guzy mózgu
- Zmiany naczyniowe
- Zmiany zapalne (infekcyjne i nieinfekcyjne)
- Zmiany demielinizacyjne

Stwardnienie rozsiane



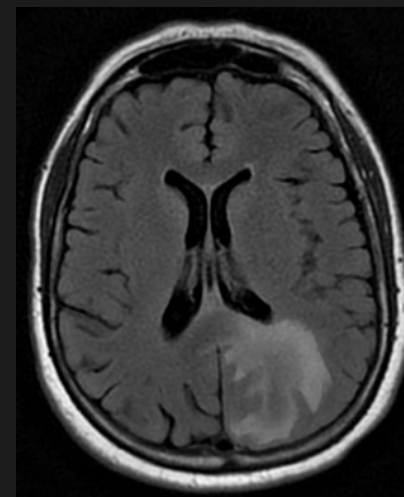
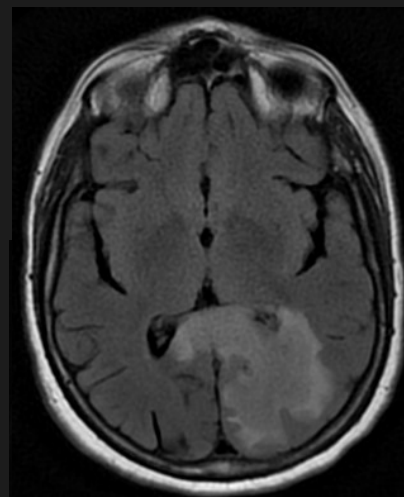
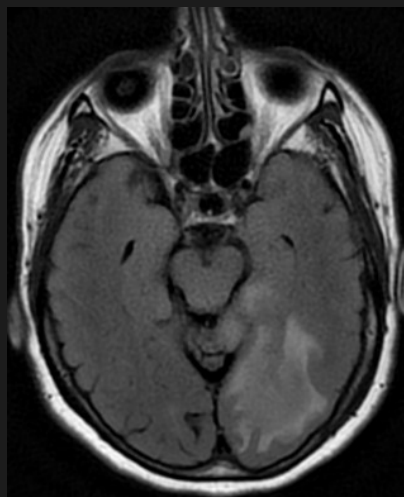
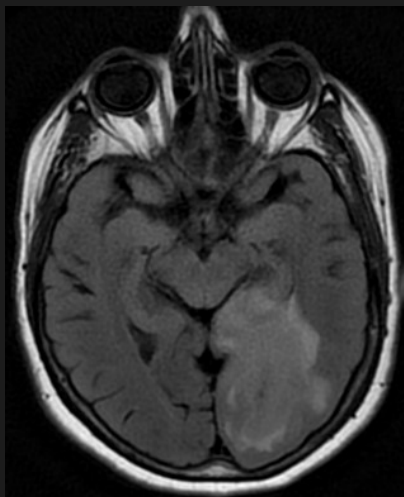
Obniżona perfuzja



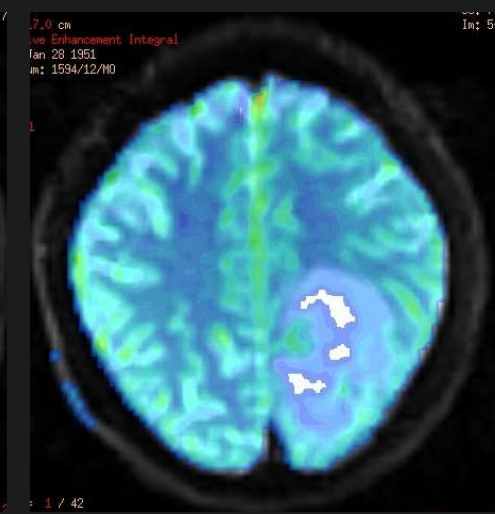
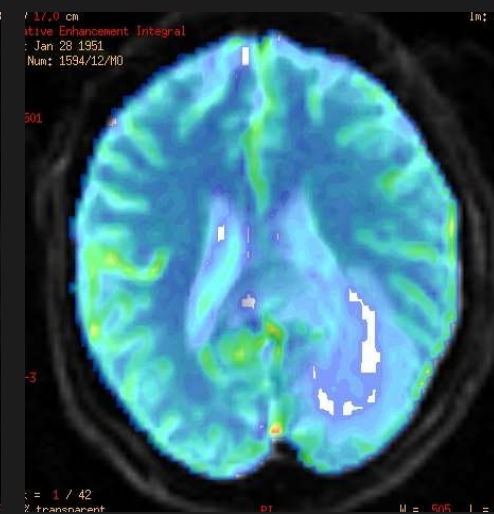
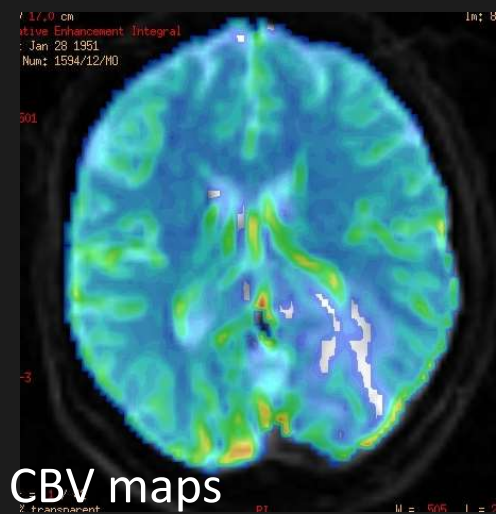
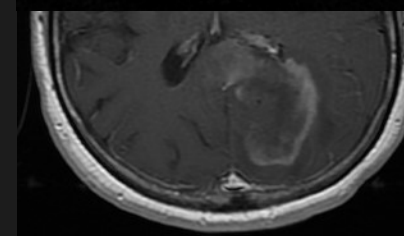
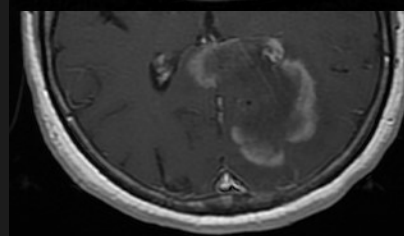
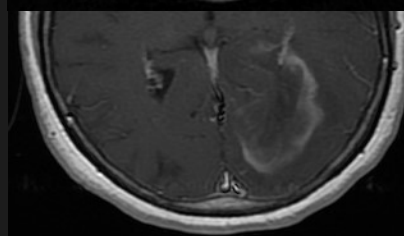
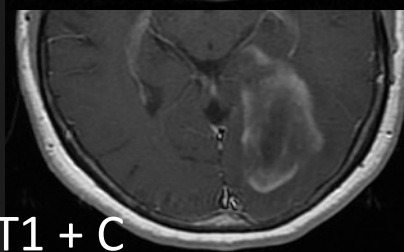
rCBV = 0.7

Tumefactive MS

FLAIR



T1 + C



Wzorzec perfuzji

↑ rCBV (> 2,0)

- Guzy (neoangiogeneza)
HGG
przerzuty
oponiaki

skąpodrzewiaki
astrocytoma pilocyticum
- Wazodilatacja
penumbra
reperfuzja

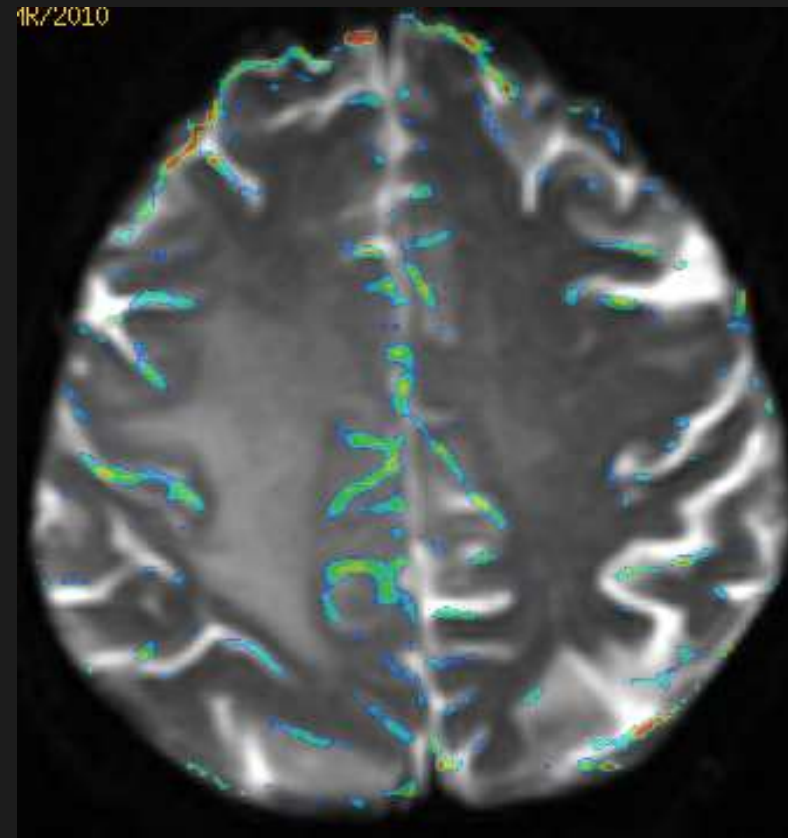
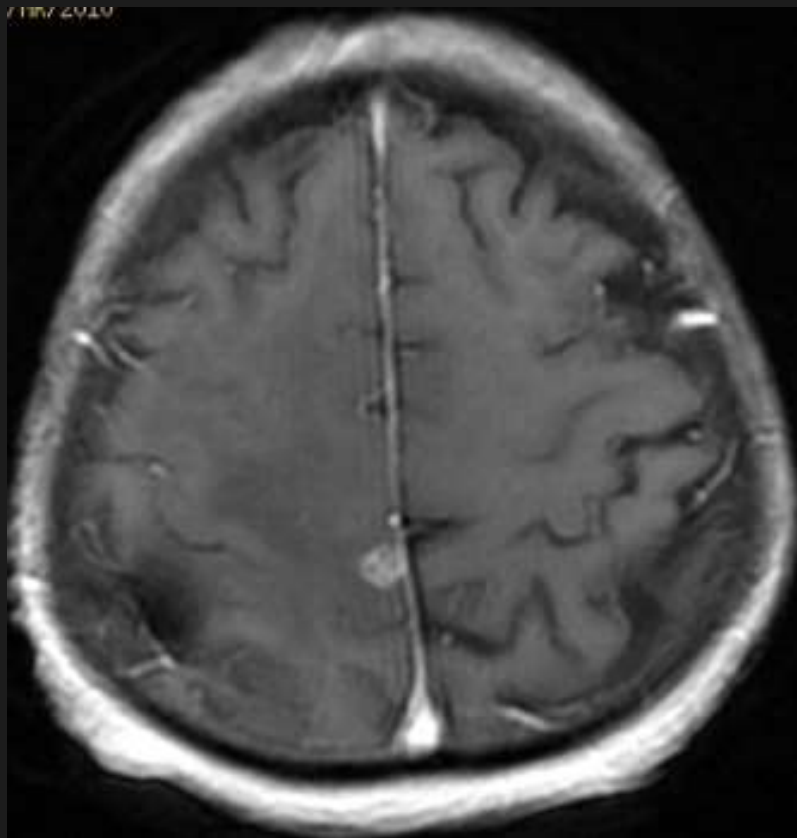
↓ rCBV (< 2,0)

- Guzy
LGG
pierwotny chłoniak mózgu
schwannoma
- zm. infekcyjne/zapalne
- demielinizacja

Przypadki

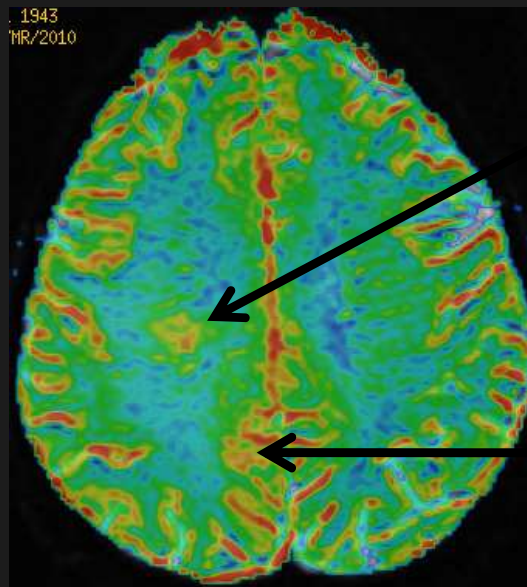
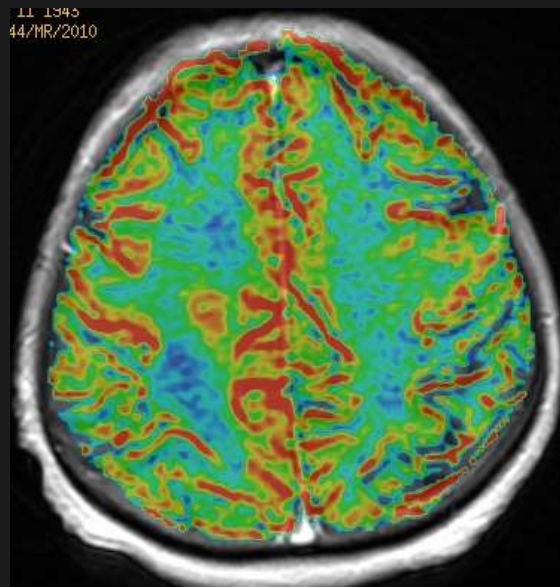
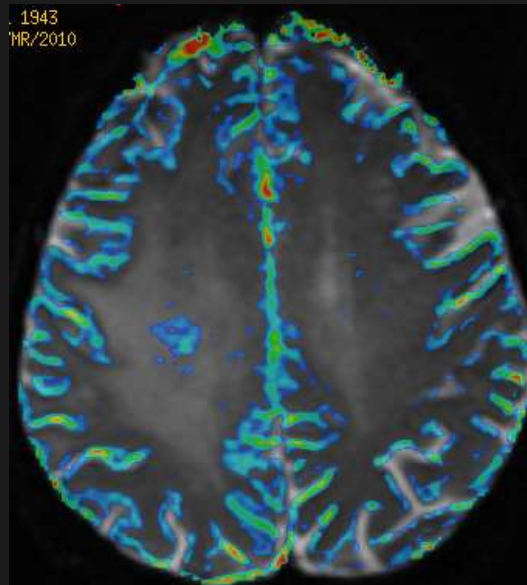
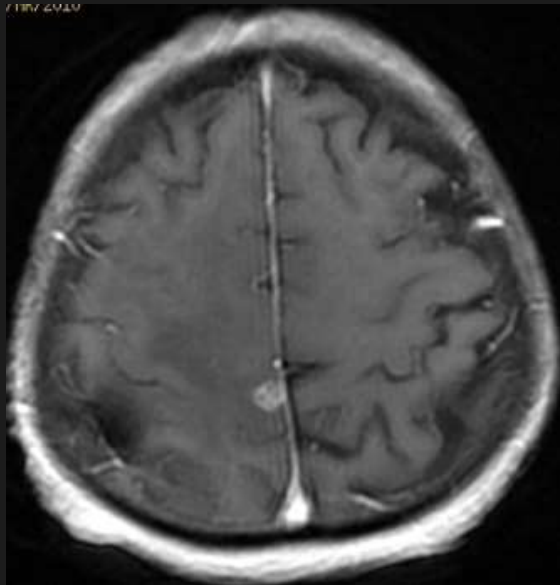
Przypadek 1

Mały pojedynczy guz otoczony rozległym obszarem obrzęku wazogennego



Guz pierwotny czy meta ???

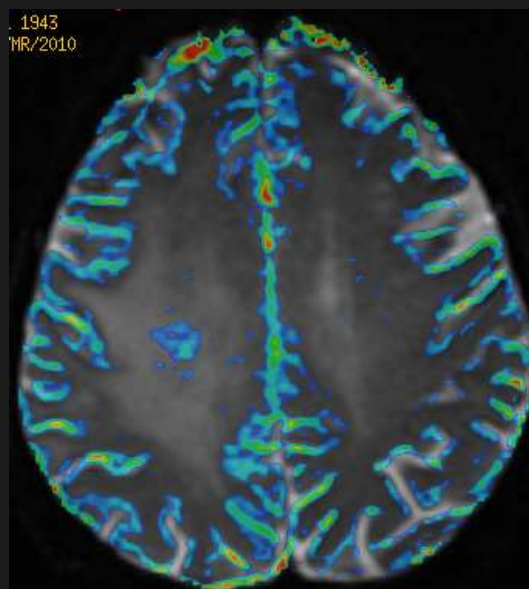
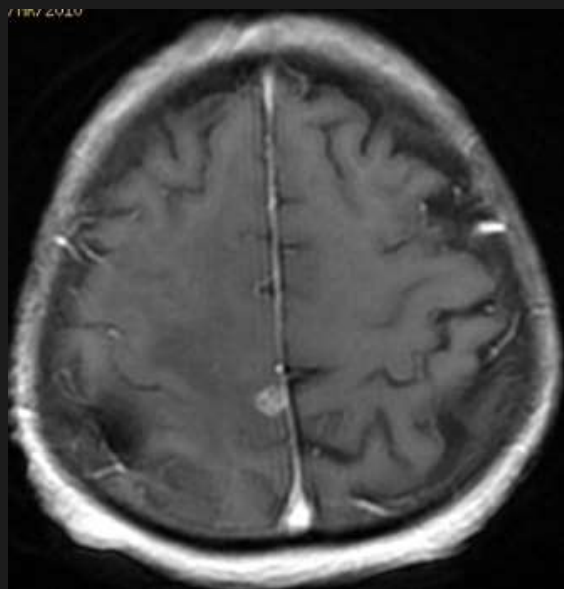
Przypadek 1



obszar
infiltracji
npl
w obrzęku

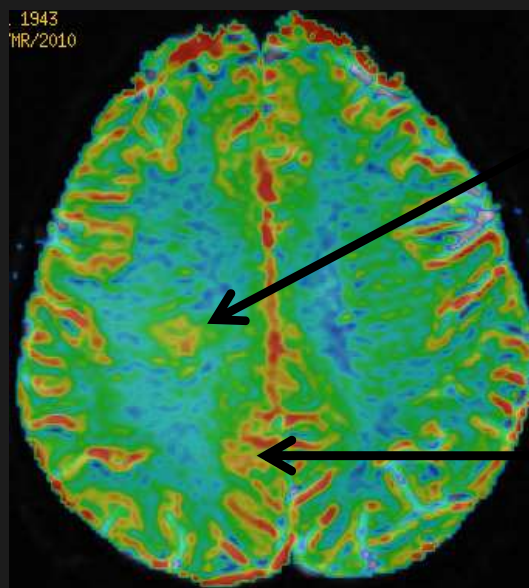
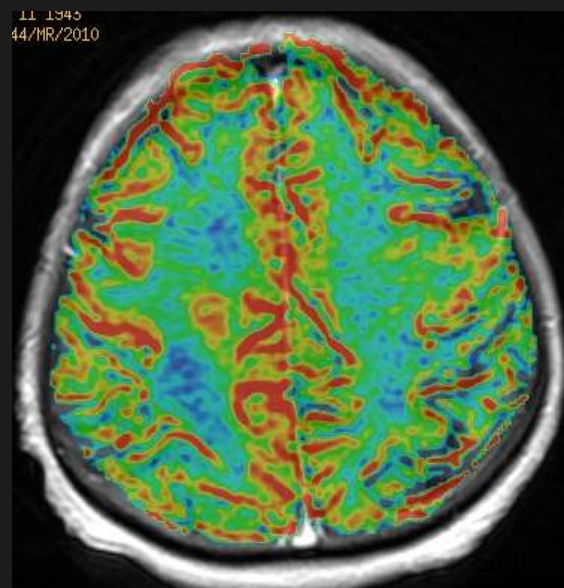
guz

Przypadek 1



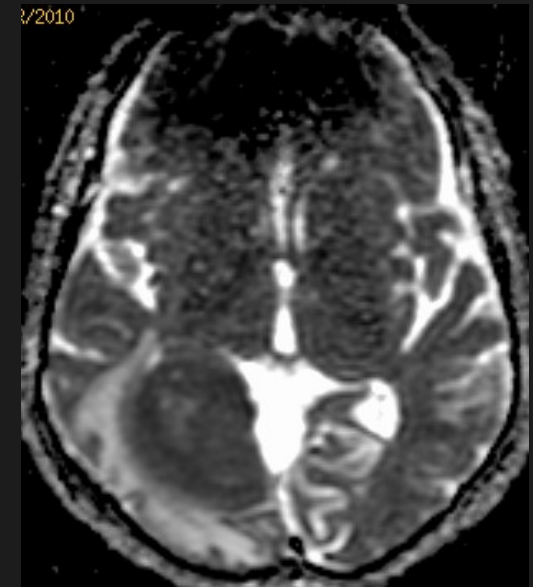
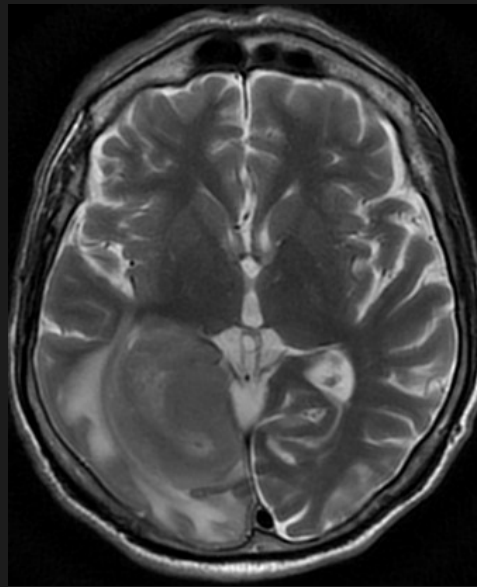
Hist-pat:
GBM

obszar
infiltracji
npl
w obrzęku



guz

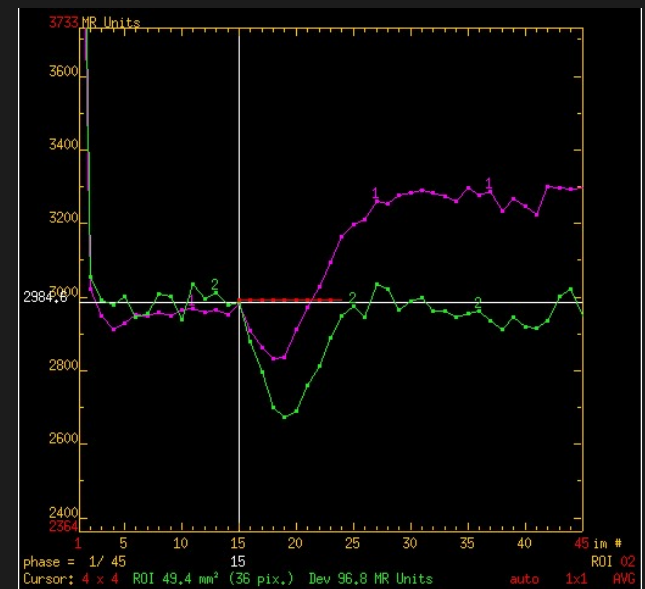
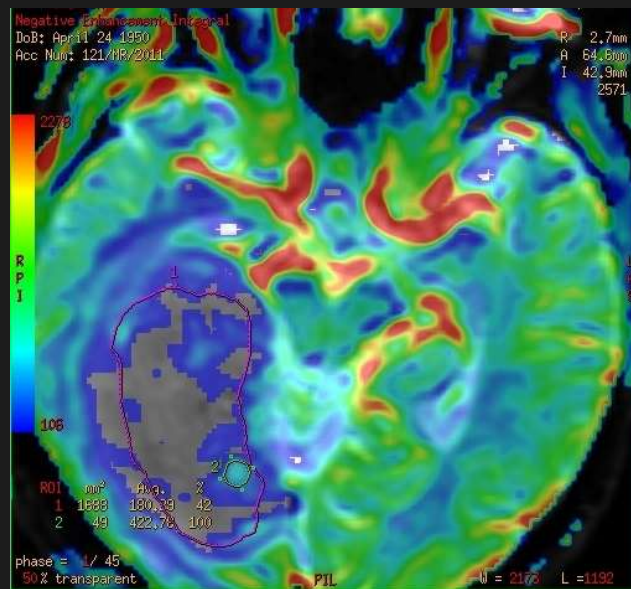
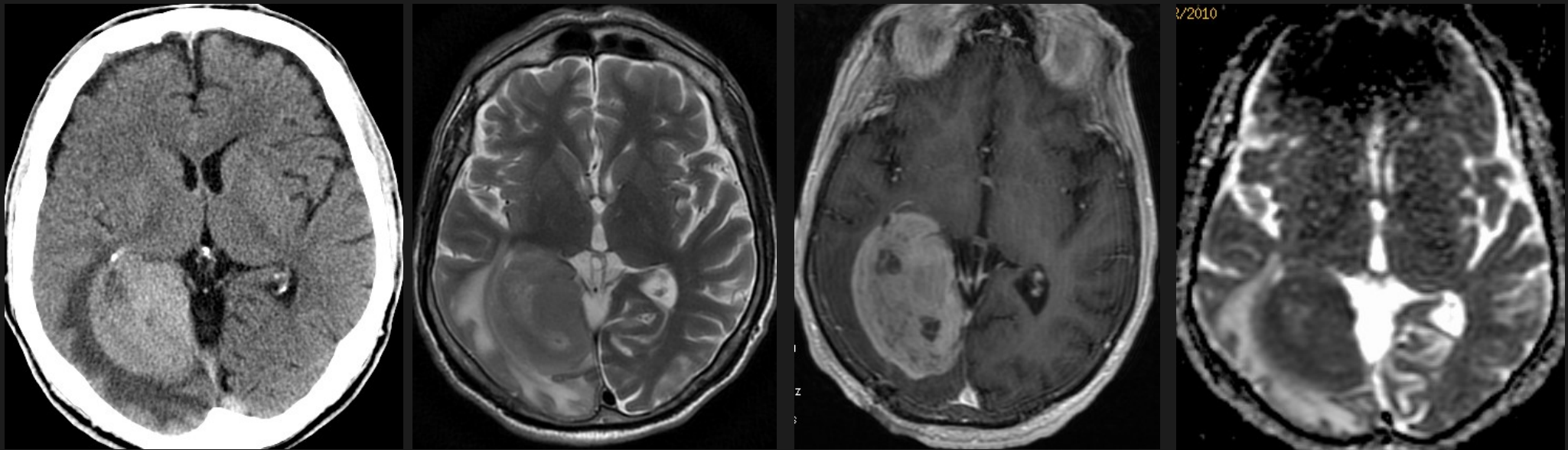
Przypadek 2



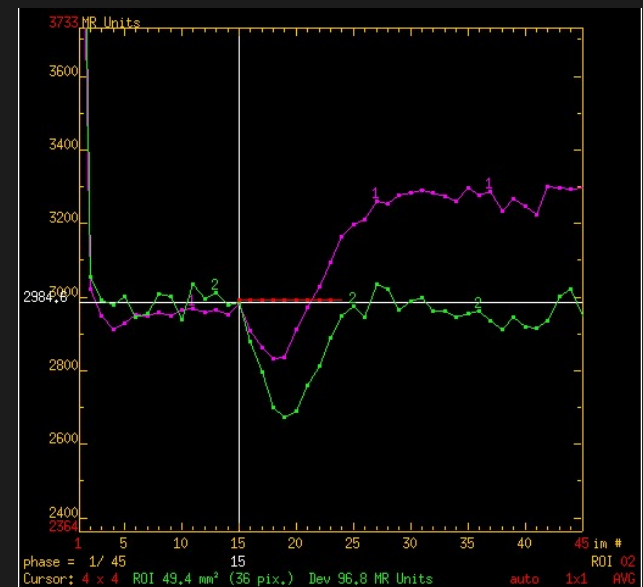
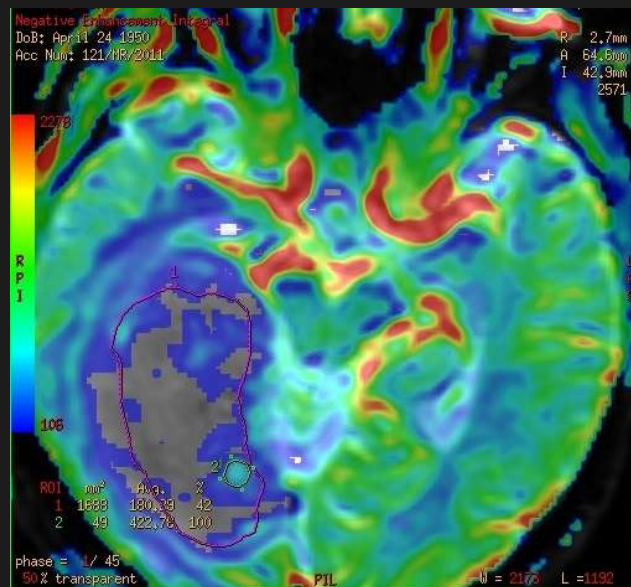
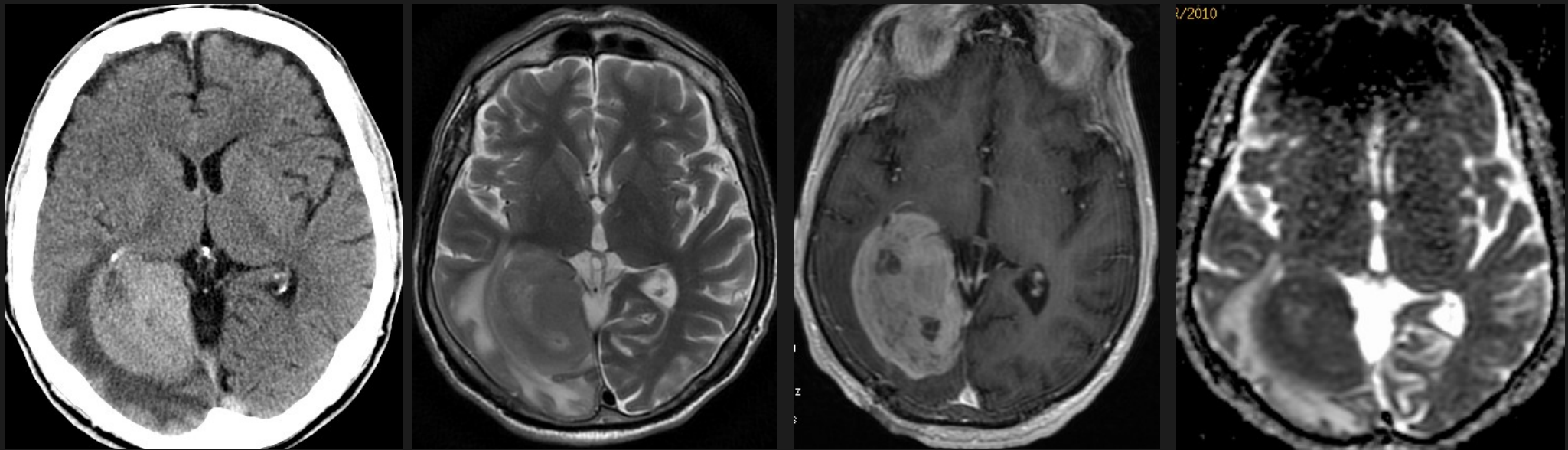
HGG?

oponiak??

Przypadek 2



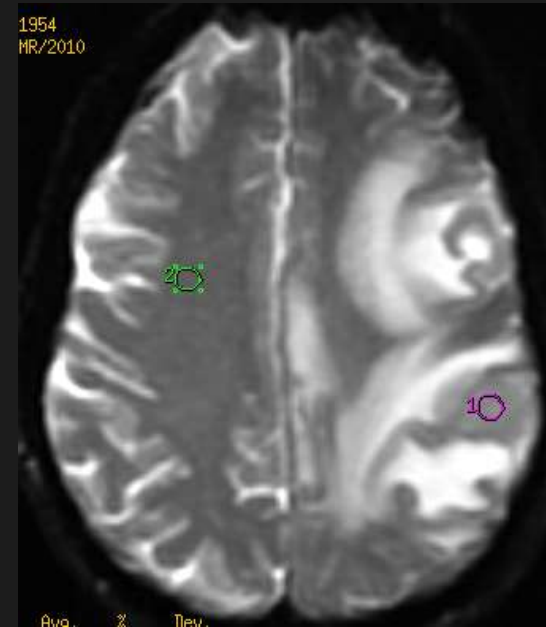
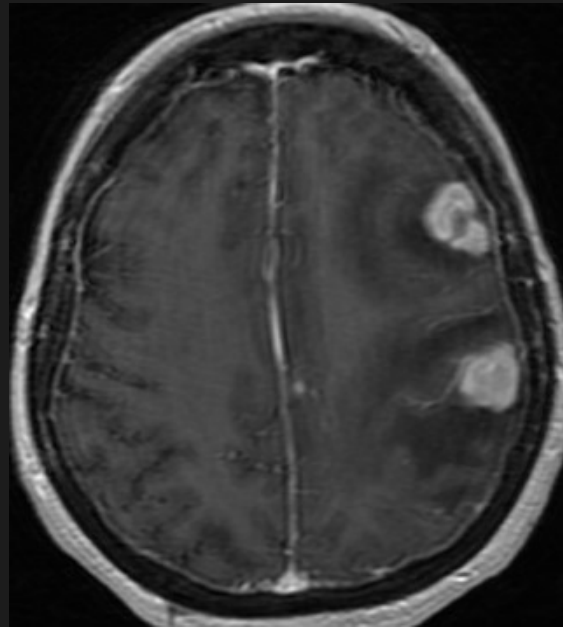
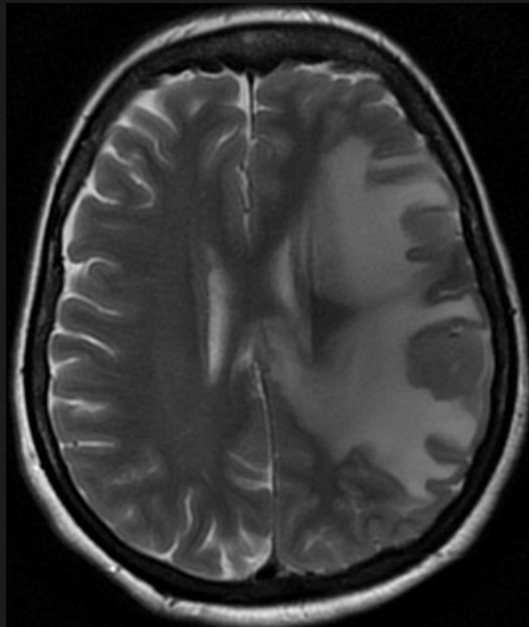
Przypadek 2



Primary CNS
Lymphoma

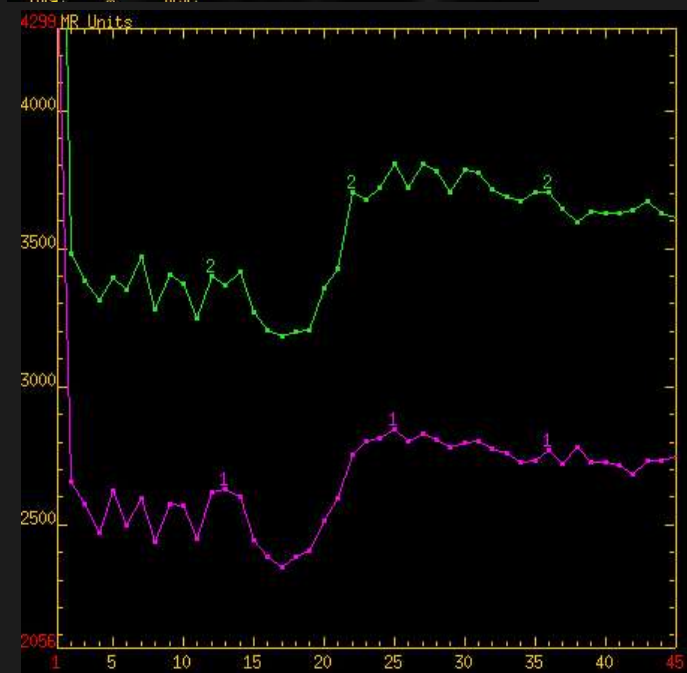
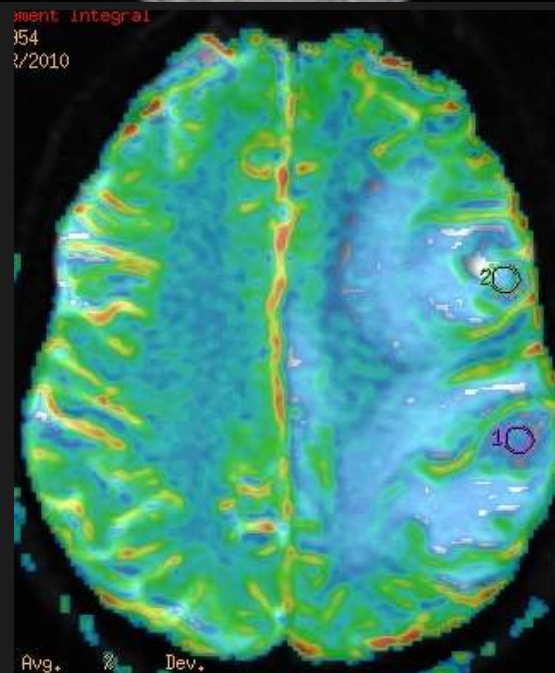
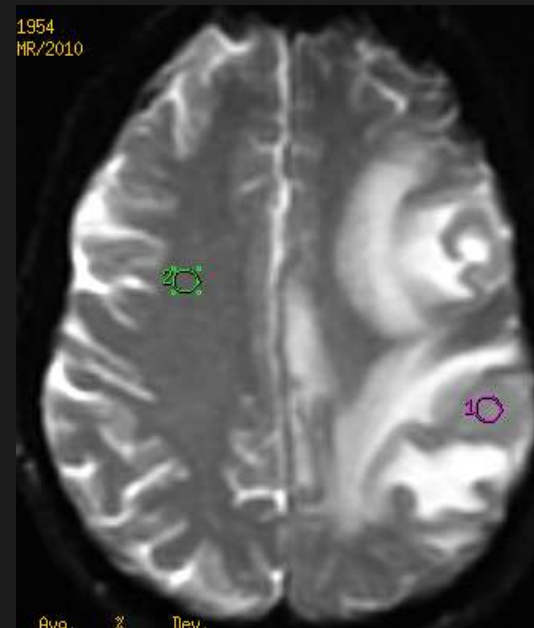
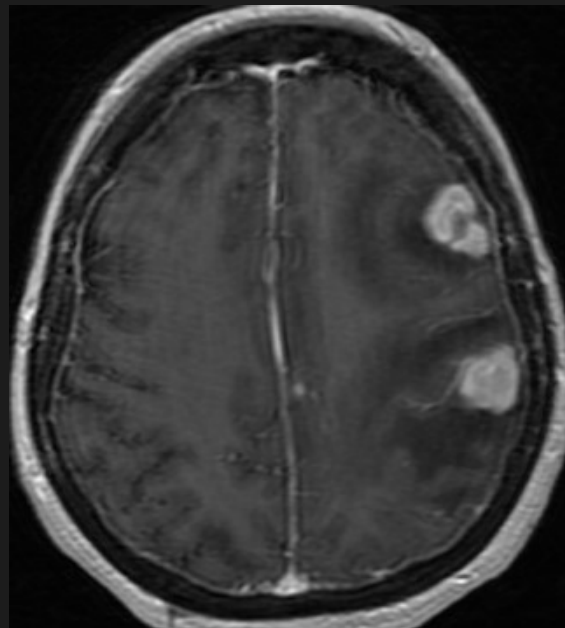
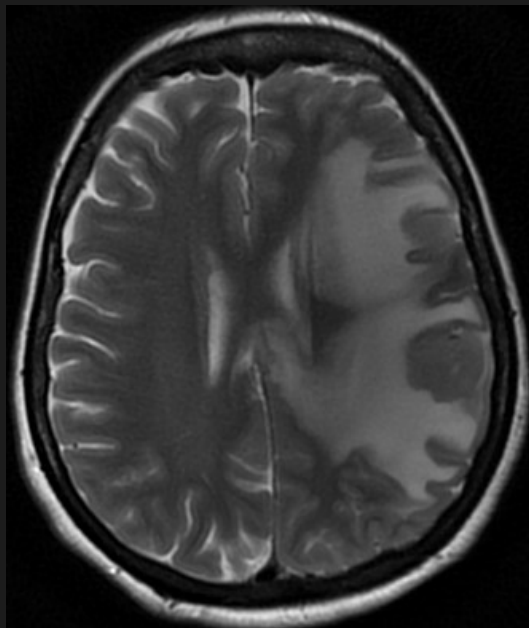
Pierwotny chłoniak
mózgu

Przypadek 3

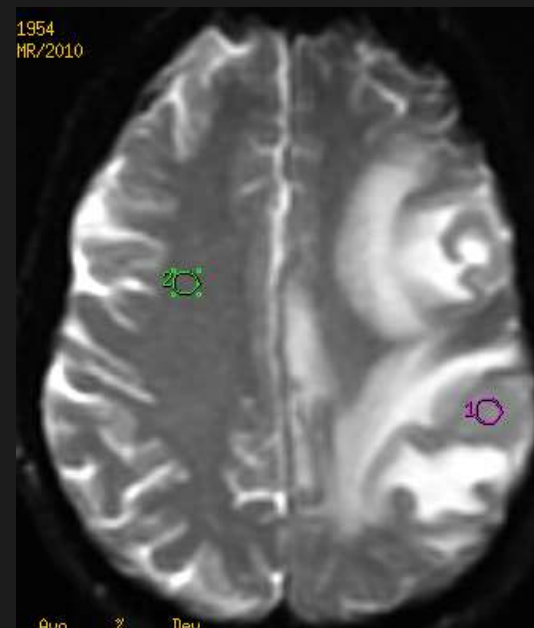
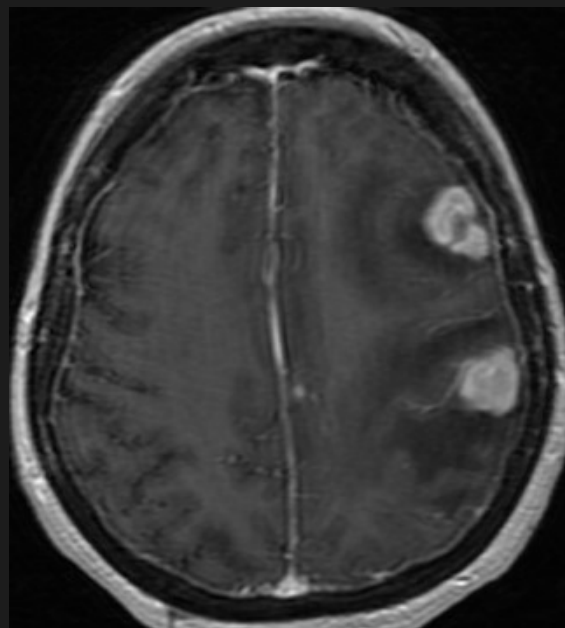
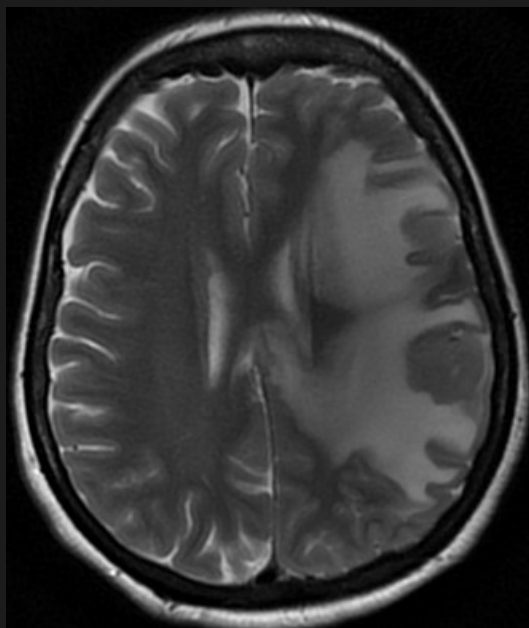


Przerzuty ???

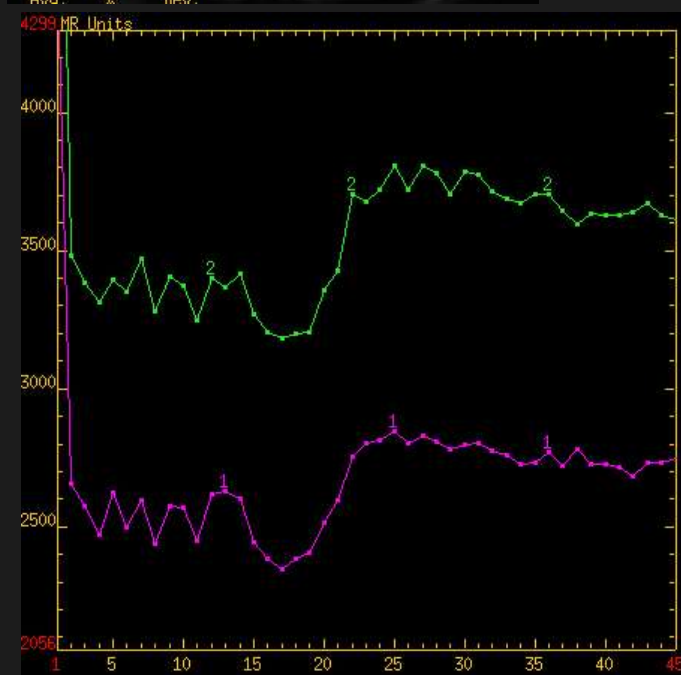
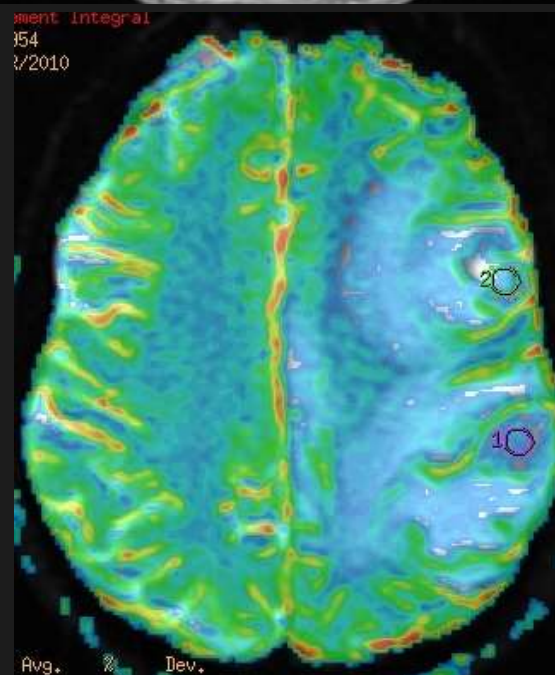
Przypadek 3



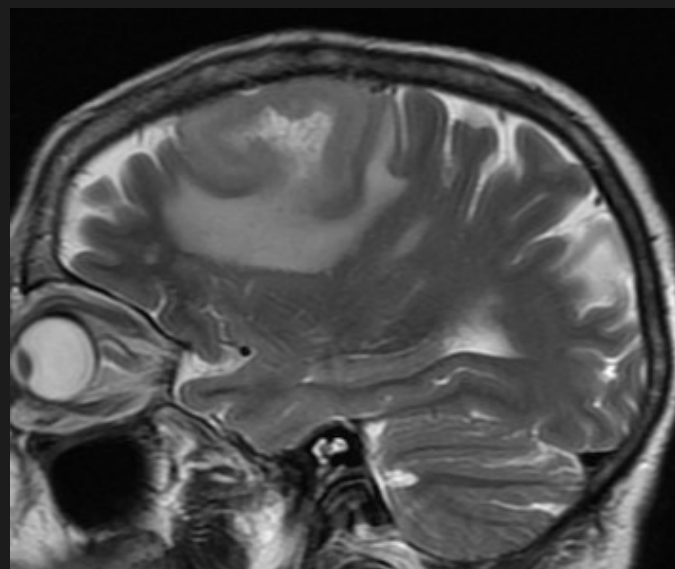
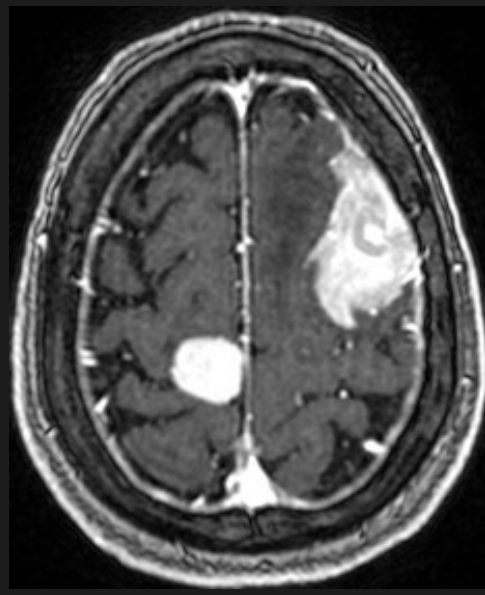
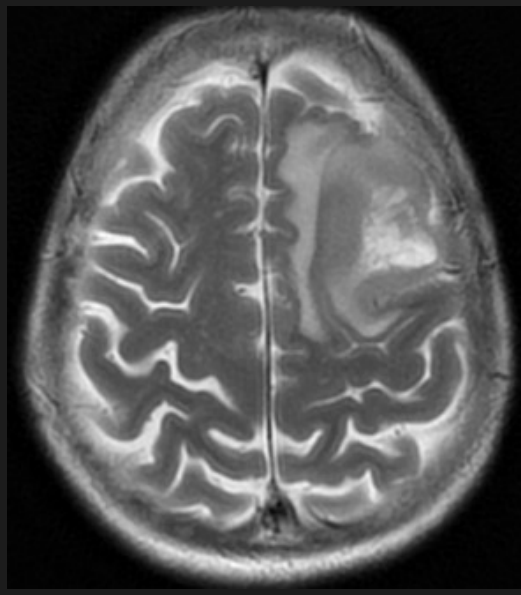
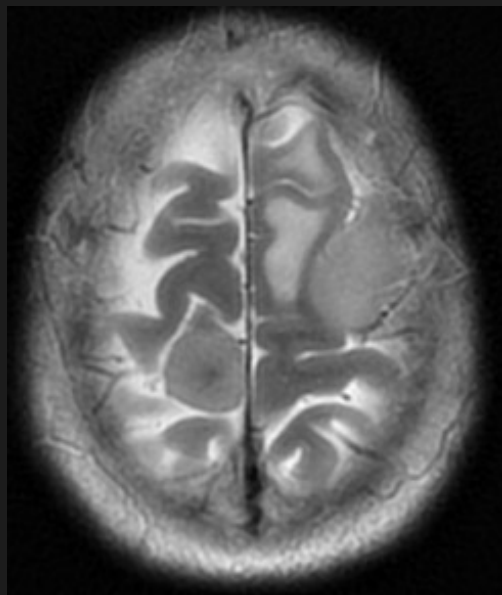
Przypadek 3

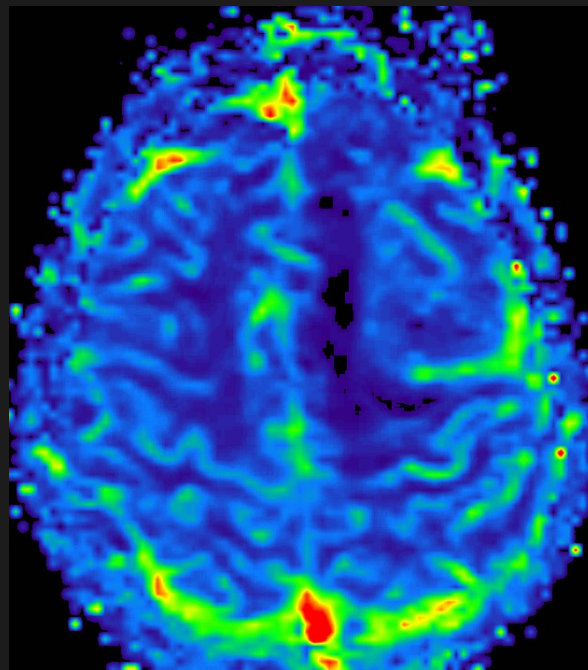
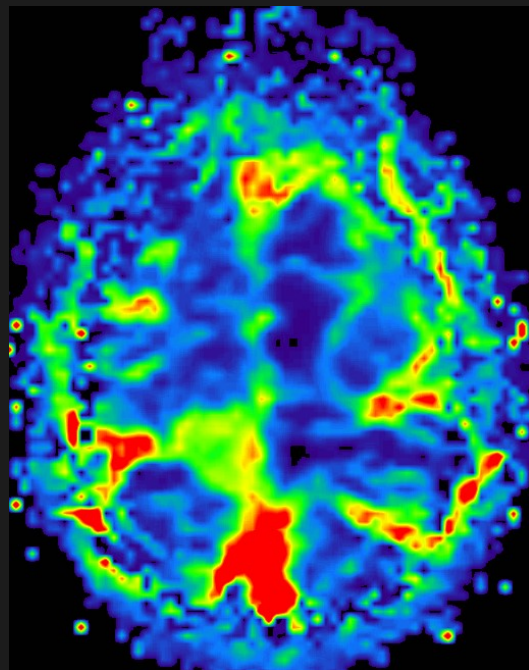
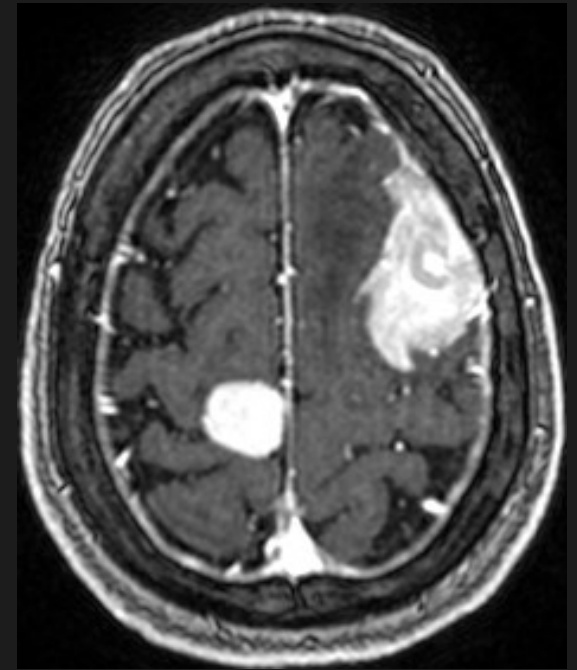
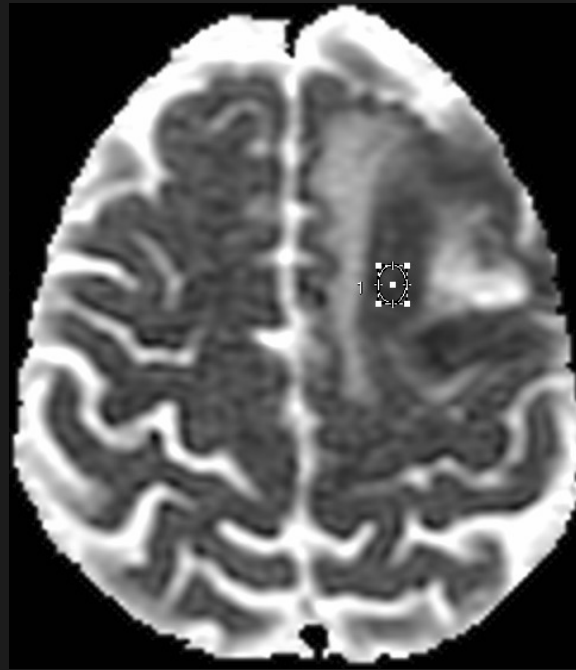
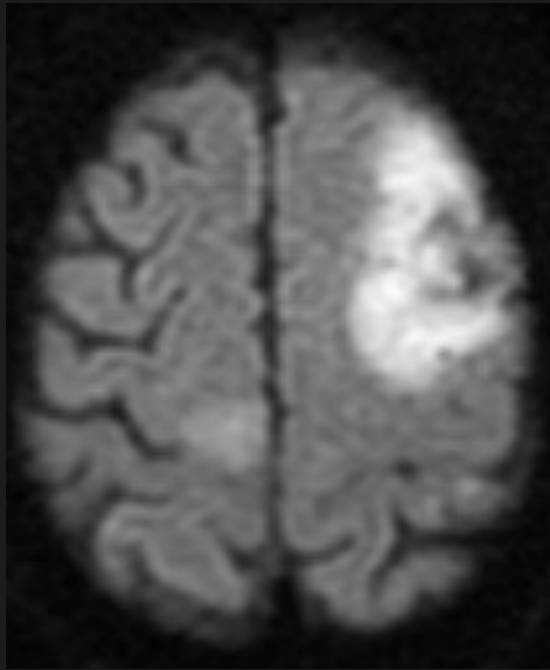


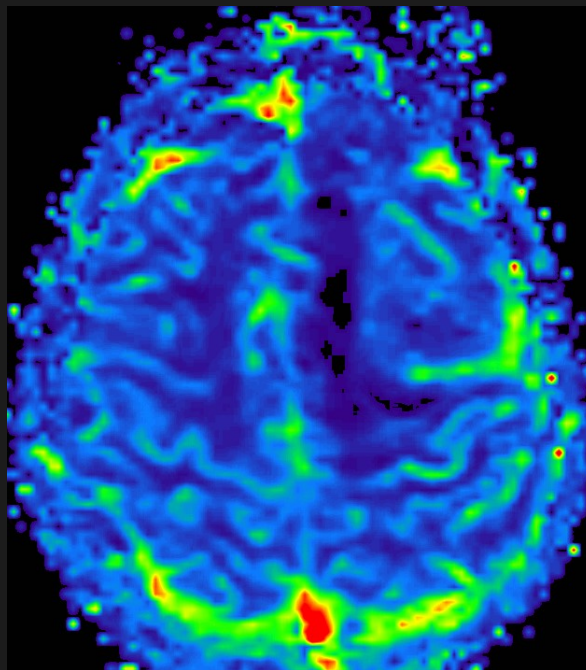
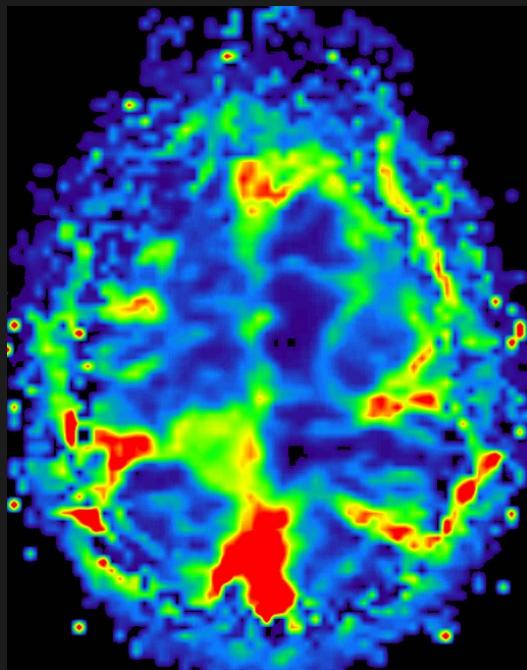
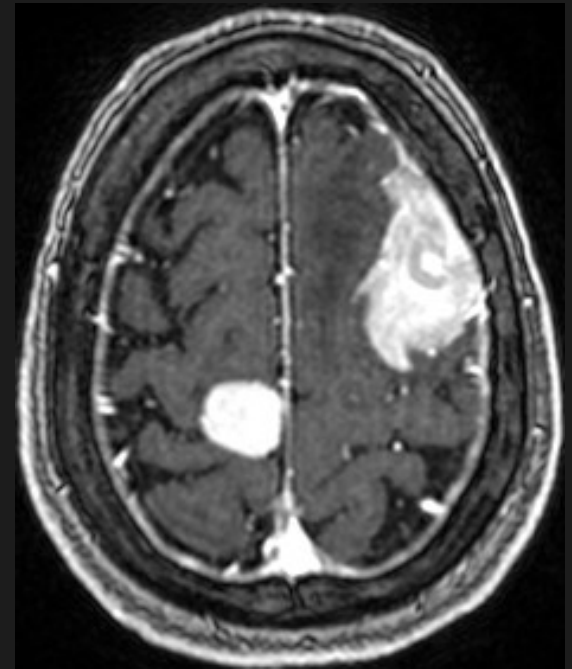
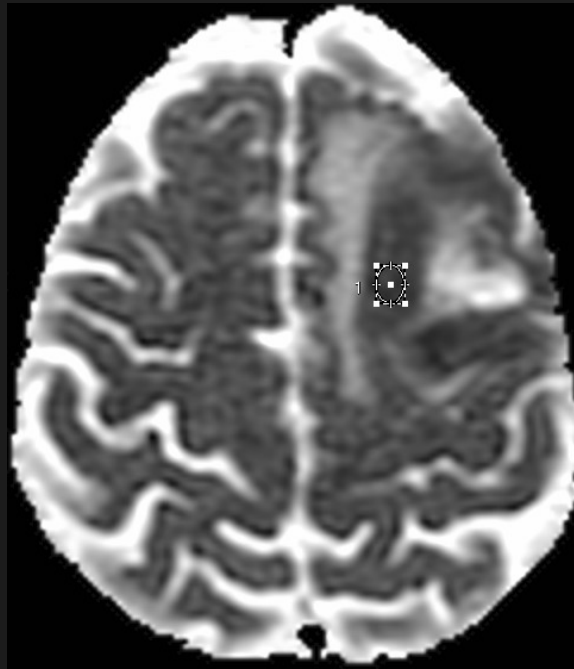
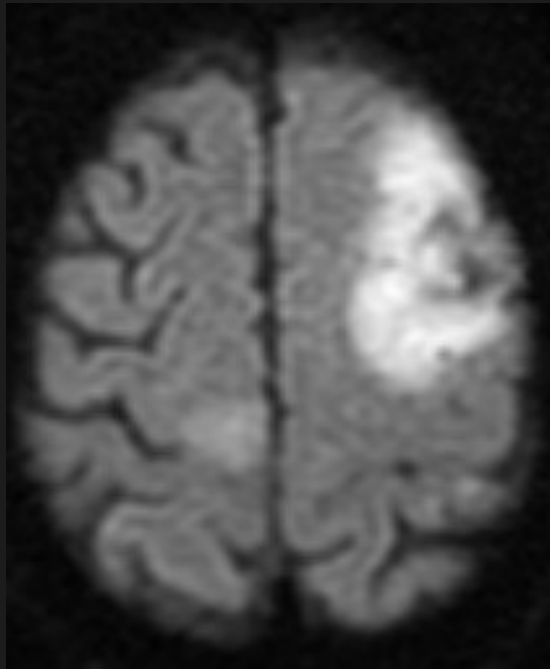
Primary CNS
Lymphoma



Przypadek 4







Primary CNS
Lymphoma

i

oponiak

Przypadek 5

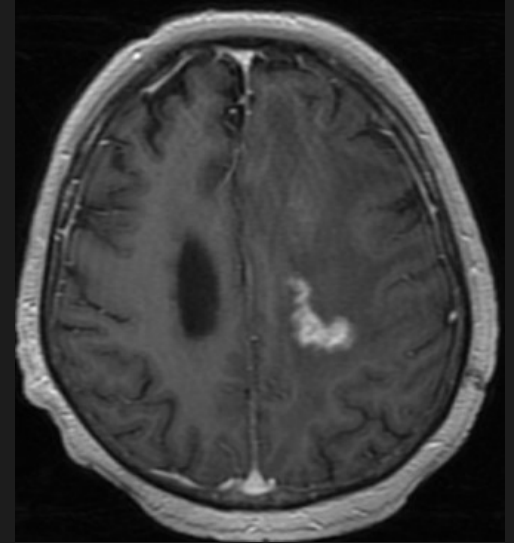
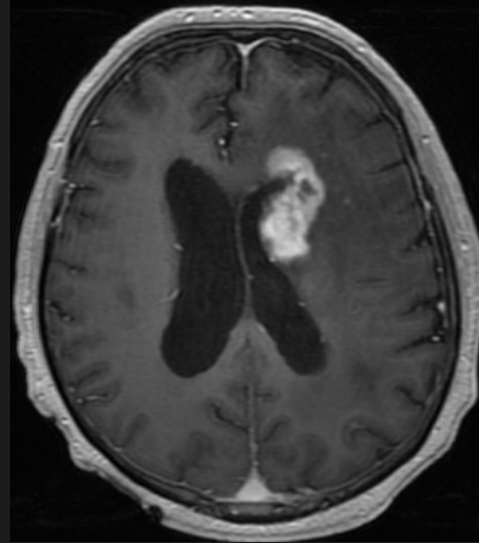
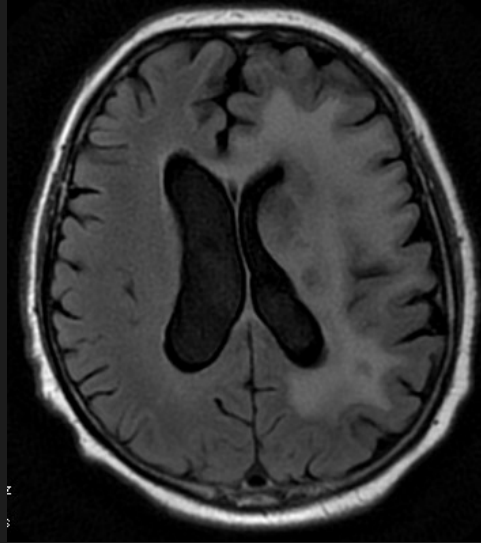
stan po resekcji AA WHO 3 w lewym płacie skroniowym,
6 miesięcy po radioterapii

wznowa npl

czy

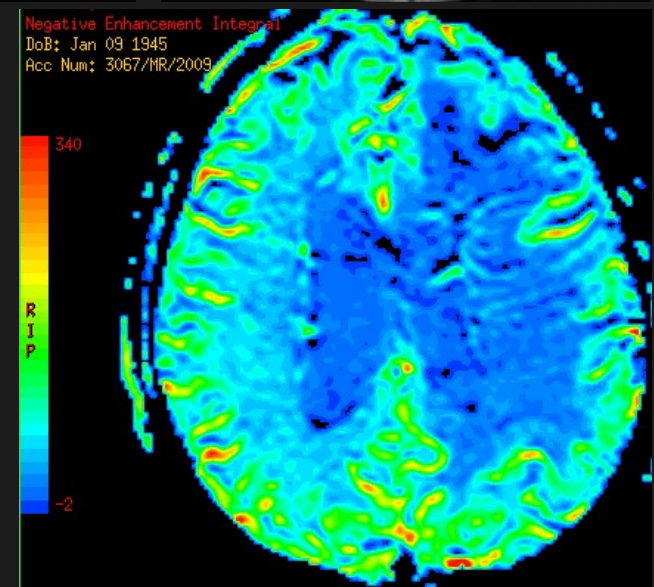
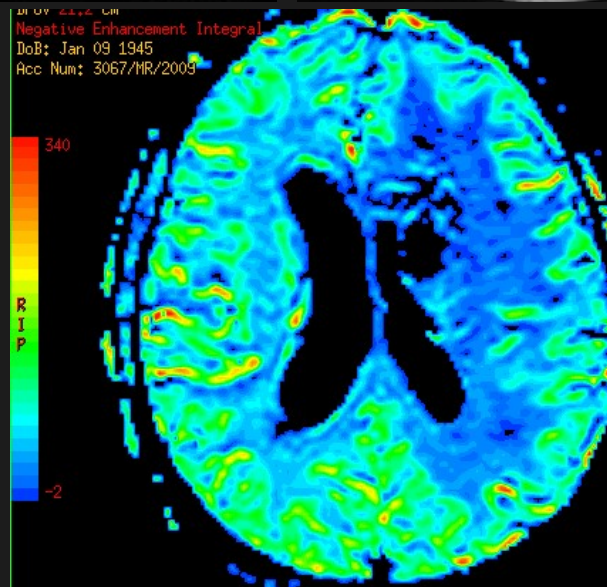
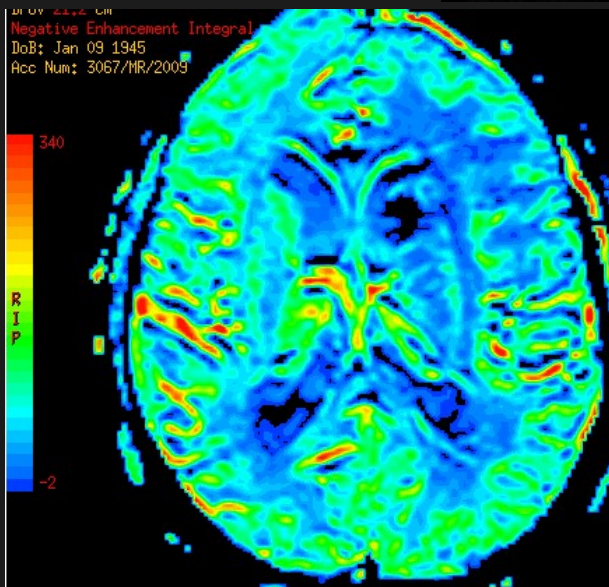
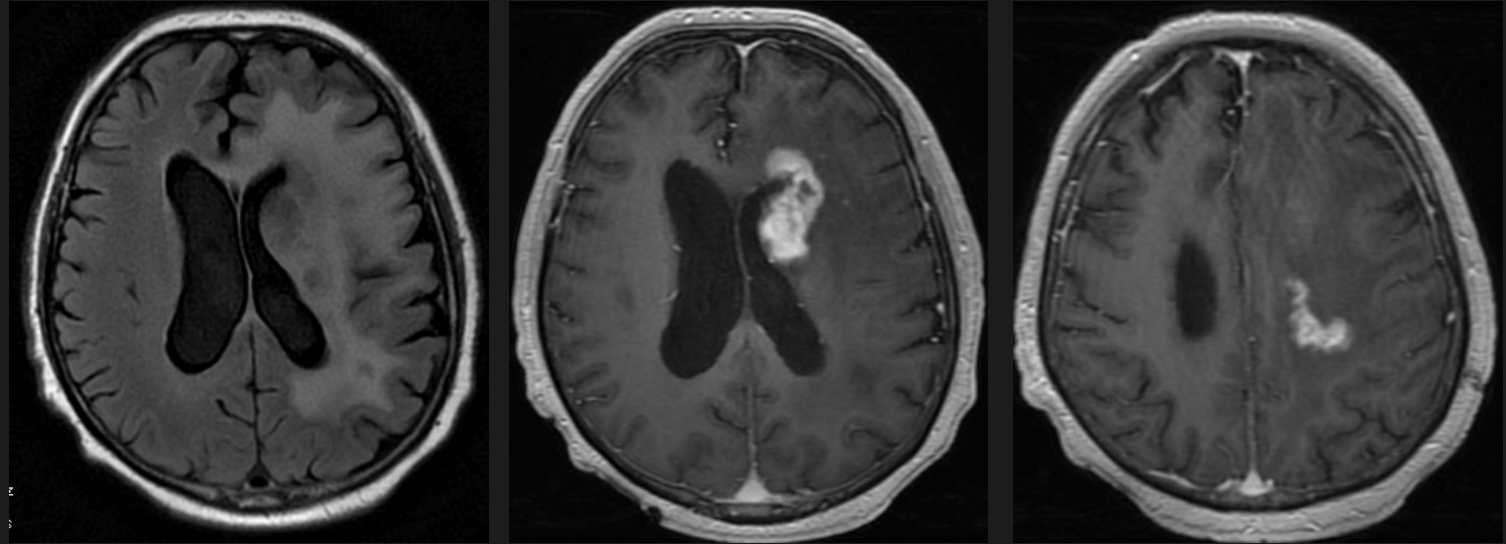
martwica

popromienna?



Przypadek 5

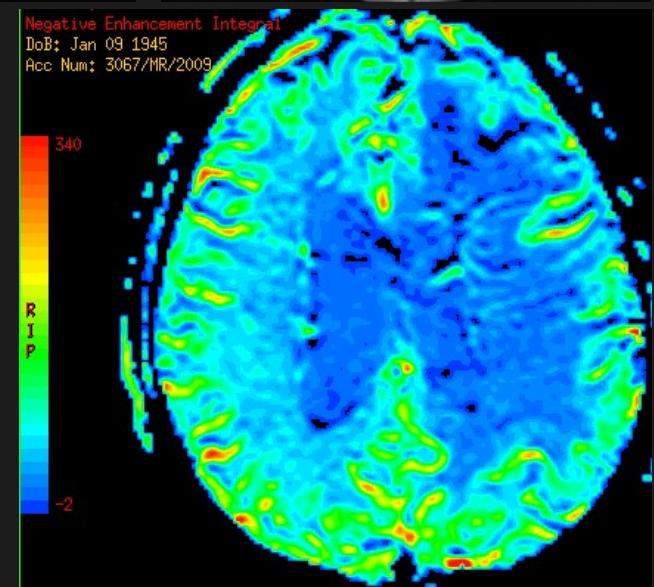
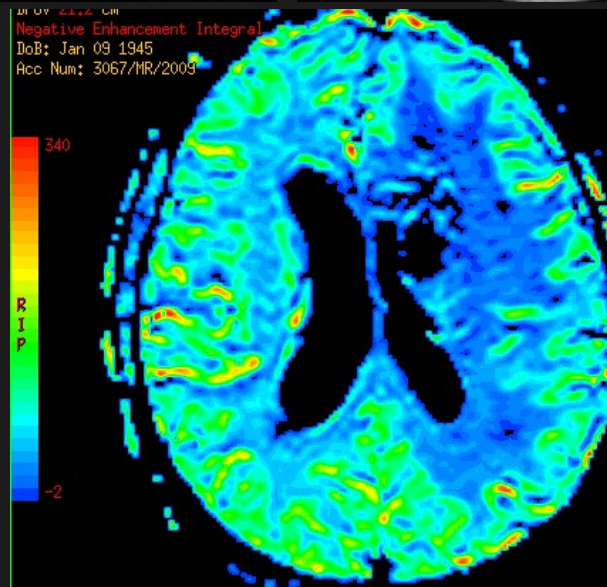
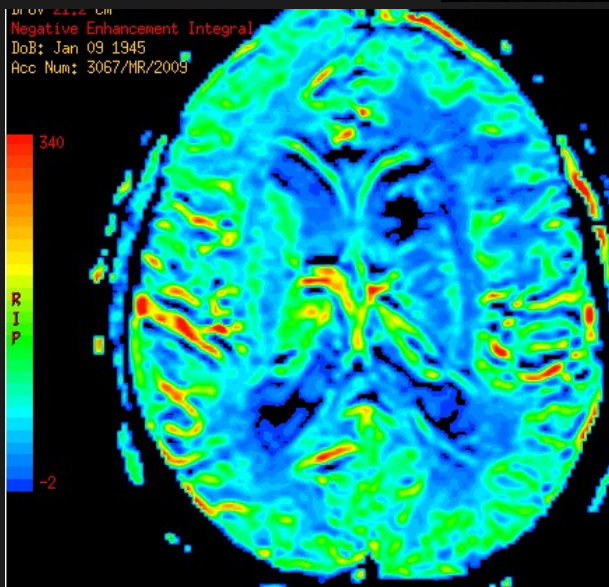
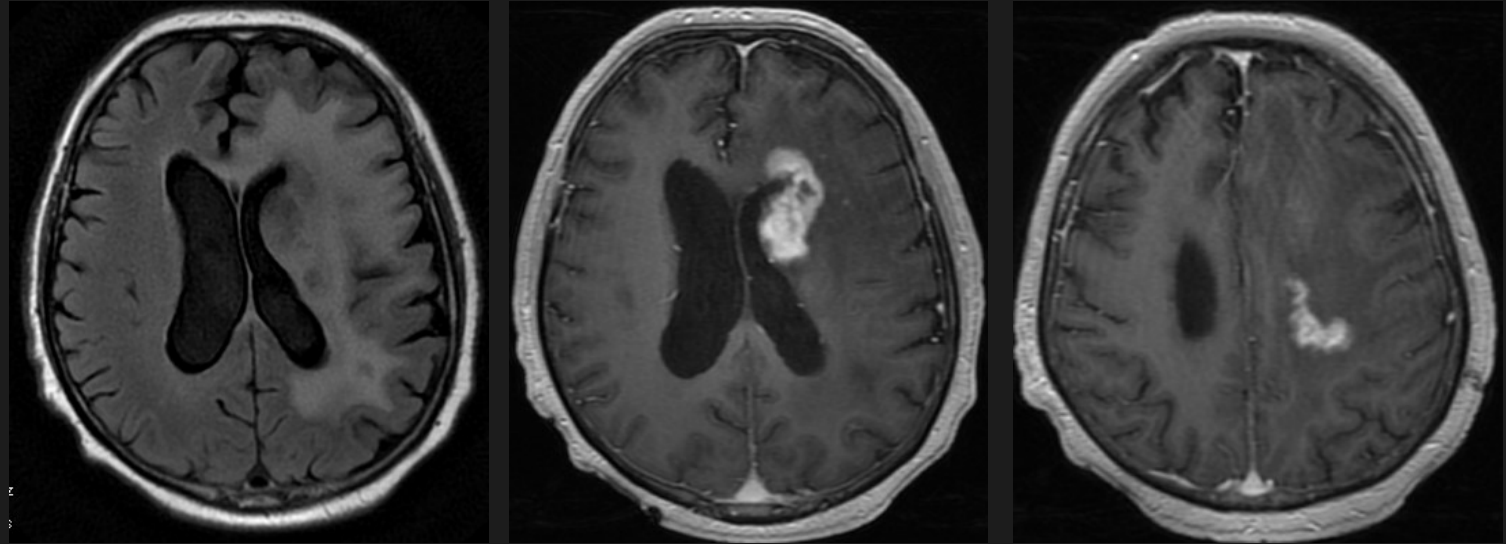
stan po resekcji AA WHO 3 w lewym płacie skroniowym,
6 miesięcy po radioterapii



Przypadek 5

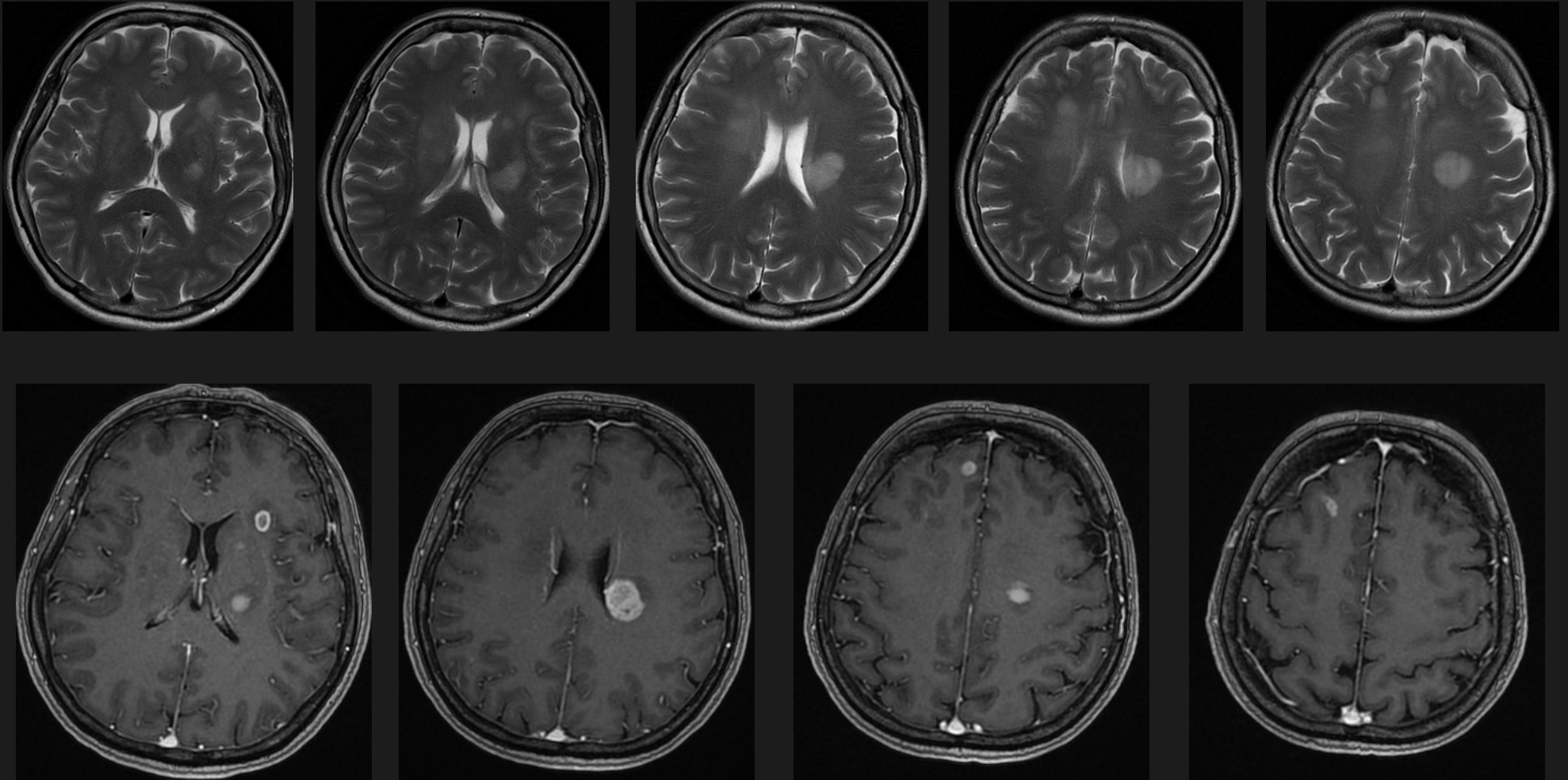
stan po resekcji AA WHO 3 w lewym płacie skroniowym,
6 miesięcy po radioterapii

Martwica
popromienna



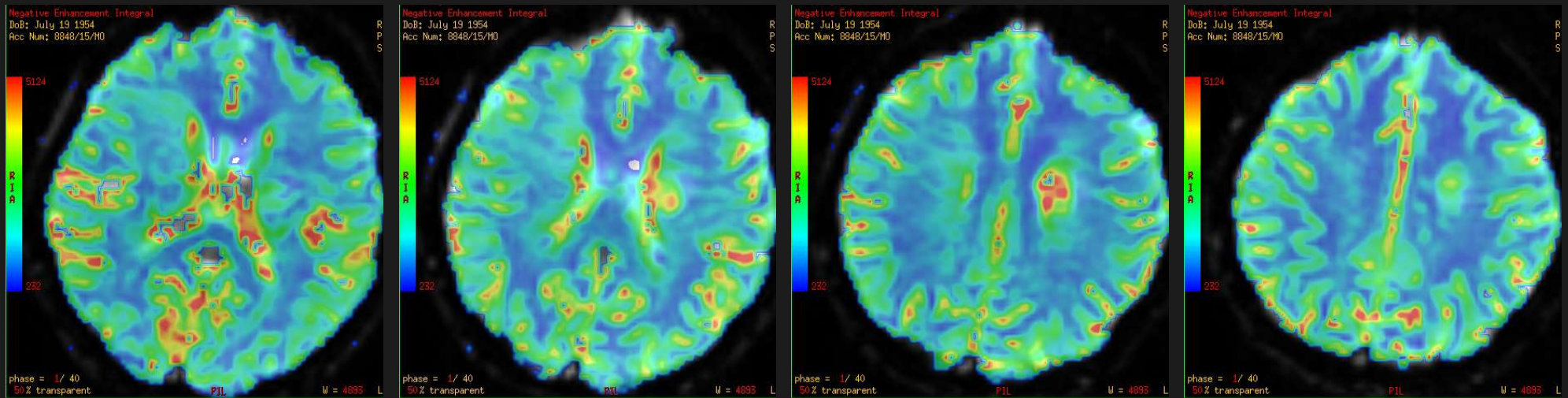
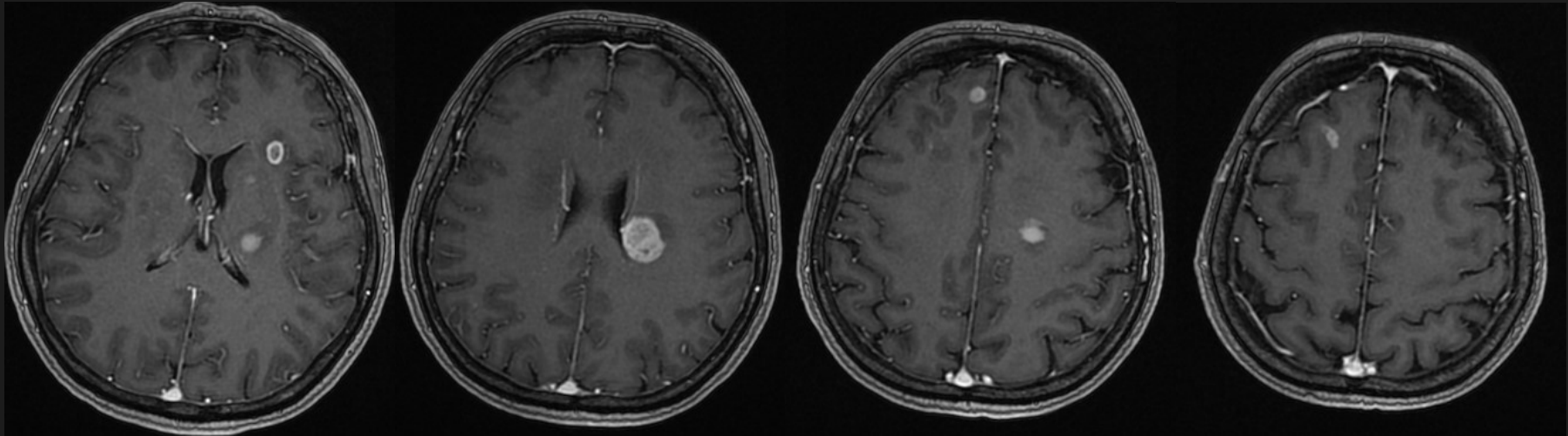
Przypadek 6

K, 61 lat, zespół piramidowo-pozapiramidowy od 1 roku,
pogorszenie stanu neurologicznego od miesiąca



tumefactive SM ??

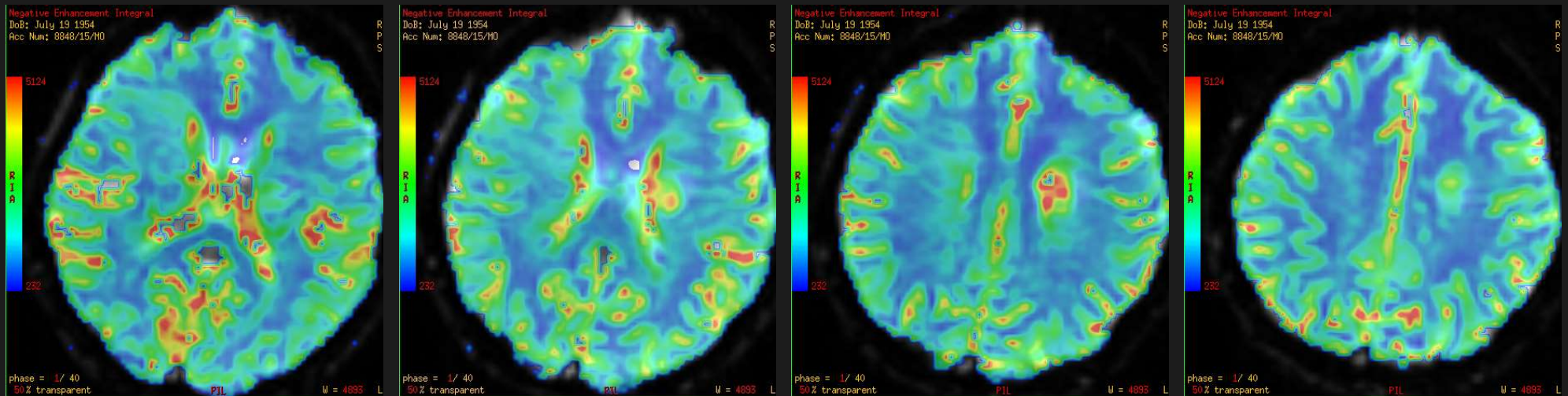
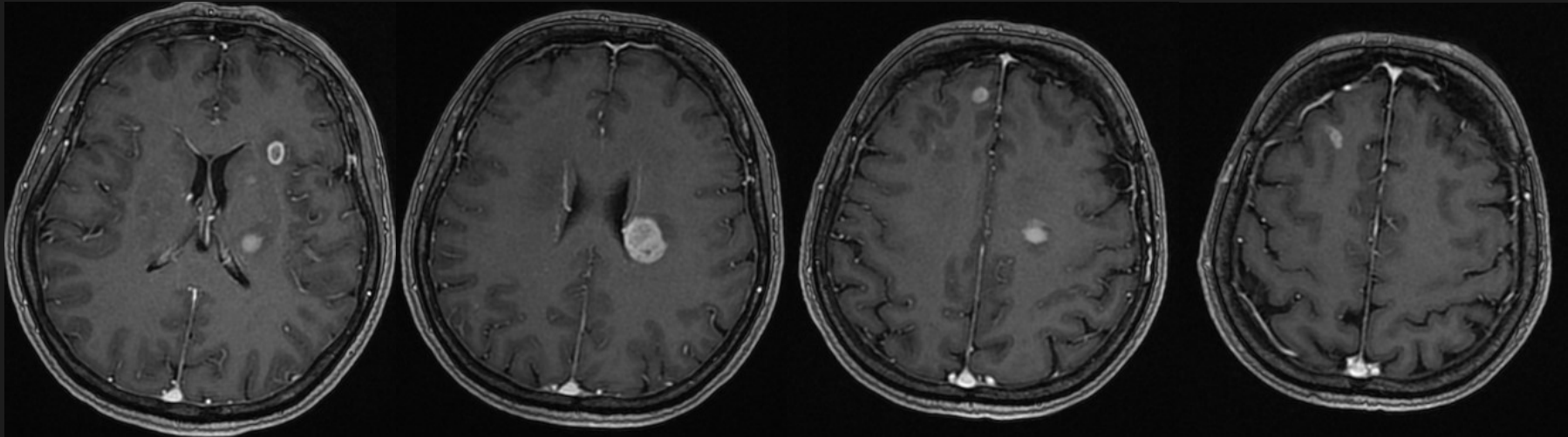
Przypadek 6



rCBV 4.5, hiperperfuzja nawet w obszarach bez wzmocnienia kontrastowego, niewielki obrzęk wokół zmian,

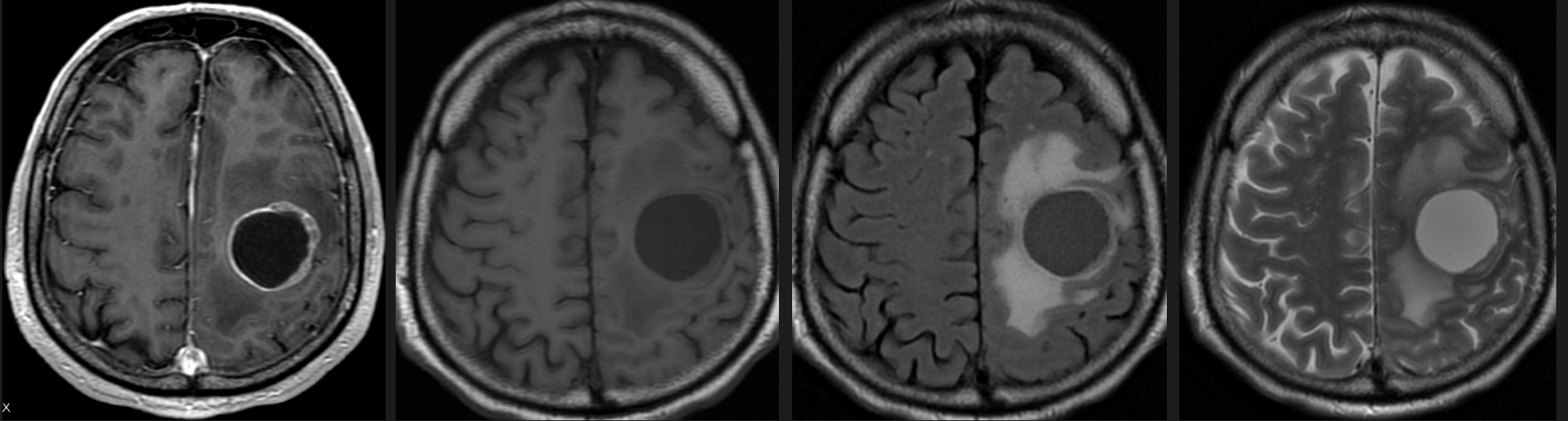
Przypadek 6

GBM wielogniskowy



rCBV 4.5, hiperperfuzja nawet w obszarach bez wzmocnienia kontrastowego,
Niewielki obrzęk wokół zmian,

Przypadek 7

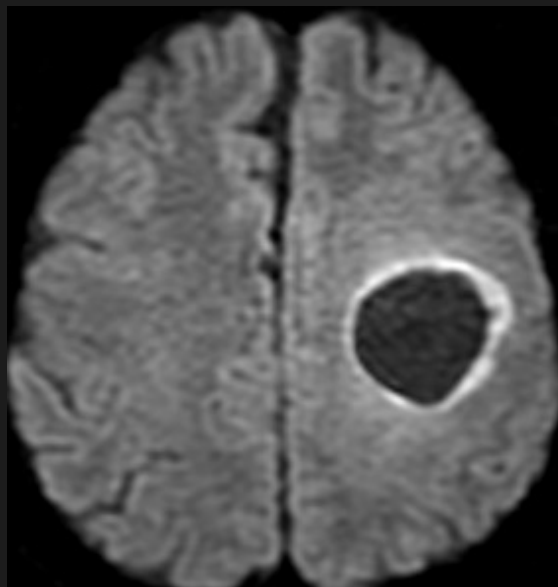
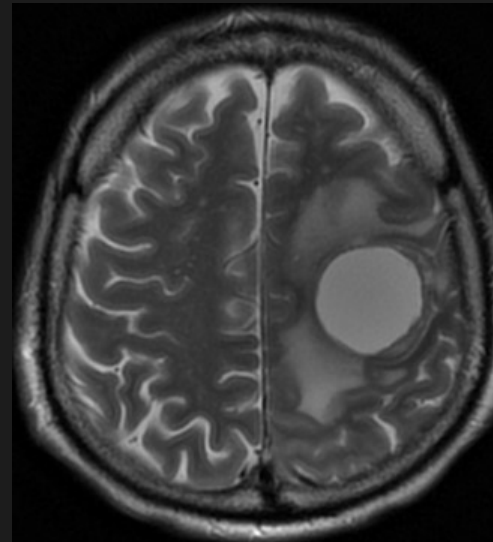
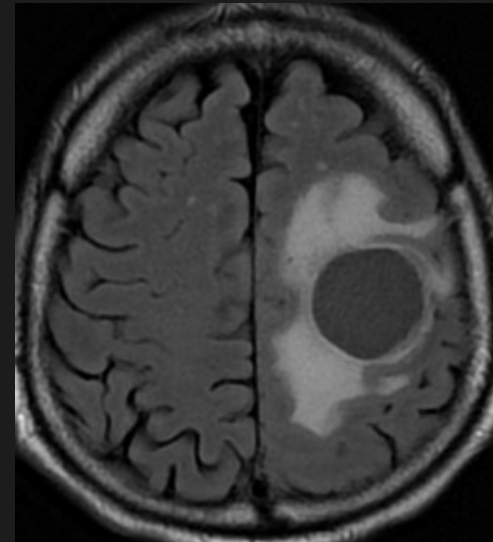
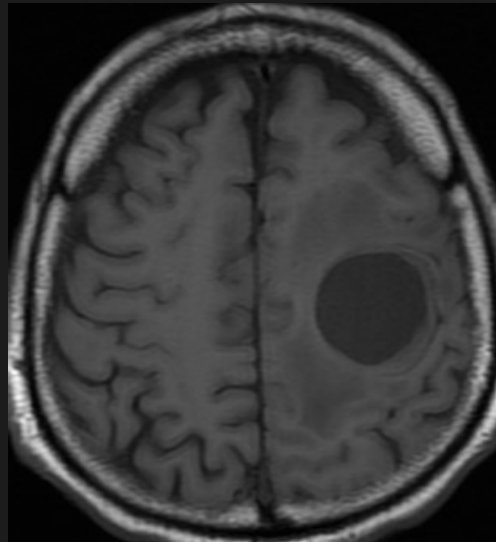
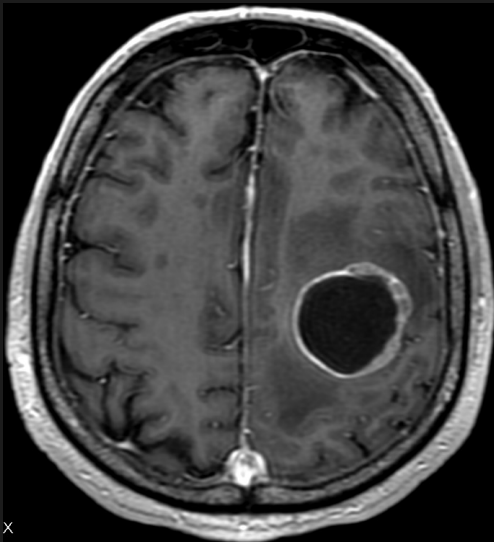


ropień

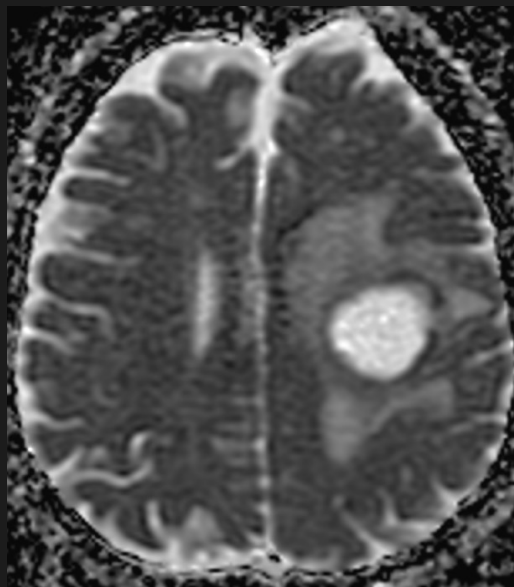
czy

guz torbielowaty ?

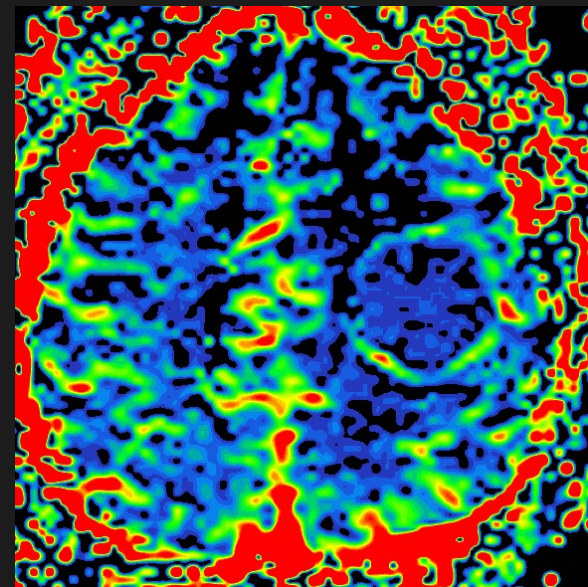
Przypadek 7



DWI

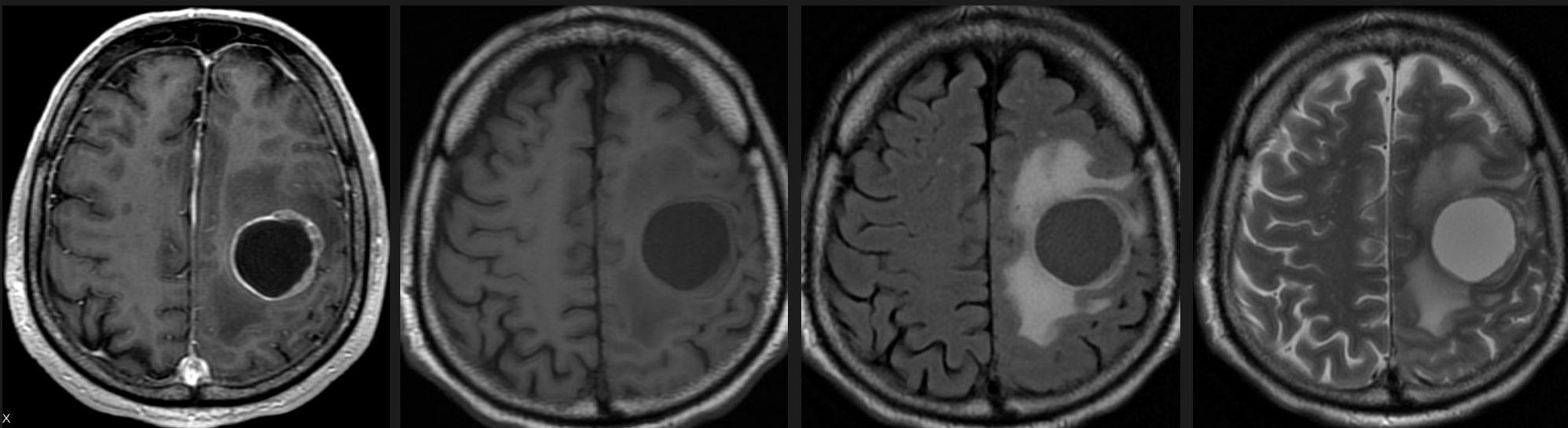


ADC map

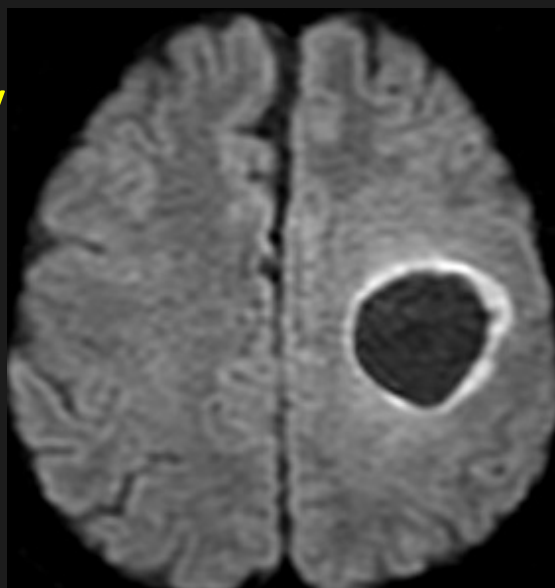


CBV map

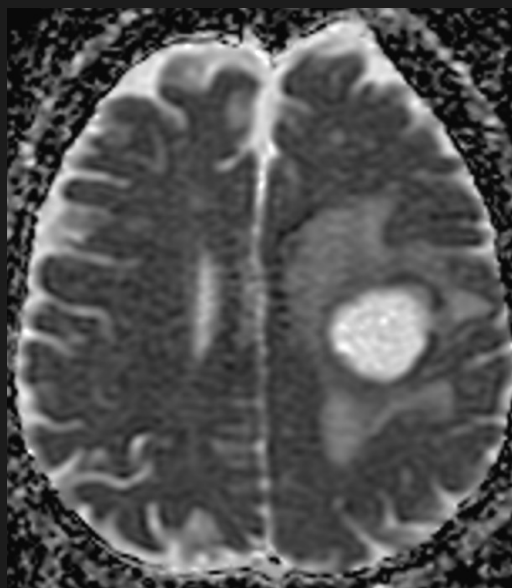
Przypadek 7



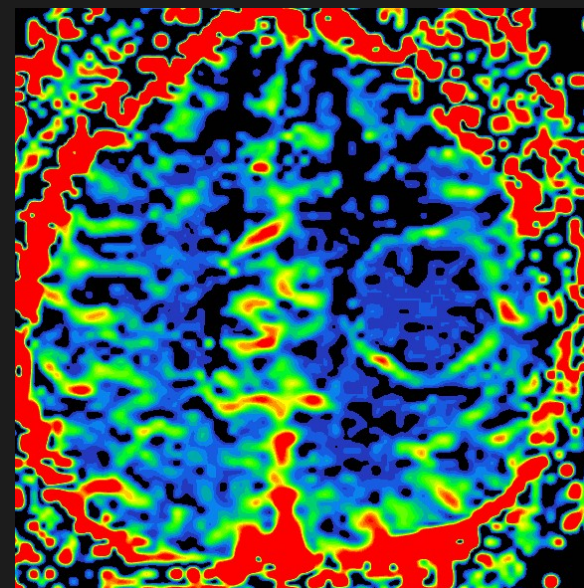
torbielowaty
przerzut



DWI



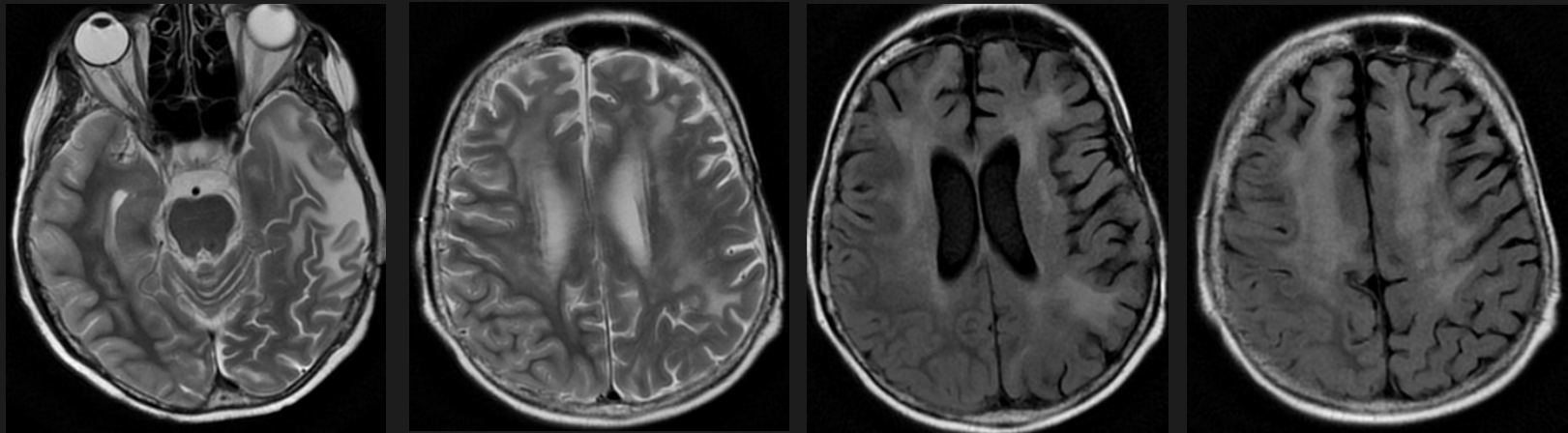
ADC map



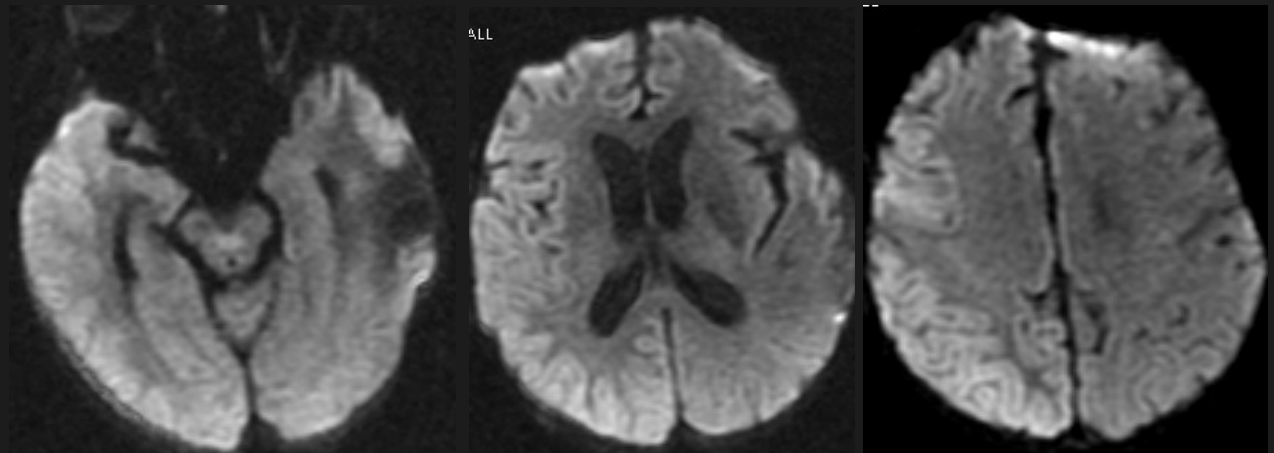
CBV map

Przypadek 8

K, lat 62, po operacji guza lewej ok. skroniowej, od miesiąca pogorszenie sprawności chodu oraz kontaktu, padaczka w wywiadzie, obecnie nieprzytomna, nasilenie niedowład lewostronnego



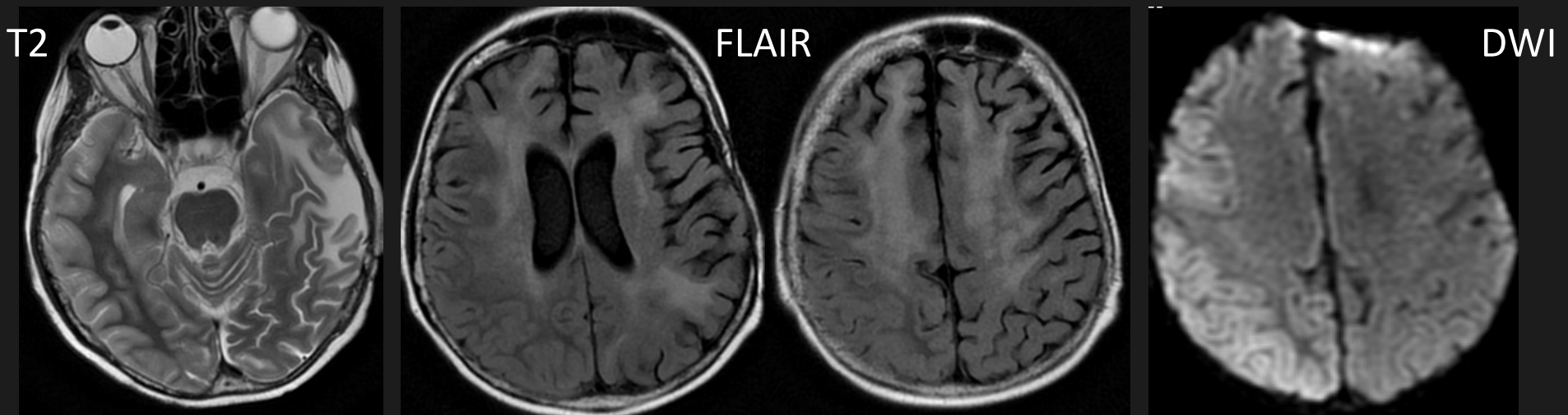
FLAIR



DWI

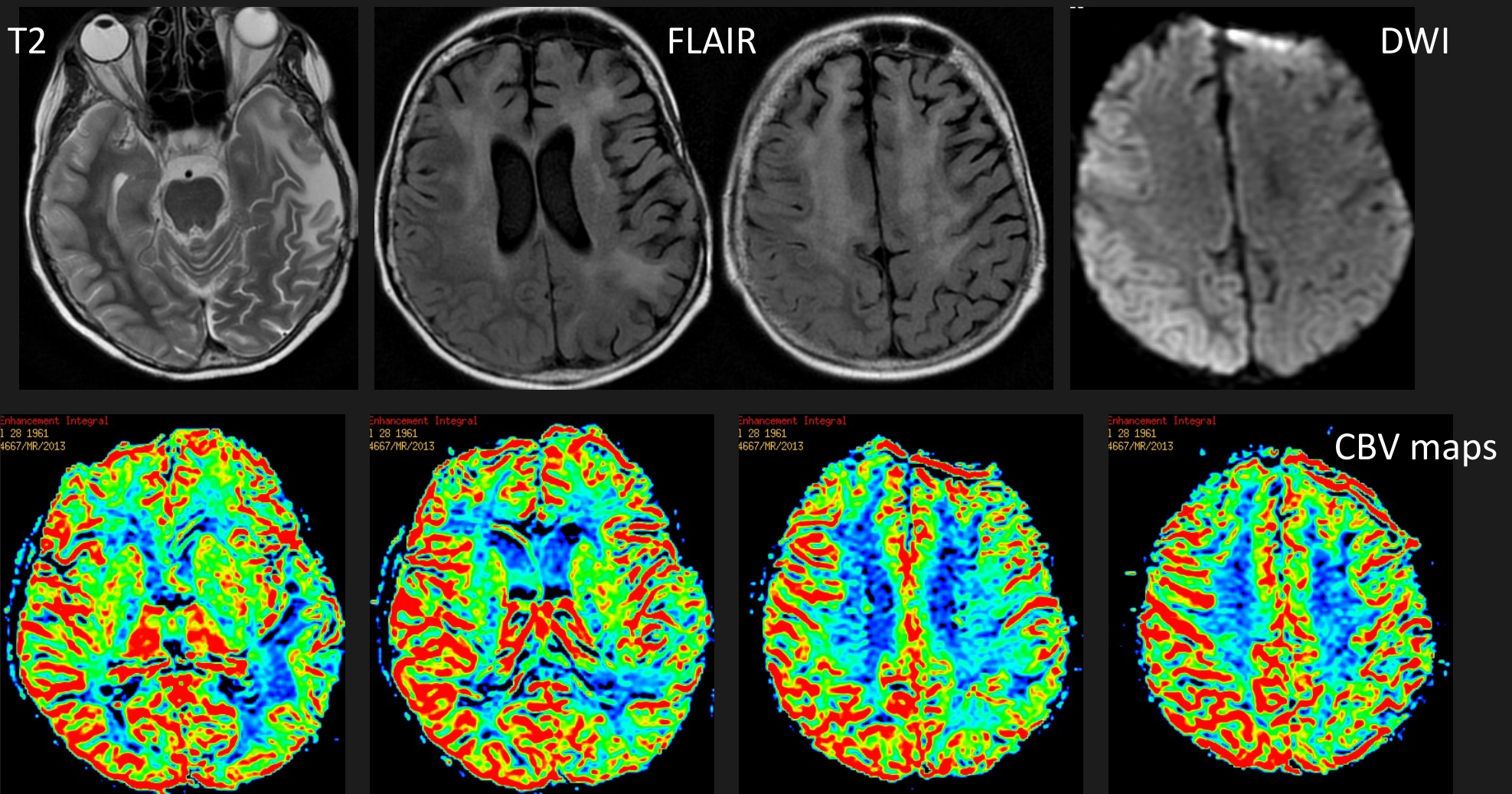
Przypadek 8

K, lat 62, po operacji guza lewej ok. skroniowej, od miesiąca pogorszenie sprawności chodu oraz kontaktu, padaczka w wywiadzie, obecnie nieprzytomna, nasilenie niedowładów lewostronnych



Przypadek 8

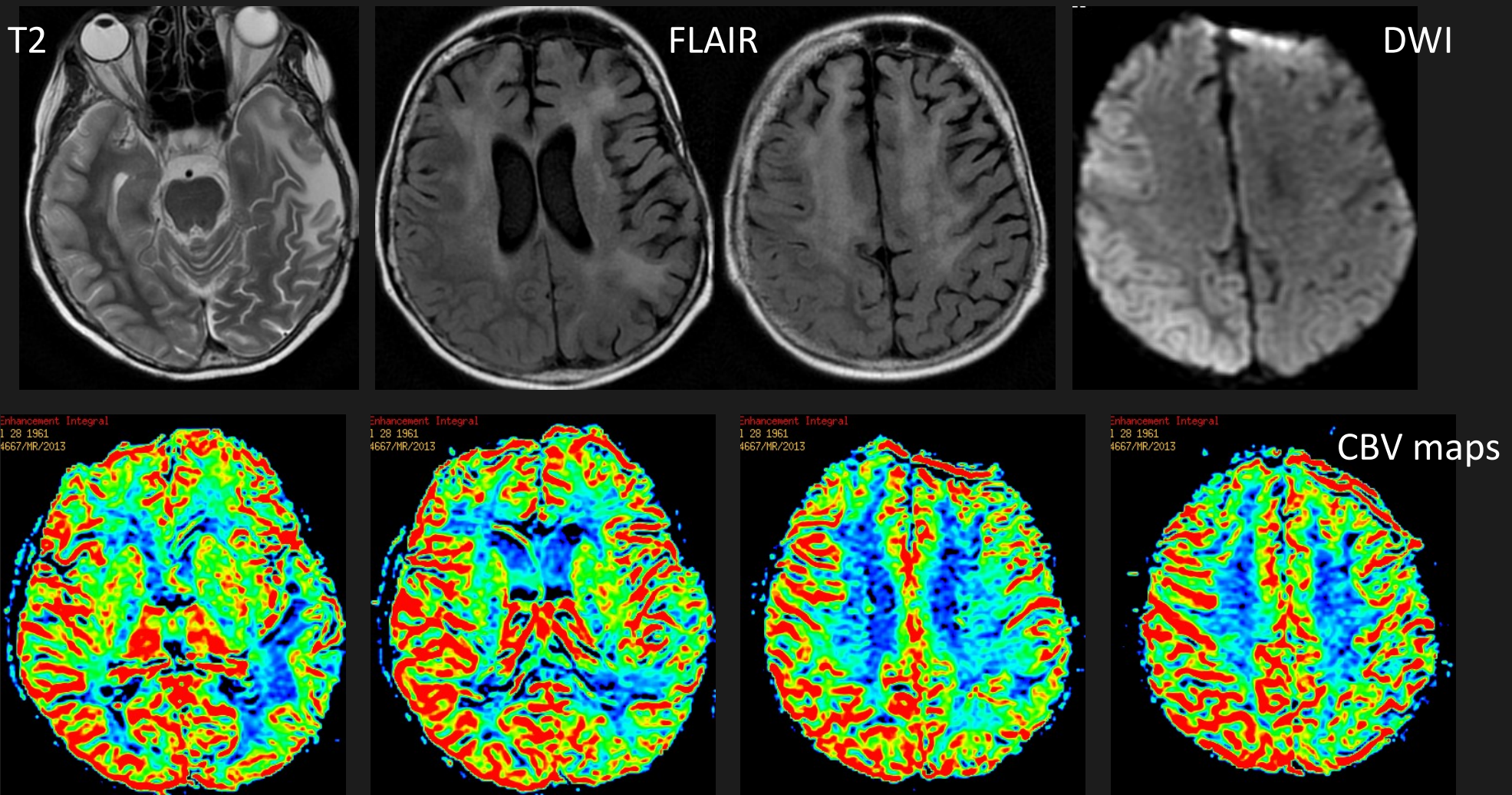
K, lat 62, po operacji guza lewej ok. skroniowej, od miesiąca pogorszenie sprawności chodu oraz kontaktu, padaczka w wywiadzie, obecnie nieprzytomna, nasilenie niedowładu lewostronnego



Przypadek 8

K, lat 62, po operacji guza lewej ok. skroniowej, od miesiąca pogorszenie sprawności chodu oraz kontaktu, padaczka w wywiadzie, obecnie nieprzytomna, nasilenie niedowładu lewostronnego

STATUS EPILEPTICUS



Perfuzja DSC T2*

co nowego?

Rekomendacje w HGG

262

Neuro-Oncology

22(9), 1262–1275, 2020 | doi:10.1093/neuonc/noaa141 | Advance Access date 9 June 2020

Consensus recommendations for a dynamic susceptibility contrast MRI protocol for use in high-grade gliomas

Jerrold L. Boxerman, Chad C. Quarles, Leland S. Hu, Bradley J. Erickson, Elizabeth R. Gerstner, Marion Smits, Timothy J. Kaufmann, Daniel P. Barboriak, Raymond H. Huang, Wolfgang Wick, Michael Weller, Evanthia Galanis, Jayashree Kalpathy-Cramer, Lalitha Shankar, Paula Jacobs, Caroline Chung, Martin J. van den Bent, Susan Chang, W.K. Al Yung, Timothy F. Cloughesy, Patrick Y. Wen, Mark R. Gilbert, Bruce R. Rosen, Benjamin M. Ellingson, and Kathleen M. Schmainda and the Jumpstarting Brain Tumor Drug Development Coalition Imaging Standardization Steering Committee

- GE T2* >> SE T2 - większy SNR, wyższe wartości CBV
- zapobieganie zaniżonym pomiarom CBV związanym z przeciekaniem ś.k. poza łożysko naczyniowe (FA, preloading, post-processing leakage correction)

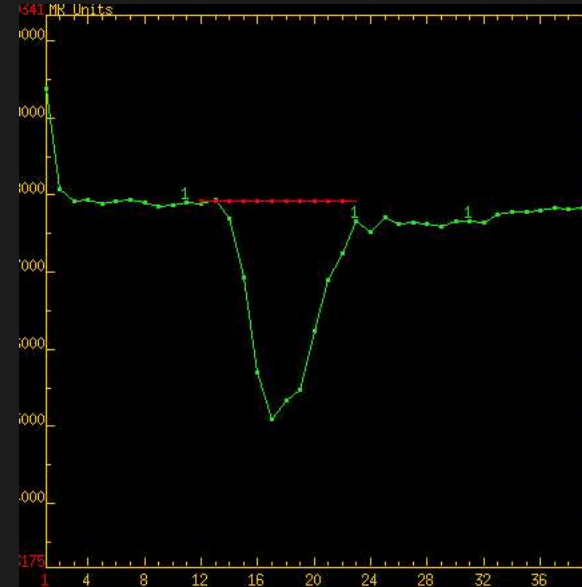
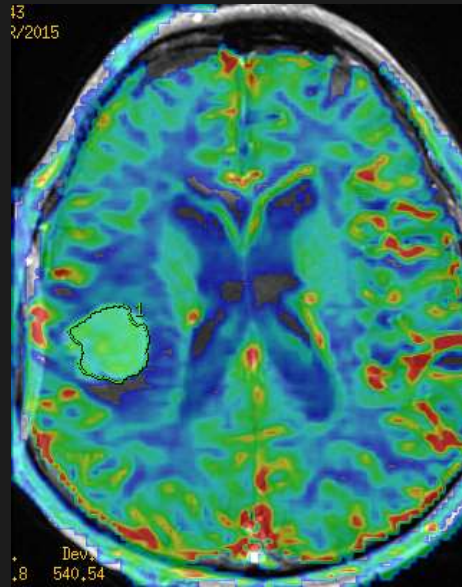
FA 60°, (1 + 1) dosing scheme

FA 30°, (0 + 1) dosing scheme (dla aparatów 1,5T i 3T)

post-processing leakage correction zalecane zawsze

Pre-loading (chłoniak)

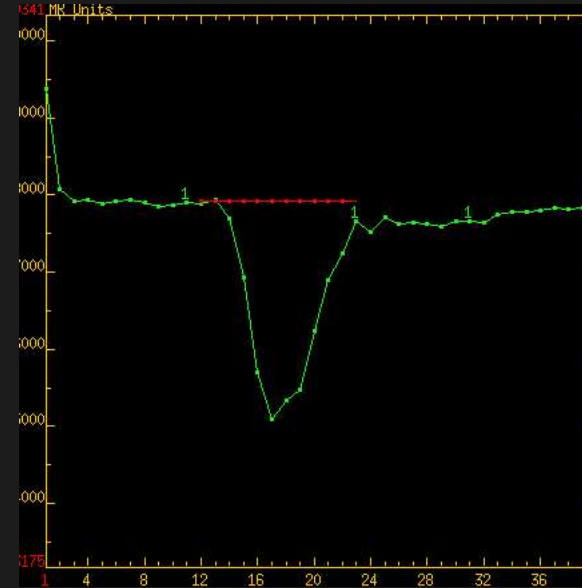
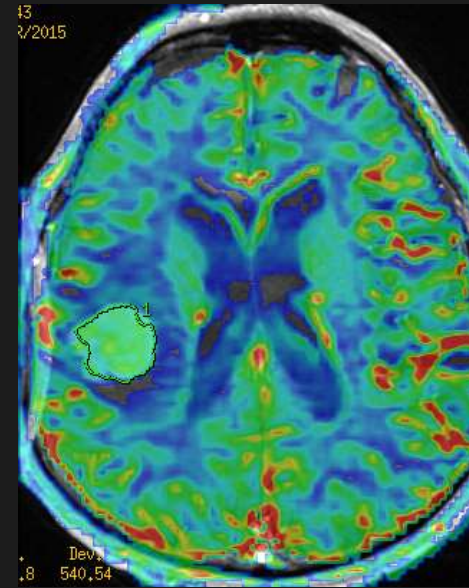
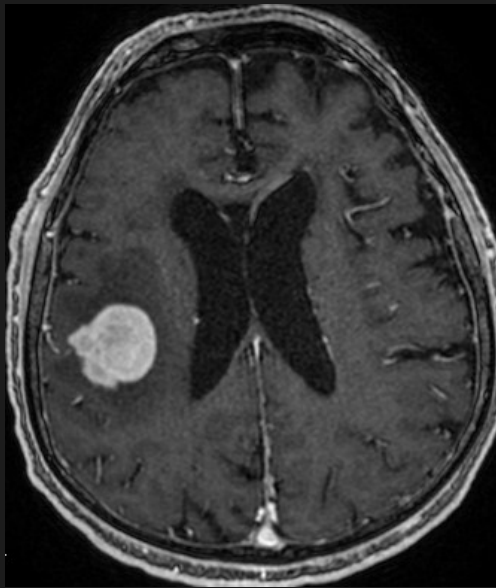
prebolus



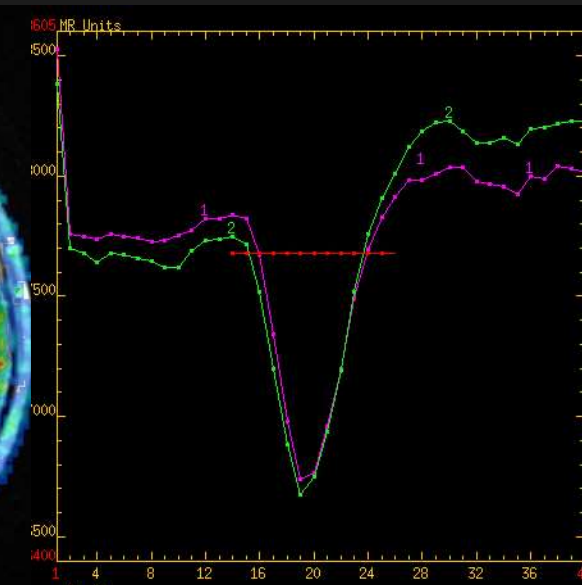
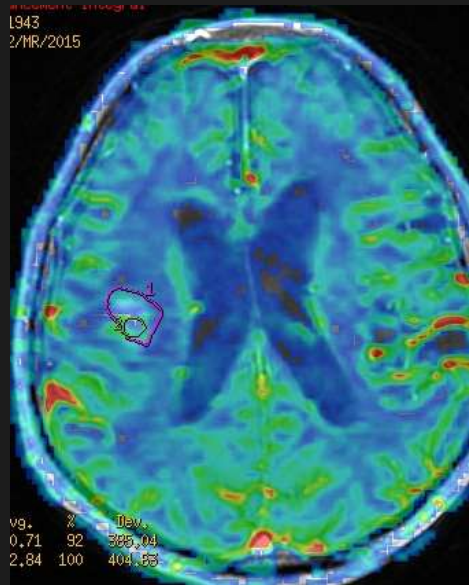
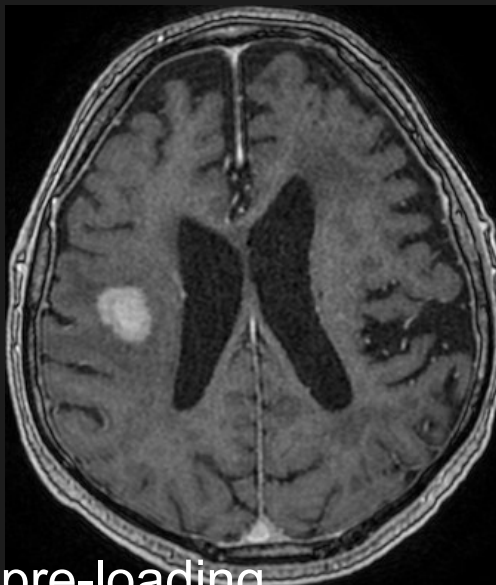
rCBV = 2,8

Pre-loading (chłoniak)

prebolus



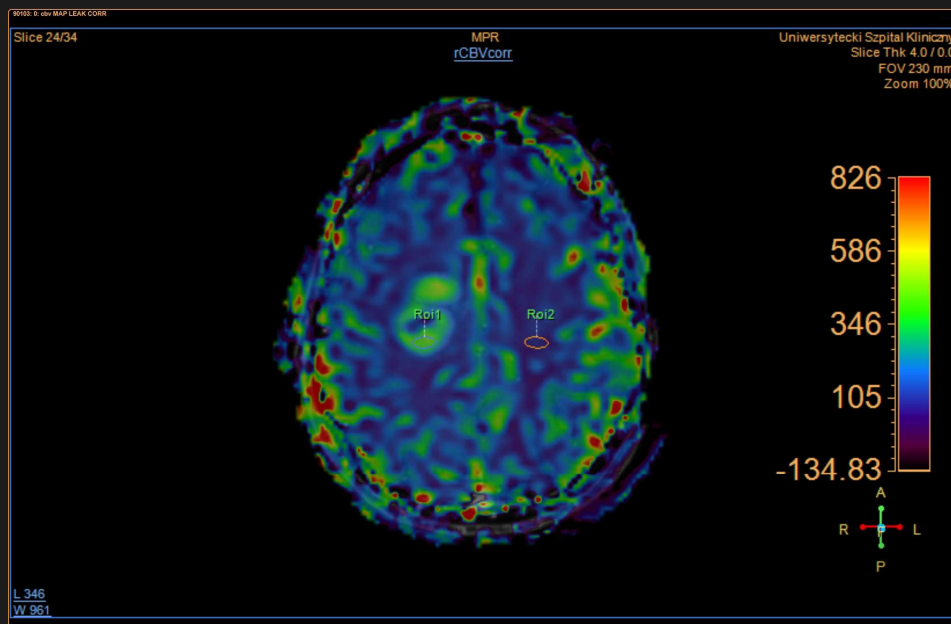
rCBV = 2,8



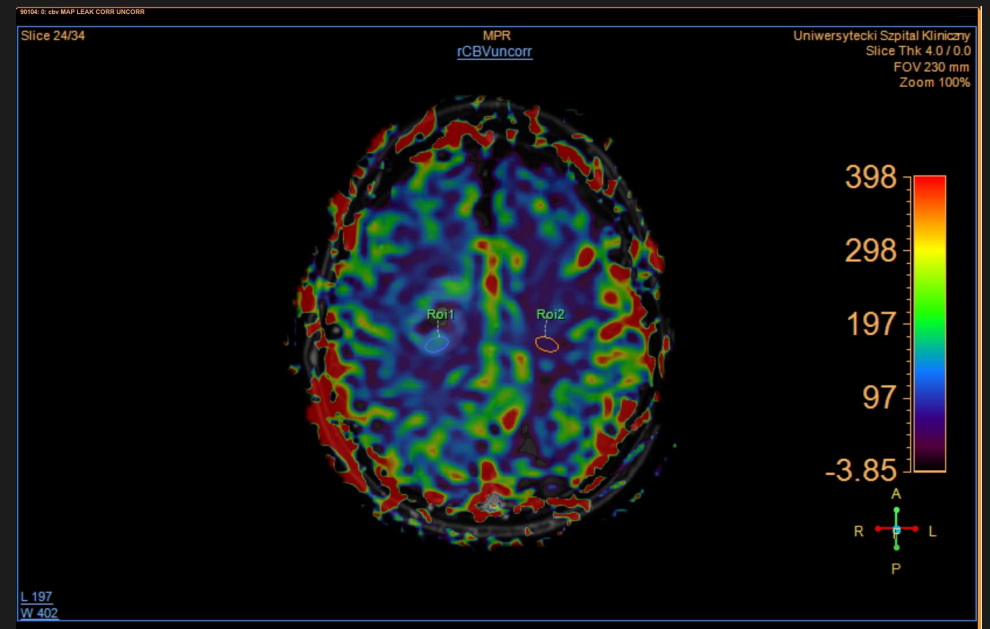
rCBV = 1,1

no pre-loading

Postprocessing - leakage correction



corr rCBV = 5,5



uncorr rCBV = 2,1

RESEARCH ARTICLE

Differentiation of glioblastoma multiforme, metastases and primary central nervous system lymphomas using multiparametric perfusion and diffusion MR imaging of a tumor core and a peritumoral zone— Searching for a practical approach

Małgorzata Neska-Matuszewska*, Joanna Bładowska, Marek Szaśniadek, Anna Zimny
 Department of General and Interventional Radiology and Neuroradiology, Wrocław Medical University, Wrocław, Poland

* neskamatuszewska@gmail.com

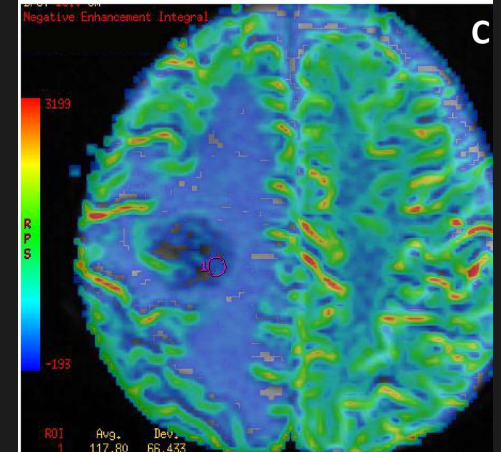
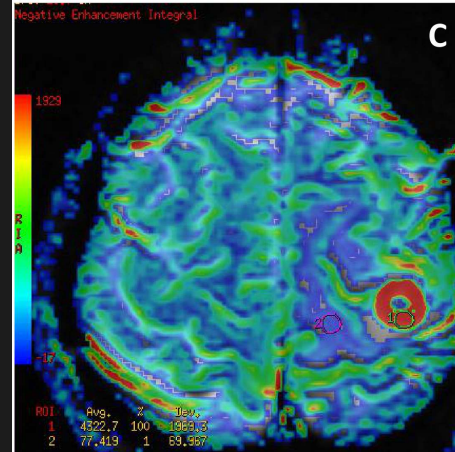
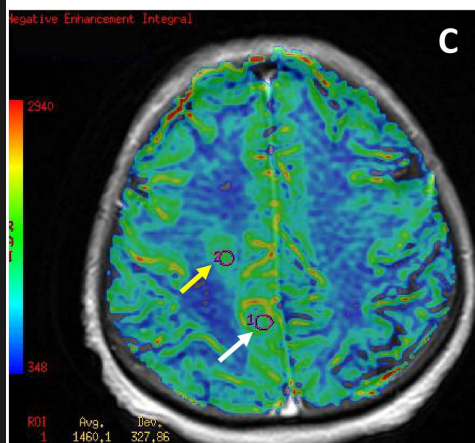
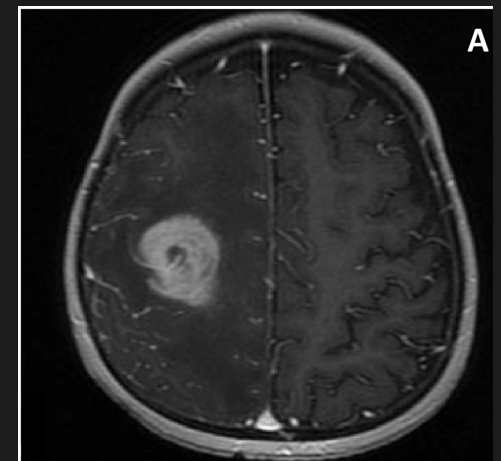
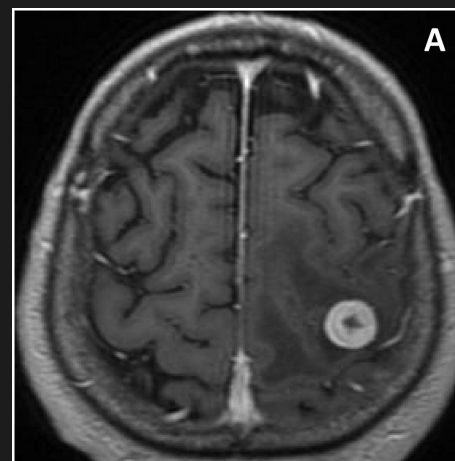


Badania własne

27 GBM

30 meta

17 lymphoma



threshold

uncorr,
 $rCBV = 2,18$

GBM

meta

lymphoma

Podsumowanie

- perfuzja DSC jest łatwą i szybką techniką
- bardzo przydatna do oceny zmian ogniskowych w mózgowiu, zwłaszcza różnicowania zmian wzmacniających się po kontraście
- wzmocnienie kontrastowe nie oznacza wysokiej perfuzji (demyelinizacja, zapalenia, chłoniaki, schwannoma)
- nowe rekomendacje – istotne w badaniach guzów typu HGG, zwłaszcza w badaniach kontrolnych

Quiz - pytanie

- Wybierz patologie, które wykazują wysokie wartości rCBV (powyżej 2,0)
 - A. GBM, aktywna demielinizacja
 - B. HGG, oponiak, status epilepticus
 - C. HGG, oponiak,
 - D. HGG, nerwiak, status epilepticus



Dziękuję za uwagę