Quantitative histogram analysis of Gd signal enhancement in low grade gliomas

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Aim: To develop suitable methods for quantification of abnormal Gd enhancement (which is a marker of high grade lesions) in untreated adult supratentorial low grade gliomas, and to monitor serially through transformation

Introduction: Adult supratentorial low grade gliomas (WHO grade II) are usually left untreated until they transform into high grade gliomas (WHO grade III and IV). We are scanning subjects with untreated low grade gliomas every 6 months, using a variety of MR techniques, to search for parameters which may predict transformation. Here we develop methods for quantifying Gd enhancement, and demonstrate clear differences between transformers (T) and non-transformers (NT).

Methods:
50 Subjects were scanned every 6 months, until transformation took place. This was defined as clinical deterioration due to tumour growth or the appearance of a new area of enhancement without any change in the patient's condition, and confirmed by biopsy of the enhancing region.
MRI: FSE FLAIR images (TR/TI/TE=8774/2192/161; pixel 0.94 x 0.94 mm; slice thickness 5 mm; gap 1.5 mm) were used to define tumour boundaries using the semi-automated contouring method in DISPIMAGE (1). 3D T_1-w IR spoilt gradient echo images (TR/TI/TE/FA = 14.4/650/6.4/20^o; voxel 0.94 x 0.70 x 1.5 mm) were collected before and 10 min after injection of double dose Gd (0.2 mM/kg). The 3D image datasets were spatially registered, using methods based on AIR, Woods' registration software (2), subtracted,, and normalised to the contralateral normal-appearing white matter (NAWM) to provide %enhancement (%E) maps in pu (percent units). The low-resolution 2D FLAIR images were interpolated and registered to the pre-Gd high-resolution 3D T_1-w dataset, using a mutual information registration algorithm (3). A tumour region of interest was defined on the interpolated FLAIR images, then copied to the %E images.
Histograms of %E, normalised to a total tumour volume of 100%, were produced for each tumour in each scan. Spikes, arising from the discontinuous intensity distribution in the unnormalised difference image (4), were removed by a suitable choice of bin width.

Results. Histograms from NT and T showed clear differences (fig 1). Peak height was reduced in Ts, as the volume of enhancing tissue, seen in the right-hand tail of the histogram, increased. The fraction of tumour volume enhancing by at least 20pu (%vol>20pu) increased dramatically after transformation (fig 2), and even before transformation may separate T from NT, giving the potential for prediction of transformation.

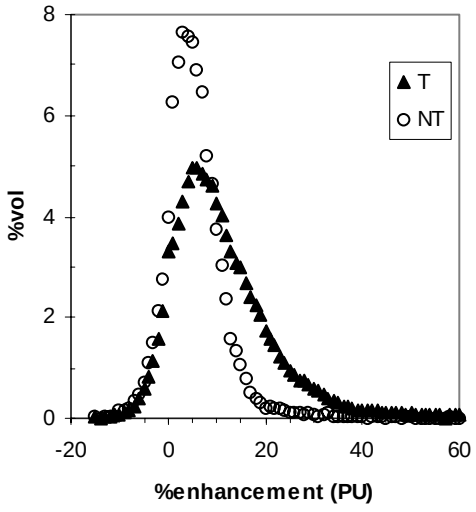

figure 1: sample histograms of NT and T

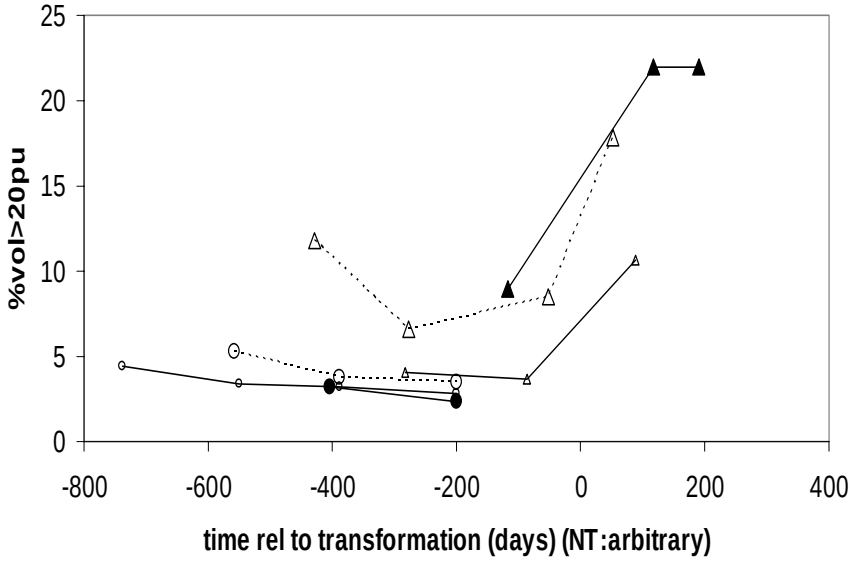

figure 2 time course of %vol>20pu (NT:circles, T:triangles)

Discussion and Conclusions
1. The %E histograms provide a reproducible, sensitive quantification of Gd enhancement in the gliomas, with minimal operator dependence.
2. Clear histogram differences between NT and T are apparent.
3. With more time points and subjects, we hope to develop statistical methods for prediction of transformation.
4. More sophisticated feature extraction from the histograms may improve the performance of predictors.

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