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High-grade and low-grade gliomas: differentiation by using perfusion MR imaging

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AIM: Relative cerebral blood volume (rCBV) is a commonly used perfusion magnetic resonance imaging (MRI) technique for the evaluation of tumour grade. Relative cerebral blood flow (rCBF) has been less studied. The goal of our study was to determine the usefulness of these parameters in evaluating the histopathological grade of the cerebral gliomas.

METHODS: This study involved 33 patients (22 high-grade and 11 low-grade glioma cases). MRI was performed for all tumours by using a first-passage gadopentetate dimeglumine T2*-weighted gradient-echo single-shot echo-planar sequence followed by conventional MRI. The rCBV and rCBF were calculated by deconvolution of an arterial input function. The rCBV and rCBF ratios of the lesions were obtained by dividing the values obtained from the normal white matter of the contralateral hemisphere. For statistical analysis Mann–Whitney testing was carried out. A p value of less than 0.05 indicated a statistically significant difference. Receiver operating characteristic curve (ROC) analysis was performed to assess the relationship between the rCBV and rCBF ratios and grade of gliomas. Their cut-off value permitting discrimination was calculated. The correlation between rCBV and CBF ratios and glioma grade was assessed using Pearson correlation analysis.

RESULTS: In high-grade gliomas, rCBV and rCBF ratios were measured as 6.50 ± 4.29 and 3.32 ± 1.87 (mean $\pm$ SD), respectively. In low-grade gliomas, rCBV and rCBF ratios were 1.69 ± 0.51 and 1.16 ± 0.38, respectively. The rCBV and rCBF ratios for high-grade gliomas were statistically different from those of low-grade gliomas ($p < 0.001$). The rCBV and CBF ratios were significantly matched with respect to grade, but difference between the two areas was not significant (ROC analysis, $p > 0.05$). The cut-off value was taken as 1.98 in the rCBV ratio and 1.25 in the rCBF ratio. There was a strong correlation between the rCBV and CBF ratios (Pearson correlation = 0.830, $p < 0.05$).

CONCLUSION: Perfusion MRI is useful in the preoperative assessment of the histopathologicalal grade of gliomas; the rCBF ratio in addition to the rCBV ratio can be incorporated in MR perfusion analysis for the evaluation.

Introduction

Gliomas are the most common primary neoplasms of the brain in adults, and histologically have a heterogeneous spectrum from low-grade to high-grade.[1] Accurate histopathological grading of gliomas is critical for planning therapeutic approaches and assessing prognosis and response to therapy. The glioma grading is based on the histopathological assessment of the tumour, which is achieved by stereotactic brain biopsy or cytoreductive surgery. Although the rate of definitive diagnosis with stereotactic brain biopsy is high, the accuracy is limited by the number of biopsy samples and the

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spatially heterogeneous nature of gliomas. Residual tumour tissue is also a cause of concern, even with after cytoreductive surgery.[2,3]

One of the important features reflecting the grade of gliomas is their ability to infiltrate the brain parenchyma. Tumour infiltration usually begins within the vascular network between the white matter tracts and spreads along the commissural fibres.[4,5] The related sign of malignity grade is the degree of vascular proliferation, which is considered a very important factor in histopathological grading of gliomas and behaviour of lesions. Therefore, defining microvascularity and neovascularity in the glial tumours is crucial.[3,6]

Although conventional magnetic resonance imaging (MRI) techniques are efficient in partial definition of gliomas, they are inefficient in determining the grade of the gliomas preoperatively.[7] The pathological contrast enhancement in conventional images may not reveal malignancy of tumoural areas, and the normal or destroyed blood–brain barrier may not fully reflect the grade of malignity[3,8] Unlike the contrast enhancement of gliomas on conventional MRI, contrast enhancement on perfusion MRI is generally independent of the disrupted blood–brain barrier.[9] The areas with contrast enhancement define microvascularity or neovascularity (angiogenesis) of the tumoural lesion.[9,10]

Perfusion MRI has recently been developed and provides some new insights for neuroradiology practice, such as showing tumour areas before stereotactic biopsy, distinguishing radiation necrosis from tumour infiltration, and assessing tumour response to therapy.[11,12] Various clinical studies have emphasized the efficiency of relative cerebral blood volume (rCBV) measured by MR perfusion imaging in the assessment of glioma grade[4,10,13–16] and in the differentiation of lymphoma[17] and brain abscess[18] from gliomas. Although rCBV measurement has been increasingly used in perfusion MRI for the evaluation of preoperative grading of gliomas, the efficiency of relative cerebral blood flow (rCBF) in the grade assessment of cerebral gliomas is still being investigated.

The purpose of this study was to investigate the efficiency of both rCBV and rCBF in discrimination of high- and low-grade gliomas, as a method complementary to biopsy and surgery.

Materials and methods

Population

This prospective study involved 33 subjects with histopathologically determined gliomas (27 male, 6 female; age range 14 to 75 years, mean age 46.4 years) between August 2002 and August 2003. In total we investigated 22 high-grade and 11 low-grade gliomas. The grading of the gliomas was based on the classification of the World Health Organization. The lesions comprised 18 grade IV glioblastomas, 2 grade III anaplastic astrocytomas, 1 grade III anaplastic oligodendroglioma, 1 grade III anaplastic oligoastrocytoma, 7 grade II astrocytomas, 3 grade I oligodendrogliomas and 1 grade I oligoastrocytoma. The study was approved by the local review board, and the informed consent of all the subjects was obtained.

Conventional and dynamic contrast-enhanced perfusion MRI protocol

The examinations were performed using a 1.5 Tesla imager (Signa LX, GE Medical Systems, Milwaukee, WI, USA). On conventional MR study, T1-weighted spin-echo (SE) sequence (TR/TE 600/14), T2-weighted fast spin-echo (FSE) sequence (TR/TE 5400/99) and fluid-attenuated inversion recovery (FLAIR) sequence (TR/TE/TI 9000/110/2100) were used in the axial plane. The imaging parameters were 256×256 matrix, 230×250 mm field of view, 5 mm section thickness and 1 mm section gap.

Cerebral perfusion MRI was performed by a first-passage contrast-enhanced T2-weighted single-shot gradient-echo echo-planar sequence. Parameters of the sequence were: TR/TE 1972/54 ms; flip angle 90°; band width 62.5; field of view 280×210 mm; matrix 96×128; section thickness 6 mm; section gap 1.5 mm; and acquisition time 76 s. We used 10 sections covering both the upper and lower margins of the lesion, observed in T2-weighted images. A series of images (10 sections, 40 images/section) were obtained at intervals of nearly 2 s before, during and after administration of the paramagnetic contrast agent. During the first 10 s, the first five images were obtained before contrast injection to establish precontrast baseline imaging. After the first five images, 15 ml Gadodiamide (Omniscan, Nycomed, Norway) was administered using a 18/20-gauge IV catheter at a rate of 5 ml/s by the antecubital venous method. This was followed by 20 ml serum physiological liquid at nearly the same rate. After the perfusion MRI, contrast-enhanced T1-weighted SE sequences were performed on axial, sagittal and coronal planes.

Data processing

Image analysis was performed Functool software