Differentiation of posttreatment effects from glioma recurrence using arterial spin labeling, susceptibility-weighted imaging, proton MR spectroscopy and diffusion-weighted imaging as non-contrast brain MRI at 3 Tesla.

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Purpose

The purpose of this study was to determine the contribution of arterial spin labeling (ASL), susceptibility-weighted imaging (SWI), proton MR spectroscopy (1H-MRS) and diffusion-weighted imaging (DWI) metrics in the differentiation of posttreatment effects from recurrent glioma, and to assess the clinical value of non-contrast brain MRI protocol at 3T.
Methods and Materials

Follow-up brain MRI examinations were performed in 27 patients (19 men, 8 women; mean age 54.2 years) after surgery and/or radio and chemotherapy of gliomas. From all of them, 21 patients had histological conformed glioblastoma multiforme (WHO grade IV), 5 had anaplastic astrocytomas (WHO grade III), and 1 was with diffuse astrocytoma (WHO grade II).

All MR images were performed with a 3T system (Skyra, Siemens, Germany). Imaging protocols included the following MR sequences: axial TSE T2 weighted imaging, axial SE T1 weighted imaging, coronal fluid-attenuated inversion recovery (FLAIR), DWI, ASL, SWI, dynamic susceptibility contrast-enhanced (DSC) MR perfusion imaging, and contrast-enhanced axial, coronal and sagittal T1 weighted imaging. The DSC MR perfusion imaging was performed during the intravenously administration of a standard dose of gadopentetate dimeglumine (Magnevist, Schering, Germany; 0.1 mmol per kilogram of body weight) with an MR-compatible power injector (Spectris, Medrad, Pittsburgh, PA) through a 20-gauge angiocatheter at a rate of 5 mL/s. The bolus of contrast material was followed by a 20 ml bolus of saline administered at the same injection rate. Image processing was performed using commercially available software (Syngo Via, Siemens, Germany).

The DSC perfusion MR images were used in the production of cerebral blood volume (CBV) maps. A single region of interest (ROI) was manually drawn around the entire contrast-enhanced region and contralateral normal-appearing white matter to standardize the cerebral hemodynamic measurements. ASL represented with cerebral blood flow (CBF) map was analyzed visually. The intralesion susceptibility signal (ILSS) seen on SWI was defined either as low-signal dot-like or tubular structures within a lesion. It was classified as grade 0 (no ILSS), grade I (1-5 dot-like or tubular ILSS), grade II (6-10 dot-like or tubular ILSS) or grade III (>11 dot-like or tubular ILSS). The gradation was based on the maximum of the ILSS on the selected imaging slice. Based on multi-voxel 1H-MRS, choline (Cho) to creatine (Cr) ratio was quantified. Apparent diffusion coefficient (ADC) values were calculated by manually drawn ROI within the solid portion of the lesion.

All lesions were confirmed pathologically or by clinical-radiological follow-up after 3-months.

Three MRI protocols were reviewed by two neuroradiologists: (1) non-contrast, including ASL, SWI, 1H-MRS and DWI, (2) contrast with DSC perfusion imaging, and (3) combined contrast and non-contrast protocols. The lesions were classified as posttreatment effects or recurrent tumors, of the same grade or with progression to a higher grade. Non-contrast protocol quantitative data included CBF, degree of ILSS, Cho/Cr ratio and ADC values within the region of interest.
Fig. 2: Recurrent glioblastoma multiforme in 32-year-old man. (A) Axial contrast-enhanced T1-weighted image reveals multiple foci of strong rim contrast enhancement in centrum semiovale on both sides, more on the left, as of the posterior border of the postoperative defect on the left side. (B) Axial ADC reveals foci of restricted diffusion. (C) Axial SWI reveals multiple intraslesion tubular and dot-like structures on the both sides. (D) Axial DSC - CBV perfusion map reveals foci of high perfusion on the both sides. (E) Axial ASL - CBF perfusion map reveals foci of high perfusion on the both sides. (F) Multivoxel 1H-MRS (TE=135 ms) reveals elevation of Cho, reduction of NAA and presence of Lipid and Lactate peaks, both in lesion and perilesion edema.

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Fig. 4: Posttreatment effects of glioblastoma multiforme in 55-year-old man. (A) Axial contrast-enhanced T1-weighted image reveals foci of contrast enhancement in insula on the right side. (B) Axial ADC reveals no foci of restricted diffusion. (C) Axial SWI do not reveal foci of intralesion microvascularity. (D) Axial DSC - CBV map and (E) axial ASL - CBF reveals no foci of hyperperfusion. (F) Multivoxel 1H-MRS reveals no elevation of Cho, small reduction of NAA and presence of Lipid and Lactate peaks.

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Fig. 1: Recurrent glioblastoma multiforme in 32-year-old man. Axial T2-weighted image reveals multiple lesions in centrum semiovale on both sides, more on the left.

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**Fig. 3:** Posttreatment effects of glioblastoma multiforme in 55-year-old man. Axial T2-weighted image reveals focal lesion in insula on the right side.

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Results

The neuroradiologists accurately differentiated tumor from posttreatment effects in 22 (81.5%) in the first review, 23 (85.2%) in the second review and 25 (91%) in the third review. Sensitivity, specificity, positive and negative predictive values of the non-contrast protocol for differentiation of recurrent tumor vs. posttreatment effects were 81.3%, 81.8%, 86.7% and 75.0%, respectively.
Conclusion

The non-contrast protocol provided diagnostic information comparable to contrast protocol which makes it suitable for patients who have a contraindication or cannot tolerate a bolus injection of paramagnetic contrast medium.
References


