Dynamic contrast enhanced and susceptibility based CBV measurements perform equally in grading of cerebral gliomas

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Introduction

Gliomas are the most common primary brain tumours [1-3]. New blood vessels formation leading to increased microvascular density (MVD) and breakdown in blood brain barrier (BBB) are hallmarks for malignancy in gliomas that can readily be probed by imaging. Perfusion MRI has shown added value over standard contrast enhanced MRI that is sensitive to BBB breakdown [4]. It is unclear which acquisition technique and derived metric yields the most useful biological information for patient management. This has been indirectly tested by assessing the accuracy to predict the WHO grade. The single best performing metric to date is the $rCBV_{max}$ derived from dynamic susceptibility contrast (DSC) techniques [5], but there are shortfalls of this technique. These relate to unavoidable susceptibility artefacts in specific regions often due to the presence of paramagnetic materials, and the overestimation of rCBV due to vascular disruption. To investigate this, our clinical protocol includes an additional low Gd dose T1 based dynamic contrast enhanced study prior to DSC. The aim of this service evaluation study was to compare rCBV metrics derived from both techniques on the same patients, and to assess whether the DCE protocol allows the measurement of rCBV in the presence of blood.

Methods

Nineteen adult patients (10 glioblastoma [GBM], 9 low grade glioma [LGG]) who underwent clinical MR perfusion with T1 weighted DCE followed by DSC at 3T (Philips Achieva) and one patient with melanoma were included. A bolus of 4ml (2.5ml/s) of Gd was used for DCE (TR: 3.56ms / TE: 2.33ms /FA: 5°) followed by normal dose DSC (TR: 15ms/ TE: 24ms/ FA: 7°). CBV maps were calculated using the Java Image software (www.xinapse.com). DSC analysis was limited to first pass data defined until half maximum signal recovery (figure 1) to minimize the contrast extravasation effect [4]. DCE analysis utilised data after signal increase (figure 2). Arterial input functions were calculated from carotid artery or middle cerebral artery samples. rCBVmax values from T1 and T2* perfusion data were derived by drawing multiple small fixed size ROIs (7 pixels) in hot spot areas on respective CBV map (figure 3) and normalising maximum values over reference in the normal white matter. SPSS (16.0) was used for statistical analysis.

Results

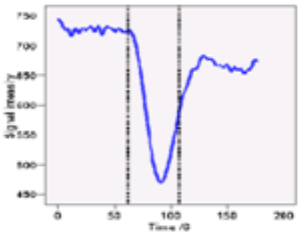

Figure 1. T2* time course

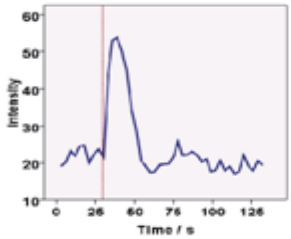

Figure 2. T1 time course

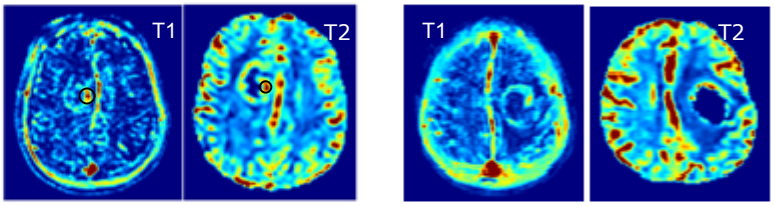

Figure 3. Two comparable rCBV maps from T1 and T2* respectively.

There was a highly significant difference (P= 0.000) in rCBV maps between GBM and LGG for both techniques (figure 4) yielding complete separation of groups for both with nominal accuracy levels of 100%. Re-test comparison between methods revealed excellent consistency (Pearson's correlation coefficient =0.81, R^2=0.66, figure 5). There was however a tendency for DSC to yield higher $rCBV_{max}$ compared to DCE (p<0.07). Inspection of the scatter plot suggests this to be due to higher rCBVmax in 3 GBM cases with fairly high $rCBV_{max}$.

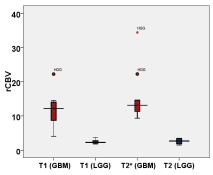

Figure 4

In the single case study of suspected complex haematoma that was histologically confirmed melanoma, DCE allowed to define a rim of moderately elevated rCBV around the T2* signal void lesion while DSC gave erroneous readings.

Discussion

Both low dose DCE and subsequent standard dose DSC MRI Perfusion studies allowed complete differentiation between GBM and LGG [6-8]. This confirms the high accuracy of DSC based rCBVmax, and also demonstrates that a low dose DCE technique achieves similar results. Also, the results were strongly correlated showing a high degree of concordance. This and the accurate separation of GBM and LGG validate our DCE protocol for clinical use in situations where DSC fails due to susceptibility artefacts as shown in one case study. Few previous studies compared different acquisitions techniques and at best found moderate correlations between metrics [8]. Despite the high correlation we found, there was a tendency for DSC to overestimate rCBVmax in areas of strongly elevated rCBV which suggests residual but minor contamination by contrast leakage. The Gd preloading and careful post processing protocol may have contributed to reducing this contamination source. In addition, the independent hot spot analysis may have contributed to the higher consistency we found between the two techniques.

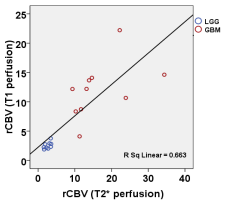

Figure 5

Conclusion

We have shown that low dose T1 based DCE and subsequent DSC perfusion protocols at 3T yield comparable results for rCBVmax with complete separation of GBM from LGG. T1 based DCE will be particularly useful in postoperative follow-up studies where large differences in susceptibility between blood and tissue can result in signal loss on T2* methods.

References

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