

## Using ASL-perfusion to detection of residual glioblastoma tissue after surgical treatment

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## Aims and objectives

MRI control in patients after surgical treatment of glioblastoma is an important neuroimaging method, both for assessing the volume of performed surgery and for detecting residual tumor tissue. Glioblastoma growth is often accompanied by impaired blood-brain barrier due to its infiltrative growth and is characterized by elevated hemodynamic parameters (CBV, CBF, MTT), associated with pronounced tumor angiogenesis (1,2,3). However, in the area of surgical intervention, the destruction of the blood-brain barrier is also noted. In this way the accumulation of a contrast agent in both cases makes it difficult to differentiate the residual tumor tissue against the background of postoperative changes in the brain (4).

One of the approaches to visualization of residual glioblastoma tissue is perfusion CT and MRI studies (5). The method of ASL perfusion allows quantifying cerebral blood flow rate (CBF) in absolute terms (ml/100g per minute of brain tissue) without introducing a contrast agent by pseudo-continuous labeling of arterial hydrogen protons arterial blood (pcASL) feeding the brain (6,7). In this study we examine the efficiency of ASL perfusion as a method for assessing hemodynamics and identifying residual tumor tissue after surgical treatment of glioblastoma.

## Methods and materials

56 patients were included - 32 men (57.1%) and 24 women (42.9%) after 2-4 weeks surgical removal of glioblastoma (WHO GRADE IV), prior to the course of radiotherapy. The average age of patients was  $56.9 \pm 10.9$  years (min- 31 years, max- 79 years), there were no significant differences in age between the examined men and women ( $56.1 \pm 11.2$  years in men,  $58.1 \pm 10.8$  years in women,  $p = 0.45$ ).

MRI studies were performed on a 1.5T magnetic induction device (Optima MR450w, GE Healthcare) using a 24-channel head coil. The study protocol included the usual T2, T1, FLAIR and DWI. All sequences had strictly axial slice positioning, 4 mm thick and 0 mm inter-slice spacing. ASL perfusion was performed by pseudo-continuous 3D labeling of arterial spins (pcASL) with the following parameters: TR time - 4710 ms; TE echo time -11.3 ms; spatial resolution - 512x8; the number of signal averages (NEX) - 4; field of view (FOV) - 24 cm; the number of sections - 40; slice thickness 4 mm; intercut interval 0 mm; Label delay after label (PLD) - 1.525 ms. In addition, post-contrast images were obtained in the T1-VI mode in the axial plane and multiplanar T1-3D Cube with a slice thickness of 1 mm. The dose of the contrast agent was 0.2 ml x kg (Gadodiamide 0.5 mmol). The total study time was 24 minutes.

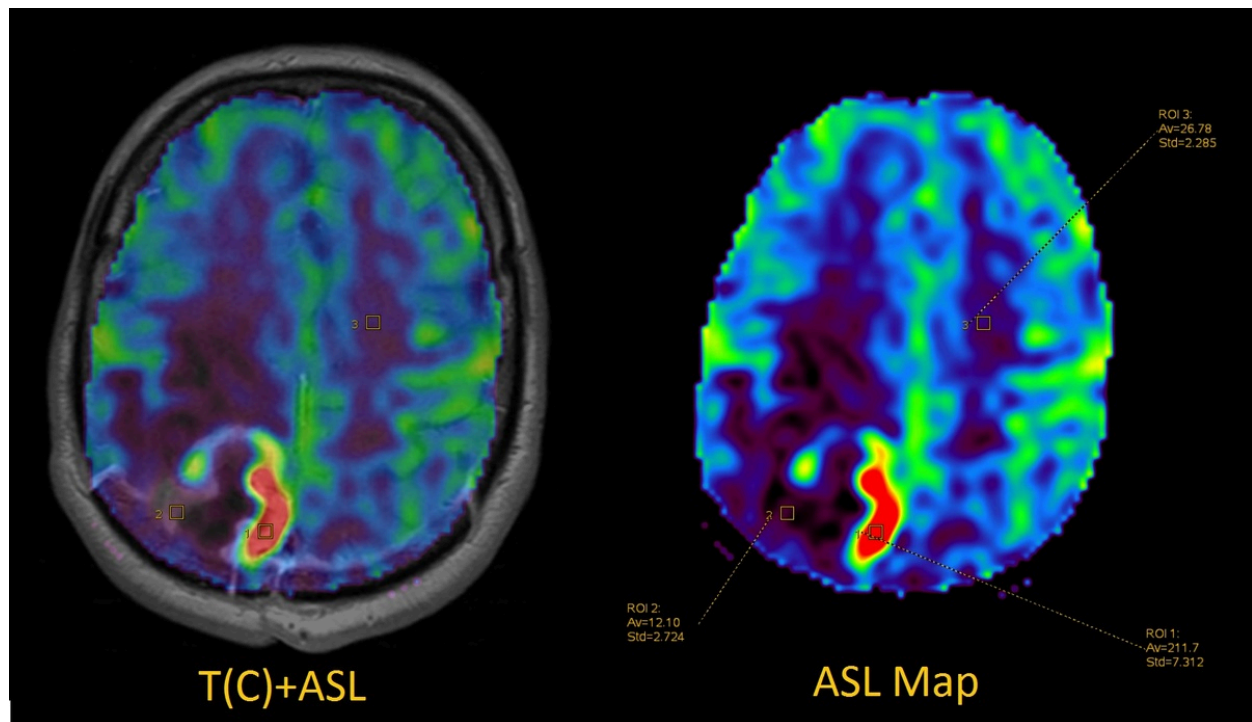
All patients had pathological areas of accumulation of a contrast agent in the peripheral and nearby parts of the postoperative defect of brain tissue.

The average CBF values were determined in 3 different areas of interest (ROI, up to 0.5 cm<sup>2</sup>) - in area of maximum perfusion (presumptive tumor tissue), in the postoperative scar tissue and in the deep white matter (at the level of the semioval centers) of opposite hemisphere (Fig. 1).

The normal CBF value of brain's gray matter ranges from 37 to 65 ml/100gr/min (8,9). As the cutoff point of CBF for diagnosis residual tumor tissue we used the upper threshold value of CBF of the brain gray matter.

For statistical analysis IBM SPSS Statistics 23 was used. Differences between the groups were tested for significance by a Mann - Whitney U-test. P-value of less than 0.05 was considered to indicate statistically significant difference.

Images for this section:



**Fig. 1:** Areas of interest. ROI 1 - presumptive tumor tissue with maximum perfusion; ROI 2 - postoperative scar; ROI 3 - deep white matter of opposite hemisphere.

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## Results

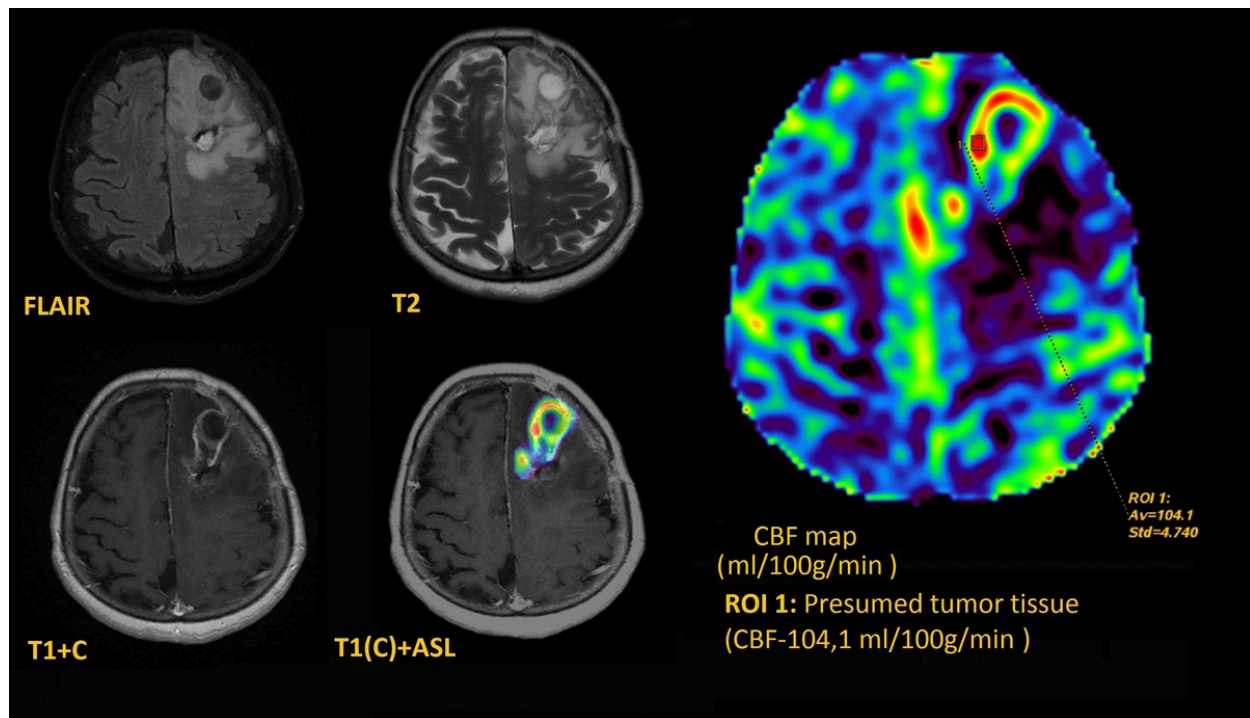
As a result of the study all patients were divided into two groups depending on the CBF value.

1st group - 38 patients (67.9%) with a pathological increase in cerebral blood flow on ASL perfusion cards (presumably a tumor - ROI 1), the average CBF was  $137.6 \pm 35.2$  ml/100g/min (minimum - 79.6 ml/100g/min, max - 227.6 ml/100g/min) (Fig.2). In this patients the CBF value of the supposed tumor site was 5-6 times higher than the blood flow in the area of postoperative scars (ROI 2), the average CBF here was  $23.6 \pm 6.3$  ml/100g/min and 6-8 times higher than the CBF of the deep white matter of the brain in the contralateral hemisphere (ROI 3), which was  $20.3 \pm 4.7$  ml/100g/min, ( $p < 0,0001$ ) (Fig. 3).

2nd Group - 18 patients (32.1%) with no areas of pathological CBF elevation on ASL-perfusion maps against the background of postoperative changes, the average level of CBF in the study area (ROI 1 and ROI 2 were similar) was  $22.3 \pm 5.9$  ml/100g/min (minimum - 13.9 ml/100g/min, maximum - 37.1 ml/100g/min). It is almost identical to the white matter of the brain in the contralateral hemisphere (ROI 3), where the average CBF was  $19.1 \pm 4.4$  ml/100g/min (Fig. 4).

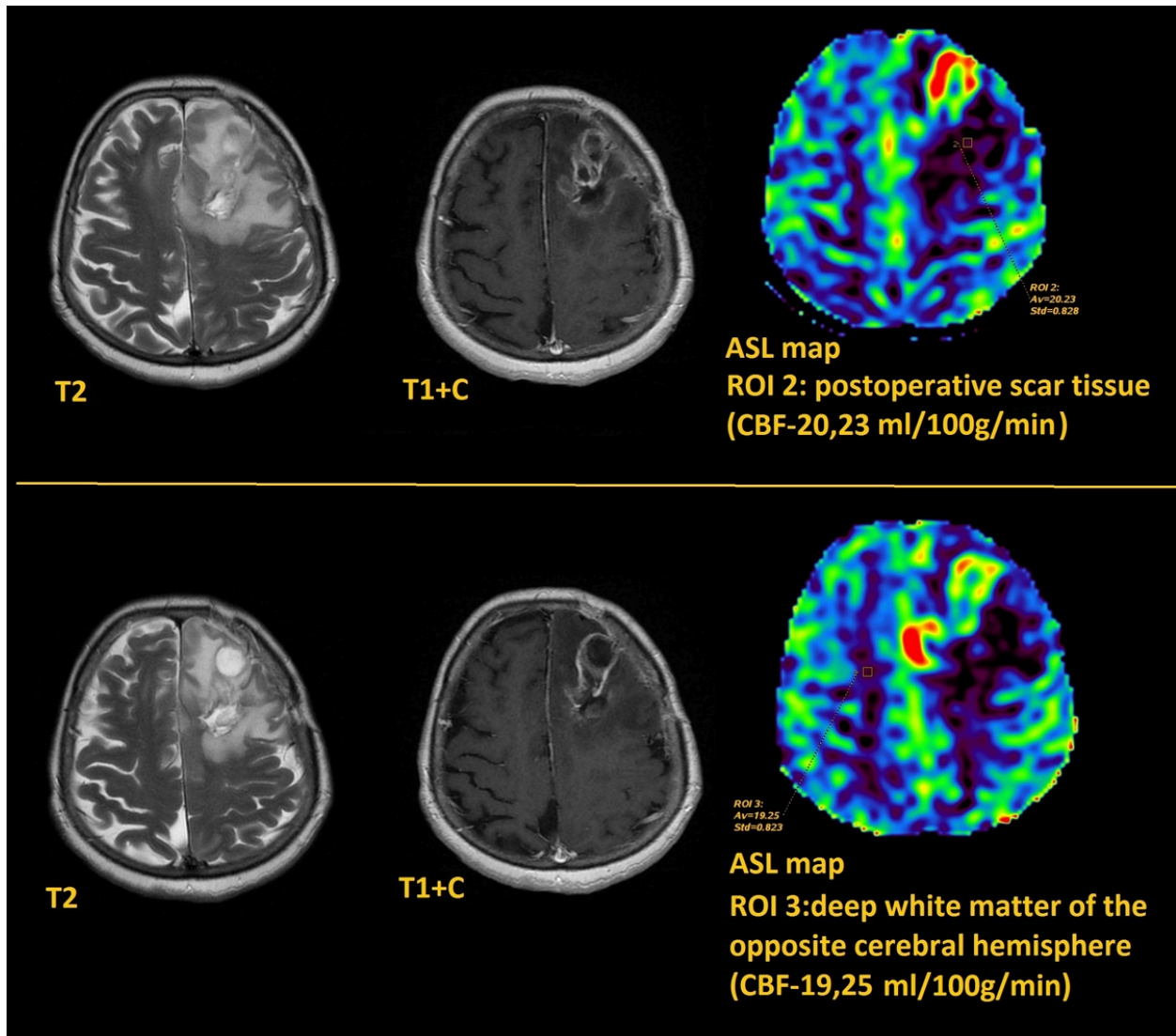
The levels of CBF in the areas of postoperative changes in patients from the 1st and 2nd groups were not significantly different,  $p = 0.52$ . Also there was no significant differences between groups in CBF levels in the white matter of the brain,  $p = 0.96$ .

Images for this section:



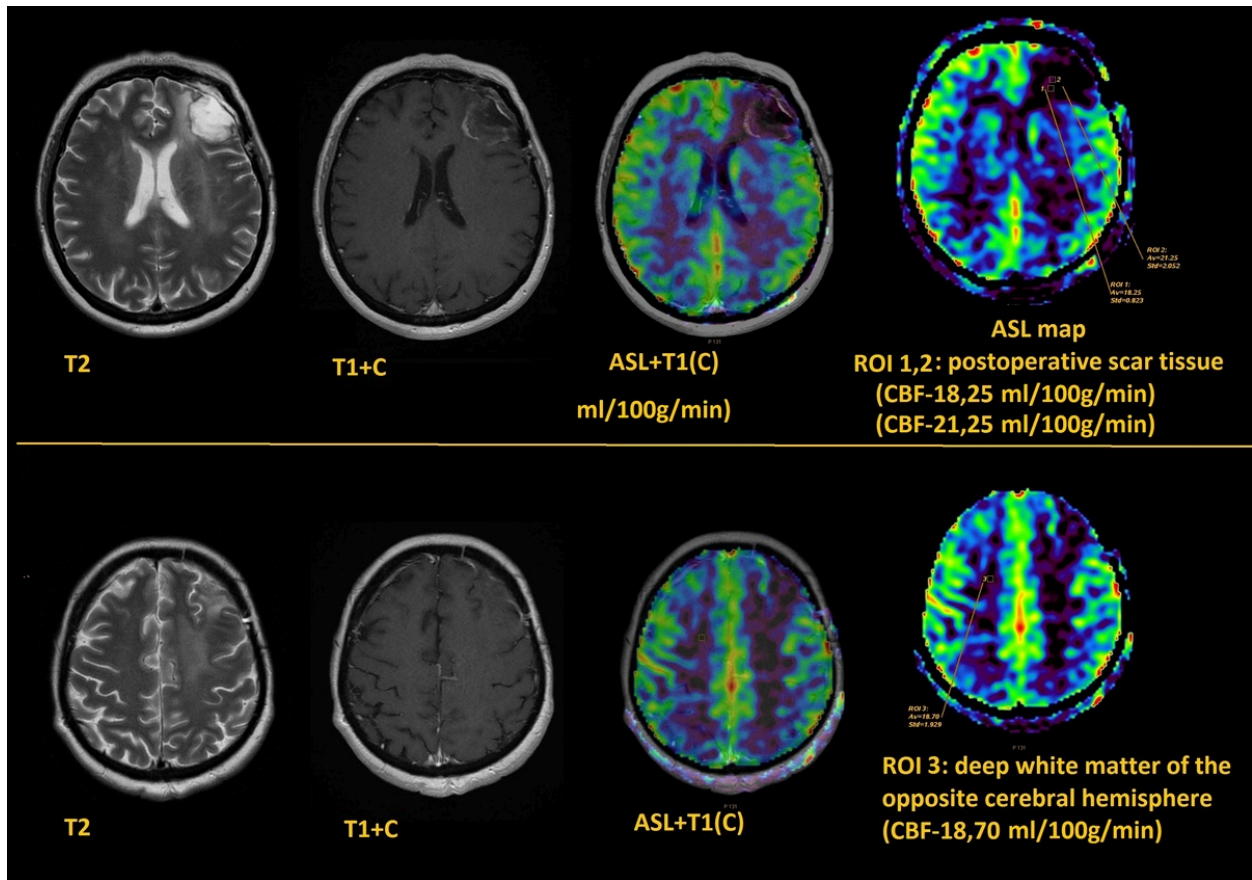
**Fig. 2:** Visualization of areas of elevated CBF (ROI 1) in the postoperative region (presumed residual tumor tissue).

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**Fig. 3:** CBF level in postoperative scar tissue (ROI 2) and in the deep white matter of the opposite cerebral hemisphere (ROI 3) in the same patient with presumed residual tumor tissue

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**Fig. 4:** CBF level in postoperative scar tissue (ROI 1 and ROI 2) and in the deep white matter (ROI 3) of the brain in a patient with no pathological evaluation of CBF.

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## Conclusion

In our study we showed the CBF value in tumor tissue is significantly higher than CBF in postoperative scar tissue. In this way the capacity of ASL perfusion is sufficient to identify residual tumor tissue in patients after surgical treatment of high-grade gliomas that have an aggressive course and expressed angiogenesis, it can be a crucial step in choosing an approach to further treatment and radiotherapy planning.

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