

Quantitative MR Perfusion in Patients with Intracranial Arteriovenous Malformations: Utilizing Spin-Echo Sequences to Characterize Vascular Steal

C. S. Eddleman¹, J. J. Mouannes², A. Sen³, G. Dabus^{3,4}, C. C. Getch⁴, B. R. Bendok^{3,4}, H. H. Batjer⁴, and T. J. Carroll³

¹Neurological Surgery, Northwestern University, Chicago, IL, United States, ²Biomedical Engineering, Northwestern University, ³Radiology, Northwestern University, ⁴Neurological Surgery, Northwestern University

INTRODUCTION

Quantitative MR perfusion is widely used in evaluating cerebral blood flow and volume changes in variety of neuropathology, including oncological and cerebrovascular diseases. T_2 -weighted gradient-echo (GRE) echo planar imaging (EPI) has been the standard of MR sequences examining cerebral blood volume changes. However, GRE-EPI acquisitions can suffer from imaging artifacts, especially from large blood vessels in the region of interest (ROI). Recently, T_2 -weighted spin-echo (SE) EPI acquisitions combined with parallel imaging have been reported to produce comparable values for cerebral perfusion as GRE-EPI images and the images were found to be of higher quality. One application of higher quality quantitative MR perfusion imaging is in the study of intracranial arteriovenous malformations (iAVMs) where quantitation of cerebral blood can be used to study the hemodynamic effects of iAVMs in situ, namely vascular steal which may put patients at higher risk for normal perfusion breakthrough, as well as after endovascular procedures and surgical resection. We studied iAVMs utilizing SE-EPI perfusion imaging and compared these images with those acquired using GRE-EPI images in the same patient acquired during the same imaging session. The findings in this study included more specific areas of vascular steal as well as perfusion changes anatomically related to the angioarchitecture of the iAVM.

MATERIALS AND METHODS

Patients with an unruptured iAVM, were scanned on a 1.5T MR scanner (Avanto, Siemens AG Healthcare Sector, Erlangen, Germany) using both GRE-EPI and SE-EPI perfusion sequences. Images were acquired using 2 single-dose injections of Gd-DTPA (0.1 mmol/kg b.w.), each time at a rate of 4ml/s: TR = 1290 ms, 13-15 slices, slice thickness/the gap between slices = 5/1.5mm, bandwidth = 1260Hz/pixel, TE (GRE/SE) = 47/60ms, tip angle = 90°. The SE-EPI images were acquired using parallel imaging (acceleration factor = 2, reference lines = 24) using GRAPPA reconstruction. GRE-EPI images were acquired prior to SE-EPI images in all cases. Regions of interest (ROI) were drawn around the peri-nidal areas of the iAVM as well as in the contralateral area without pathology. Total and hemispheric ROIs were also drawn to compare "unaffected" regions of cerebral perfusion. Paired comparisons of qCBV and qCBF values from the GRE- and SE-EPI perfusion images were performed. Perfusion images were also overlaid onto T_2 -weighted MR images to correlate perfusion changes with the angioarchitecture of the iAVM.

RESULTS

In all cases, the image quality of the SE-EPI images was superior to GRE-EPI images (Figure 1). Regions of perfusion change corresponding to the iAVM nidus were more anatomically correct in the SE-EPI images. As a result, cerebral perfusion changes near the boundary of the iAVM nidus could be determined more accurately. Areas of hypoperfusion, i.e., vascular steal, were noted in brain parenchyma near large draining veins, which were not specifically notable in the GRE-EPI images. Figure 2 shows the comparison of peri-nidal, contralateral, and hemispheric qCBF and qCBV values. Peri-nidal values of qCBF and qCBV were overestimated in the GRE-EPI sequences due to the inclusion of part of the iAVM nidus within the ROI,

which was drawn on the T_2 -weighted MR image. SE-EPI images clearly demonstrated more pronounced hypoperfusion when the ROI was selected based on the T_2 -weighted MR image. All other qCBF and qCBV values were insignificantly different; however, the SE-EPI images allowed more direct comparisons to the angioarchitecture of the iAVM (Figure 3).

CONCLUSIONS

Improved anatomical correlation and vascular steal is more clearly demonstrated in SE-EPI perfusion images of iAVMs than GRE-EPI imaging. The use of parallel imaging with SE-EPI acquisitions can improve image quality, while maintaining the same acquisition time. Use of this SE-EPI perfusion sequence may be used effectively when studying the perfusion changes affected by iAVMs.

REFERENCES

[1] Greenberg et al. 2007, [2] Shin et al., MRM 2007, [3] Spetzler and Martin, J. Neurosurg, 1980

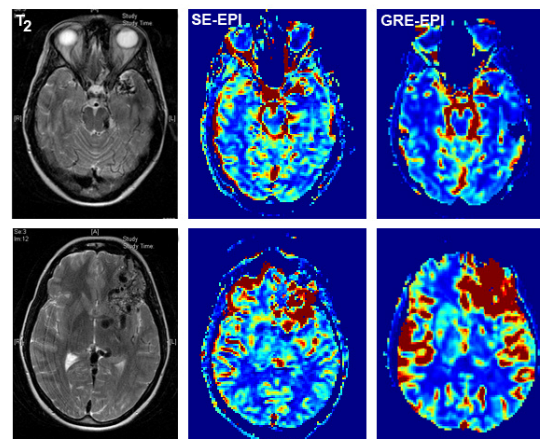


Figure 1: Comparison of T_2 , SE-EPI, and GRE-EPI

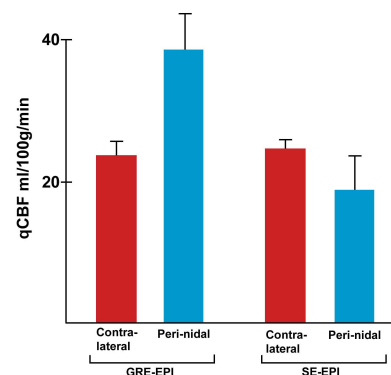


Figure 2: Contralateral vs Peri-nidal qCBF by GRE-EPI and SE-EPI

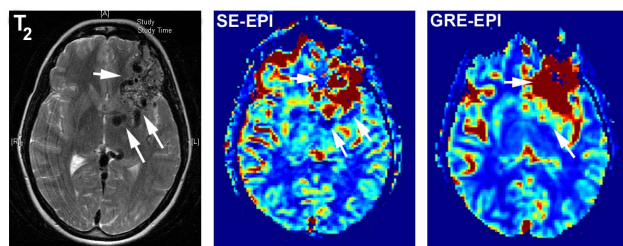


Figure 3: Comparison of T_2 , SE-EPI, and GRE-EPI anatomical correlation to areas of vascular steal (arrows)