GIOTI

Ente Ospedaliero Cantonale

Tumori cerebrali: sintomi – trattamenti – ripercussioni

Neuroradiologia dei tumori cerebrali

Cadempino, 16.11.2023

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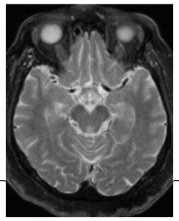
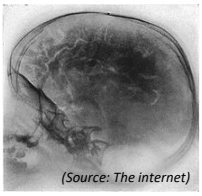
MRI Technicians



Outline

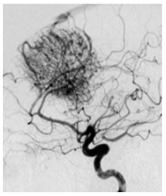
- Diagnosis and Differential Diagnosis
- Presurgical mapping by MRI
- Disease and Tx monitoring

1919 – 70s
Pneumoencephalography

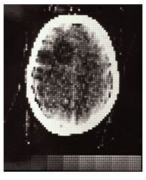


(Source: The internet)

1927 – 70s
Angiography

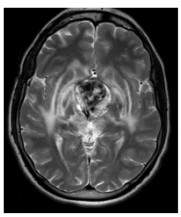


1971
Computed
Assisted
Tomography

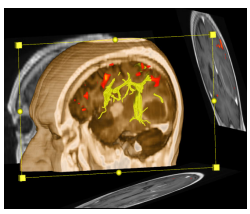


The first clinical scan: Atkinson Morley's Hospital, October 1971

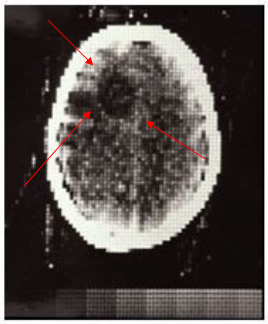
80s-90s
Conventional
MRI



2000s
Advanced
MRI Techniques

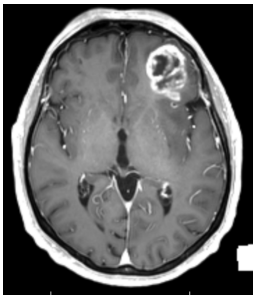


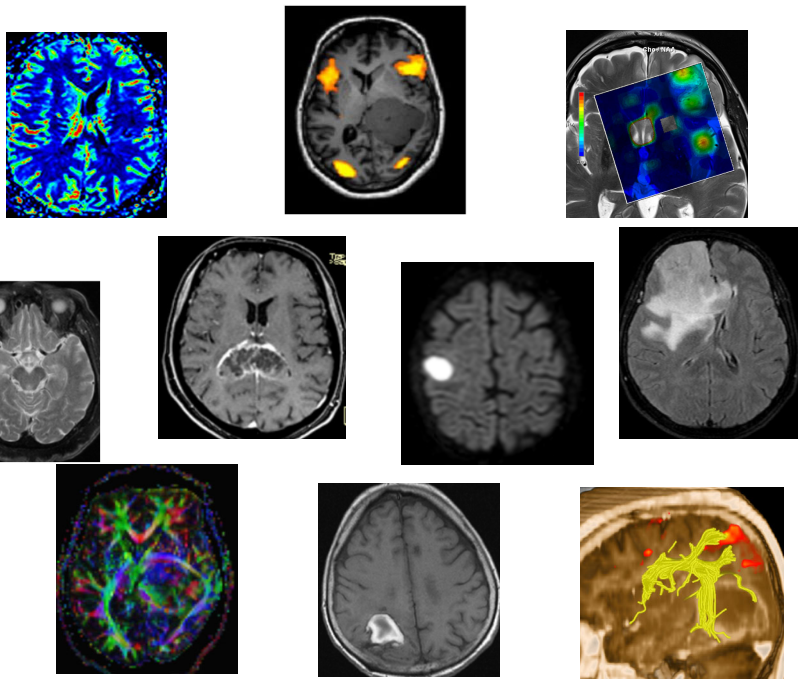
1971
Computed
Assisted
Tomography



The first clinical scan: Atkinson Morley's Hospital, October 1971

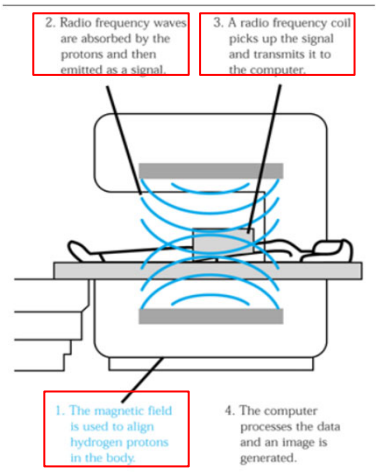
2000s
Magnetic
Resonance
Imaging





MRI: how does it work?

Why do we use head coils?



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Abbreviations: ADC = apparent diffusion coefficient, AF = arcuate fasciculus, BOLD = blood oxygen level–dependent, CBV = cerebral blood volume, CNS = central nervous system, CST = corticospinal tract, CTV = clinical target volume, DSC = dynamic susceptibility contrast, DTI = diffusion tensor imaging, DW = diffusion-weighted, ESM = electrocortical stimulation mapping, FLAIR = fluid-attenuated inversion recovery, GBM = glioblastoma multiforme, GTV = gross tumor volume, NAA = *N*-acetylaspartate, TE = echo time

RadioGraphics 2014; 34:702–721

Published online 10.1148/rg.343130156

Content Codes: CT MR NR OI

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TEACHING POINTS
See last page

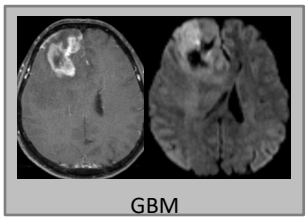
Critical Role of Imaging in the Neurosurgical and Radiotherapeutic Management of Brain Tumors[1]

Introduction

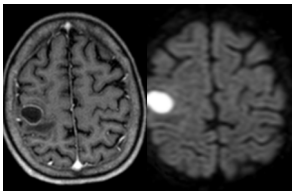
Imaging has played an increasingly crucial role in guiding neurosurgical and radiotherapeutic management of brain tumors, especially since the development of computed tomography (CT) and magnetic resonance (MR) imaging. In recent years, the evolution of new imaging techniques, including diffusion-weighted (DW) imaging, perfusion MR imaging, spectroscopy, functional MR imaging, and diffusion tensor imaging (DTI), has not only improved the preoperative assessment of tumors, but has also expanded surgical approaches, aided in radiation treatment planning, and become a critical tool in evaluating therapeutic outcomes. The 2012 Oncodiagnosis Panel presented an overview of how comprehensive MR imaging plays an integral role in the multidisciplinary approach to brain tumors. In this article, we discuss how the use of a variety of imaging techniques can aid in the diagnosis and appropriate treatment of intracranial lesions.

RadioGraphics 2014

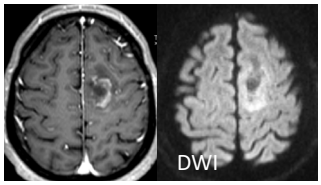
MRI Helps Differential Diagnosis !



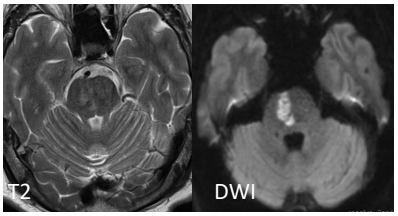
GBM



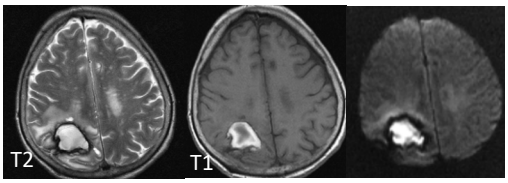
Pyogenic Abscess



Tumefactive Demyelinating Plaque

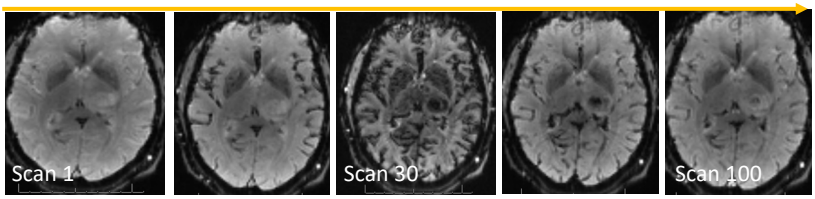


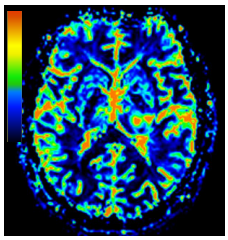
Acute/Subacute Stroke

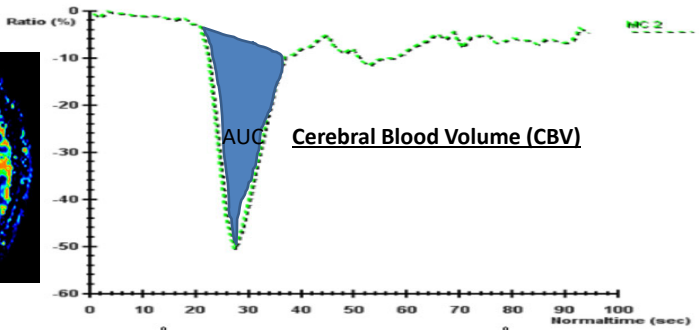


Hemorrhage

Perfusion using Contrast Media inj.







Cerebral Blood Volume (CBV)

WHITE PAPER

ASFNR Recommendations for Clinical Performance of MR Dynamic Susceptibility Contrast Perfusion Imaging of the Brain

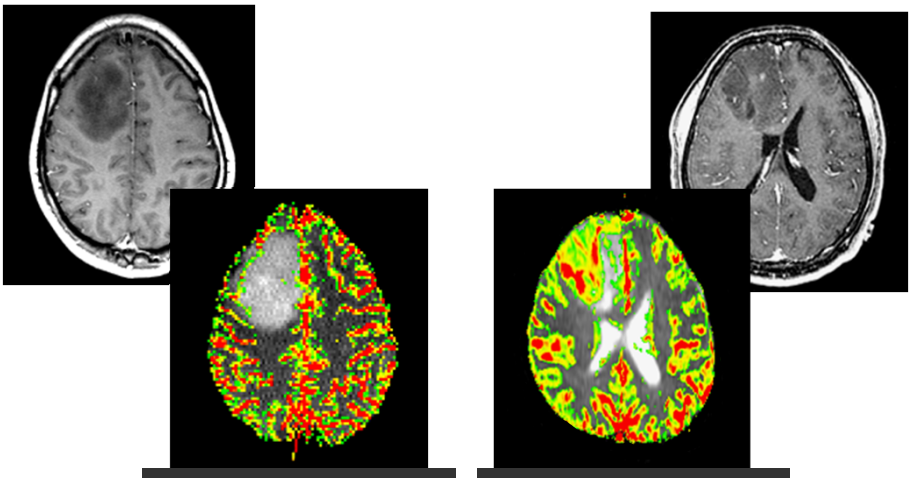
K. Welker, J. Boxerman, A. Kalnin, T. Kaufmann, M. Shiroishi, and M. Wintermark; for the American Society of Functional Neuroradiolgy MR Perfusion Standards and Practice Subcommittee of the ASFNR Clinical Practice Committee

Table 1: Summary of recommended acquisition parameters for DSC perfusion imaging

Acquisition Parameter	Recommendation
Pulse sequence	Generally GRE-EPI rather than SE-EPI
TR	1.0–1.5 seconds (SE-EPI); minimum (vs "as short as possible") for GRE-EPI; generally 1.0–1.5 seconds
TE	40–45 ms at 1.5T; 25–35 ms at 3T
Flip angle	60°–70°
Temporal coverage	120 Time points
Preload Gd-based contrast agent dose (particularly for studies performed with a high flip angle)	One-fourth to single dose (0.025–0.1 mmol/kg Gd), given 5–10 minutes prior to dynamic imaging
Slice thickness	3–5 mm
Matrix	128 × 128 (range, 64 × 64 to 256 × 256)
FOV	20 × 20 cm (range, 20 × 20 to 24 × 24 cm)
IV catheter gauge	18- to 20-ga antecubital IV, right arm preferred
Injection rate	3–5 mL/s
Total acquisition time	Approximately 2 minutes

Note:—Gd indicates gadolinium.

Why do we do perfusion ?



Low Vascularization

High Vascularization

New WHO classification (2021)

- 2016 Classification: Central nervous system (CNS) tumors are defined by molecular markers
- 2021 Classification: Further expands their role
- Histologic and molecular features "layered" diagnosis: e.g. Glioblastoma, IDH-wildtype

Table 2: Mechanisms of Molecular Alterations in Diffuse Gliomas

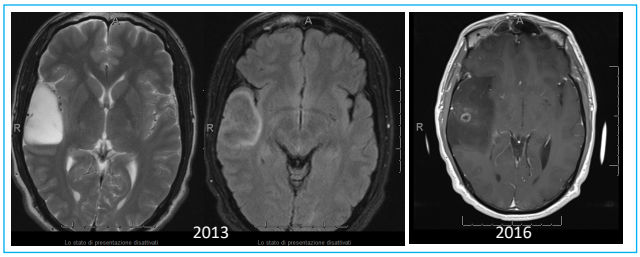
Molecular Alteration	Function
IDH1 p.R132 or *IDH2* p.R172 mutation	IDH mutations generate the oncometabolite 2-hydroxyglutarate, resulting in DNA hypermethylation (G-CIMP phenotype)
ATRX mutation	Activates alternative lengthening of telomeres (ALT) pathway to maintain telomere length
TERT promoter mutation	Activates telomerase to maintain telomere length
CDKN2A/B homozygous deletion	Results in loss of tumor suppressor and cell cycle regulator p16
EGFR amplification	Activates receptor tyrosine kinase pathway
H3 K27M mutation	Histone H3 mutations result in widespread loss of H3 K27-trimethylation and aberrant gene transcription
H3 G34R or G34 V mutation	Histone H3 mutation alters H3 K36 methylation and results in aberrant gene transcription

Note.—IDH = isocitrate dehydrogenase, MAPK = mitogen-activated protein kinase.

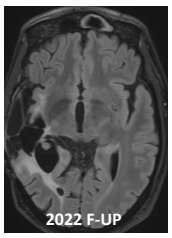
Have we got reliable biomarkers for these?

«Lower grade» to «higher grade» glioma progression

- **Darker FLAIR signal within T2-bright tumor:** ***indicates IDH1/2 mut, 1p/19q intact genotype***
- PPV: 100%, NPV 68%, SS 51%, and **SP 100%**. *[Broen et al., Neuroncol 2018. N=154 LGG]*

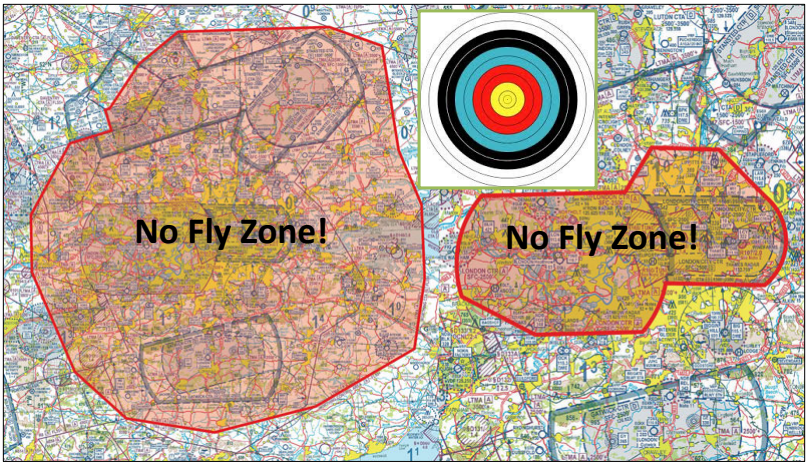


T2-FLAIR mismatch



Astrocytoma grade 4, IDH1-mut, 1p/19q-intact (WHO 2021)
Ex- «secondary» GBM

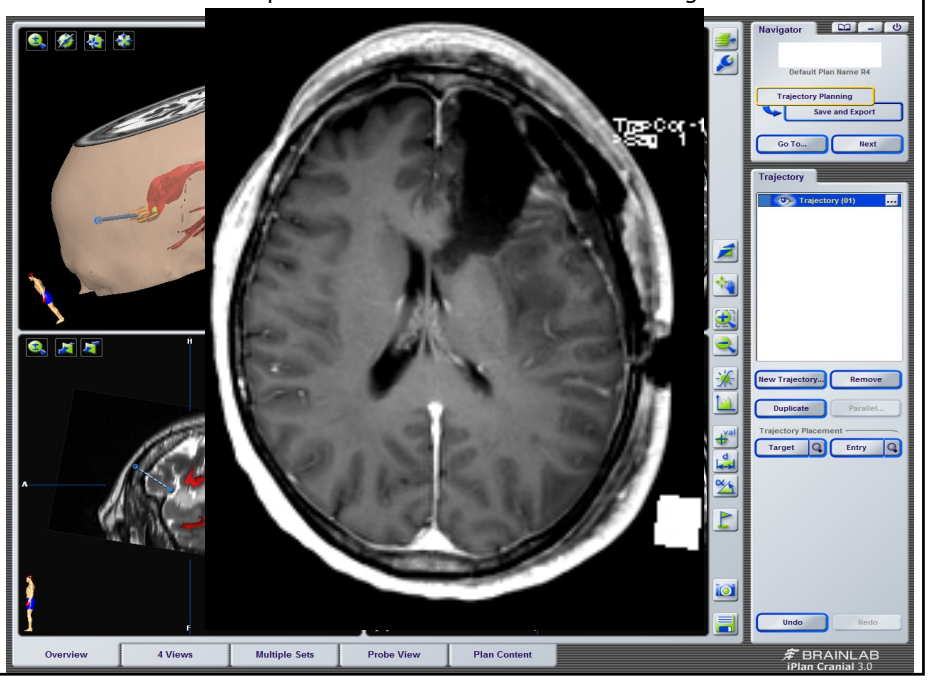
Treatment guidance:
Sparing critical structures



Presurgical Mapping: Benefits

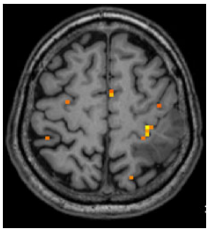
- Needed **in selected cases** were a lesion is close to critical brain areas
- To **facilitate therapeutic decisions** based on improved surgical risk estimation
- To **Optimize Treatment Plans**
- To **Reduce Need for invasive testing** (e.g. Wada)

What's important around it? - *Treatment Planning*



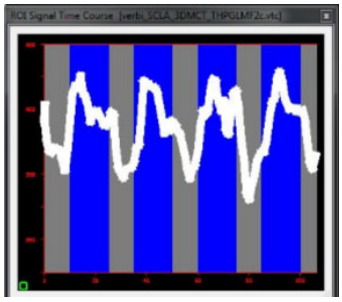
Finger Tapping: How Does it Work?

STOP

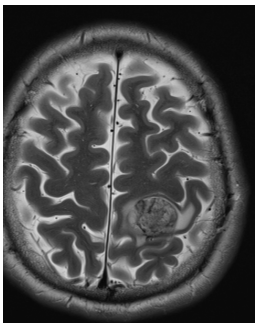


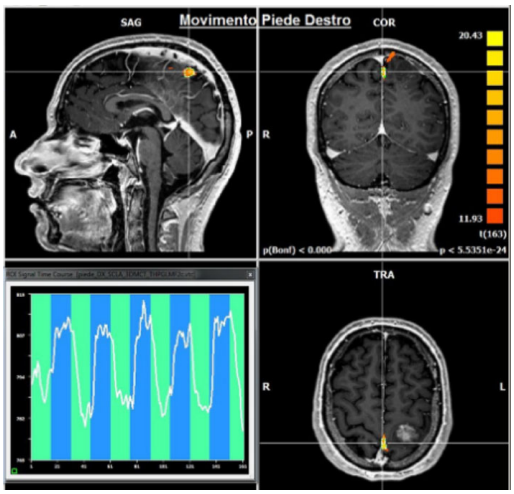
Statistics (GLM)

Signal Change in each Brain Voxel

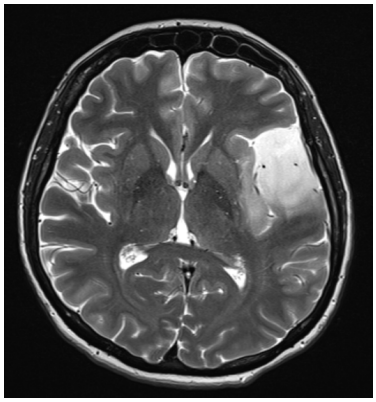


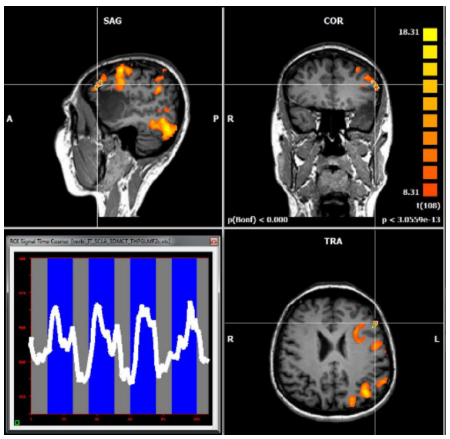
What's important around it? *Foot Movement*





Left-Lateralized Language in A Right-Handed Patient: (normally expected in 85%)



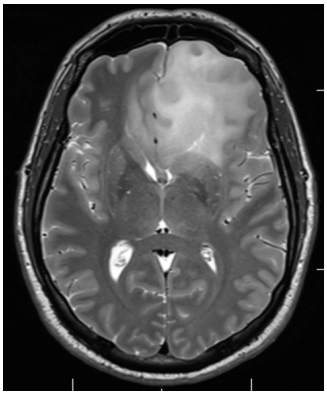


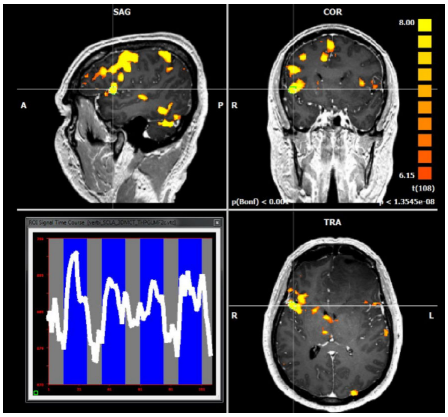
Verb Generation ($p < 0.001$, Bonferroni-corr)

Left – Lateralized!

LI = +0.6

Right-Lateralized Language in a Right-Handed Patient



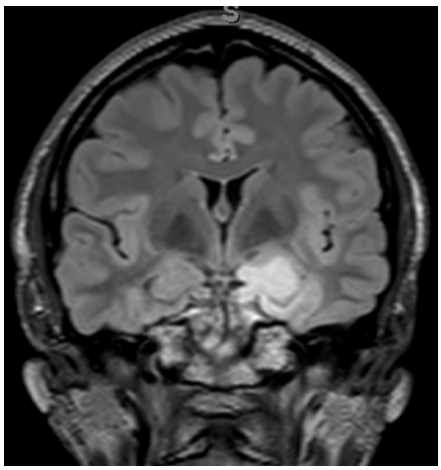


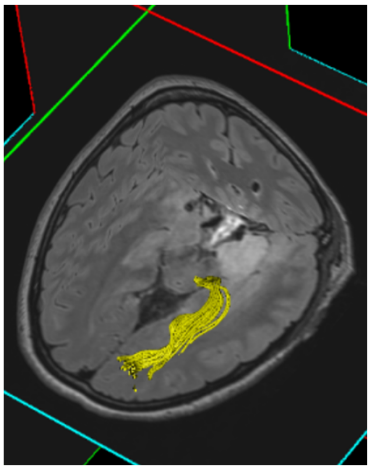
Verb Generation ($p < 0.001$, Bonferroni-corr)

Right – Lateralized!

LI = -0.35

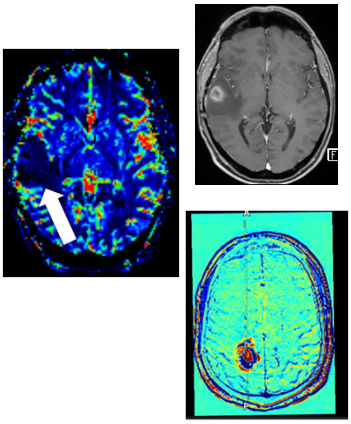
Optic Patways



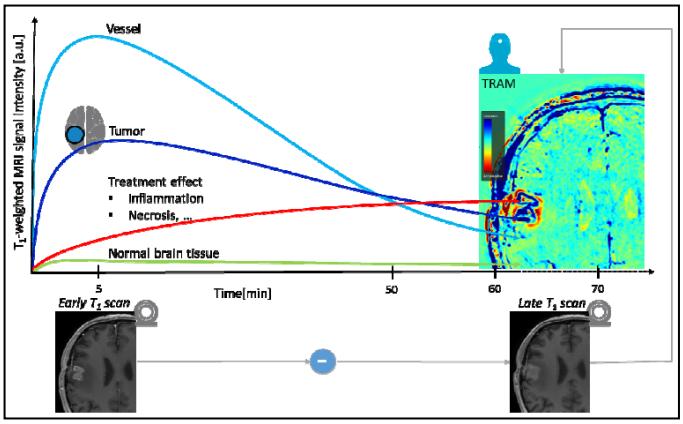


NeuroImaging in glioma follow-up:
Current challenges at MRI

- **<u>Pseudoprogression (30%)</u>**
- Radionecrosis
- Immunotherapy-related (checkpoint inhibitors):
  - Pseudoresponse, Hyperprogression, Abscopal effect



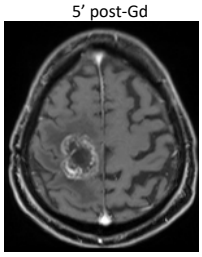
Delayed Contrast Clearance Analysis
Treatment response assessment maps (TRAMs)



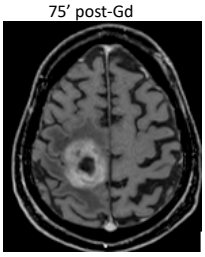
= slow contrast clearance → no washout → no viable tissue → Necrosis

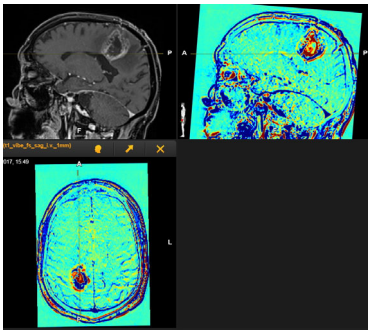
= fast contrast clearance → washout → viable tissue → Tumor, vessels

5' post-Gd



75' post-Gd





GBM following Stupp protocol:
Disentangling admixed viable tumor and inflmmation

Il Team di Neuroradiologia del Neurocentro