Brain: Glioma

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Introduction

Multiparametric MRI in brain tumours is an invaluable methodology for obtaining in-depth information for the structural and functional tissue features guiding the differential diagnosis and assisting the tumour staging. Each MRI parametric maps provides crucial information for the different histomolecular tumour substrates, whereas the 'tier-like' interpretation of the combined structural-functional outputs helps the radiologist to reach an accurate diagnosis.

Patient history

48-year-old male patient with clinical history of non-'migraine-like' headaches accompanied with two seizures during the last 3 months presented currently with left leg and hand weakness. The patient is non-smoker without any previous chronic diseases.

Morphological findings

A large space-occupying mass within the right hemisphere (arrows on T2w and T2-FLAIR images, see Figures 1 and 2) with epicentre on the frontal operculum is clearly demonstrated. The mass shows cortical and subcortical infiltration extending into the deep periventricular white matter, though without any discernible midline shift.

The mass shows a large central CSF-filled compartment (red arrow on T2-FLAIR, see Figure 2) and a rim of intermediate T2 signal, which shows blood-brain-barrier disruption on the post-contrast T1w image (black arrow, see Figure 4).

The central part of the lesion (dashed arrow on pre- and post-contrast T1w, see Figures 3 and 4) does not demonstrate any convincing gadolinium enhancement. The rather increased T1 shortening in the pre-contrast T1w images can be attributed to haemorrhagic features or calcification.

Diffusion-weighted images

The ADC map shows a central part in the lesion with predominantly high ADC signal, owing to the cystic CSF-filled compartment, and tissue with intermediate ADC values on the lateral tumour part. The tissue on the tumour margin shows a mixed pattern of rather high signal (white arrow, see Figure 5) indicating low cellularity/oedema, and low ADC signal (black arrow, see Figure 5), which is in spatial agreement with the gadolinium rim enhancement (white arrow, see Figure 5).

These features are suggesting an aggressive growth pattern with hypercellular tumour zone infiltration.

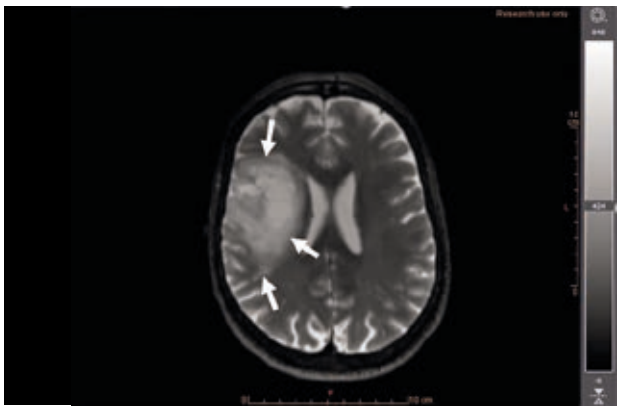

Figure 1 T2w map

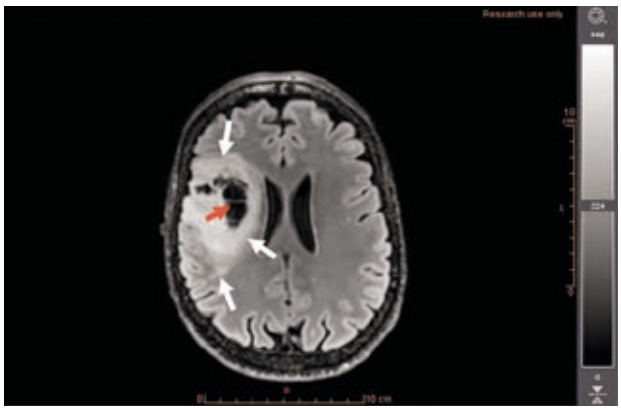

Figure 2 T2-FLAIR map

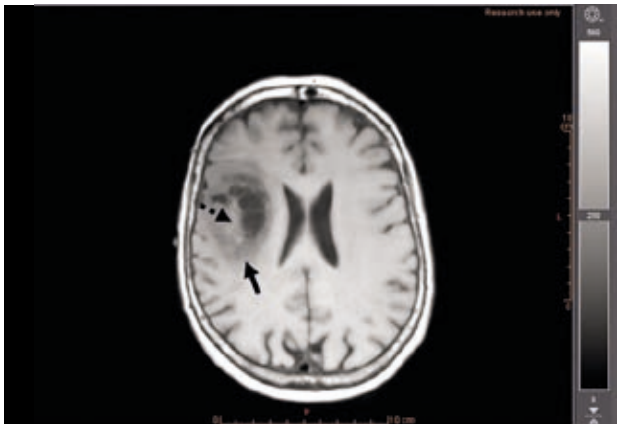

Figure 3 Pre-contrast T1w map

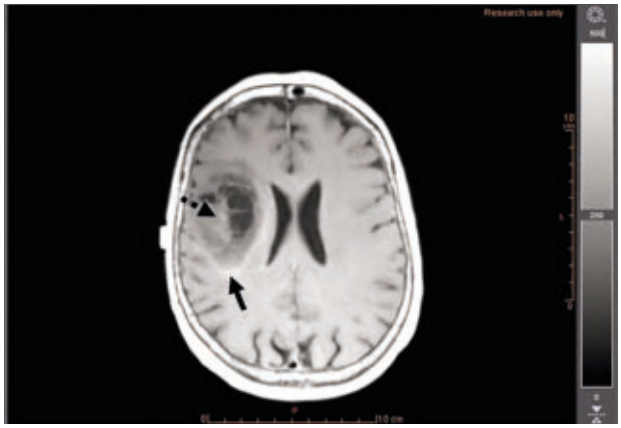

Figure 4 Post-contrast T1w map

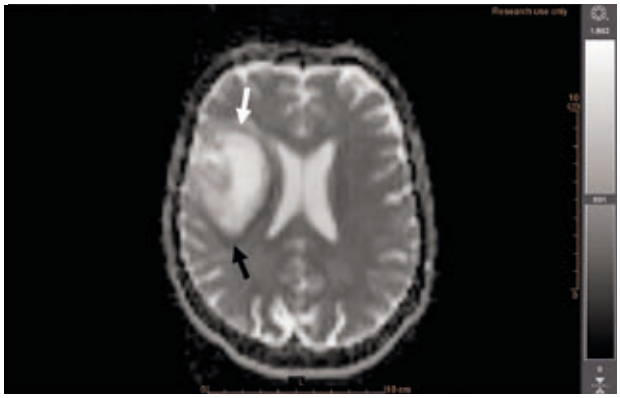

Figure 5 ADC map (gray palette)

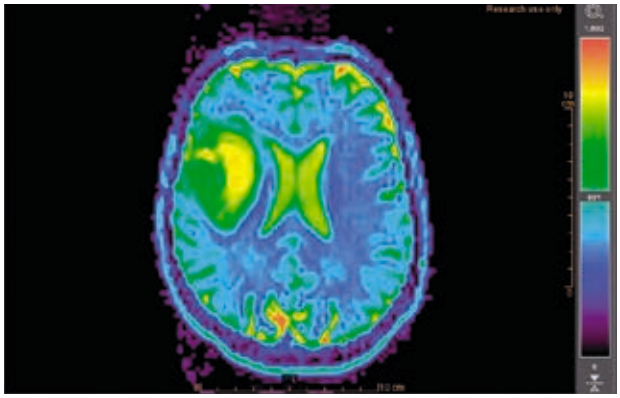

Figure 6 ADC map (rainbow palette)

Perfusion-weighted images

The blood volume and blood flow maps derived from the dynamic susceptibility-weighted contrast-enhanced (DSC) MR acquisition with leakage correction show increased intravascular blood volume and blood flow on the tumour periphery (arrows in the vascular maps, see Figures 7, 8 and 9). The increased angiogenic activity grossly overlaps with the low ADC signal abnormalities indicating again the most malignant tumour components and predicting a rather rapidly growing tumour. Interestingly and despite the assumed blood-brain-barrier disruption, the DSC-derived leakage maps demonstrate only vaguely increased gadolinium leakage, which is a pattern seen in mature tumour vasculature.

APT-CEST-weighted images

The increased concentration of peptides throughout the visualised tumour tissue is superbly captured by the APT-CEST imaging (3-4 ppm) and the contrast-to-noise ratio is increased by the concurrent fluid suppression (arrowhead, see Figure 10) hence avoiding false positive signal elevation. The distribution of the pathological peptide concentration, the magnitude of which can be simply observed by comparing the signal to the normal appearing white matter, shows a distinct pattern that encompasses the non-enhancing and low ADC tumour parts (arrows, see Figure 10), whereas the rich-in-vasculature peripheral lesion components have lower peptide-based signal.

MR Spectroscopy

Selected 1H-MR spectra from the high- and low-APTw signal tumour areas demonstrate similar patterns of increased choline and myo-Inositol, decreased NAA/NAAG, and increased lipids. The spectra analysis in the 0.6-1.4 ppm spectrum part shows higher concentration of macromolecules and lipids in the enhanced APTw-signal area than in the hypointense APTw region. The latter demonstrates however higher lactate concentration, an imaging biomarker correlated also with hypoxic conditions and anaerobic metabolism (See Figure 11).

Impression

The disentanglement between the tumour peptide 'hot-spots' and the traditional gadolinium-based conventional, perfusion and ADC features mapping in this patient highlights

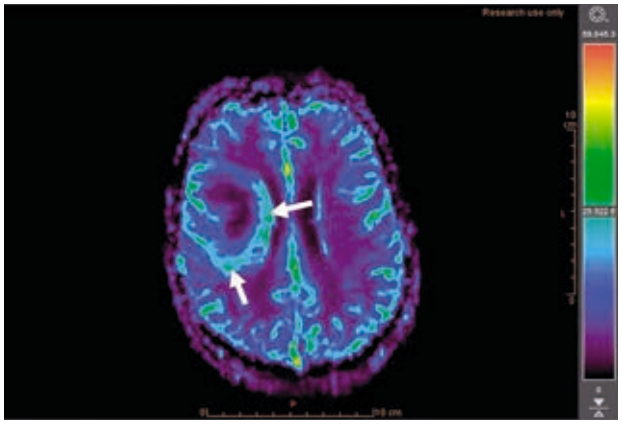

Figure 7 Perfusion rBV map

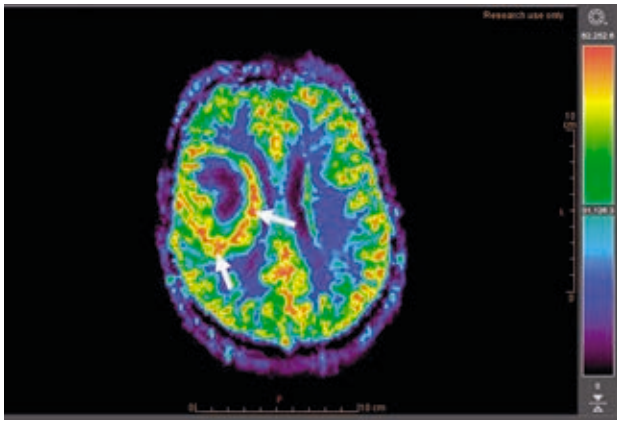

Figure 8 Perfusion rBF map

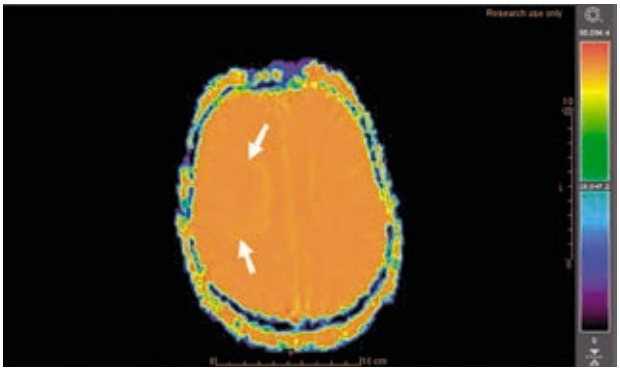

Figure 9 Perfusion K2 map

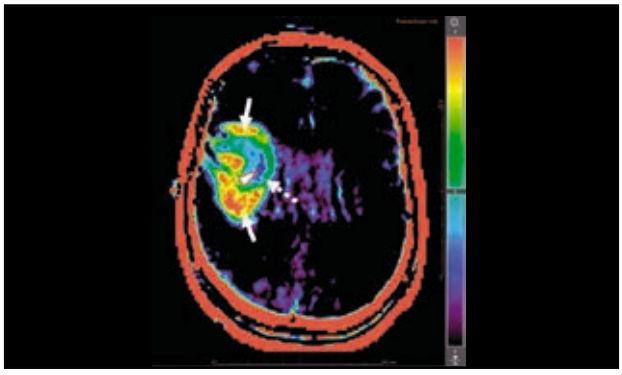

Figure 10 Fluid-suppressed APTw map (3-4 ppm)

the indispensable value of multi-parametric MRI in tumour diagnosis and image-guided therapy. The APT-weighted image unravels the pathological metabolically altered substrate of the solid tumour parts with higher mobile protein and peptide concentrations but seemingly low or no gadolinium enhancement.

The synthesis of the imaging evidence in this case suggests a highly heterogenous intrinsic brain tumour with APT-CEST signal hallmarks of malignant viable active tumour core and an aggressively expanding, in terms of cellularity and vascularity, tumour rim. These features are consistent with high-grade glioma and the histomolecular diagnosis after tumour resection was consistent with WHO grade 4, IDH wild-type glioma.

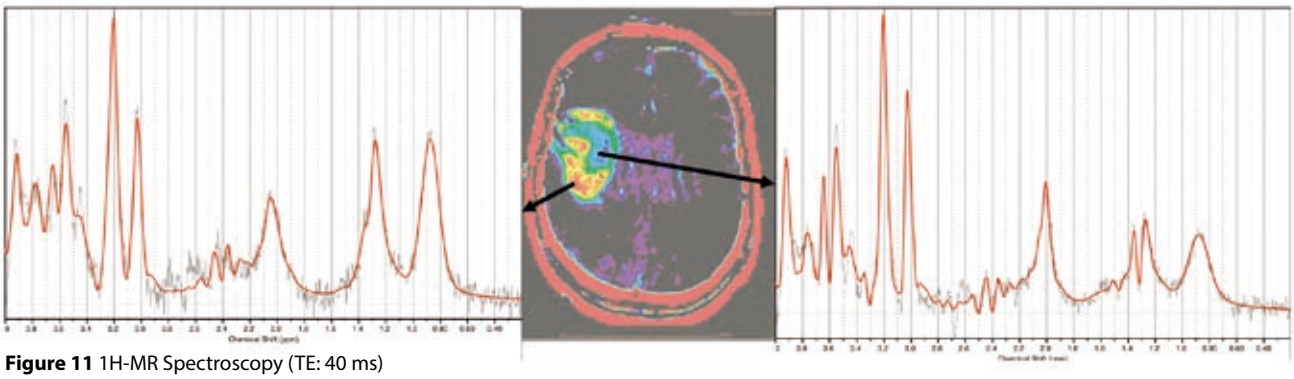

Figure 11 1H-MR Spectroscopy (TE: 40 ms)

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