The Impact of EPI-based Distortion Correction of Dynamic Susceptibility Contrast MRI in Patients with Glioblastoma

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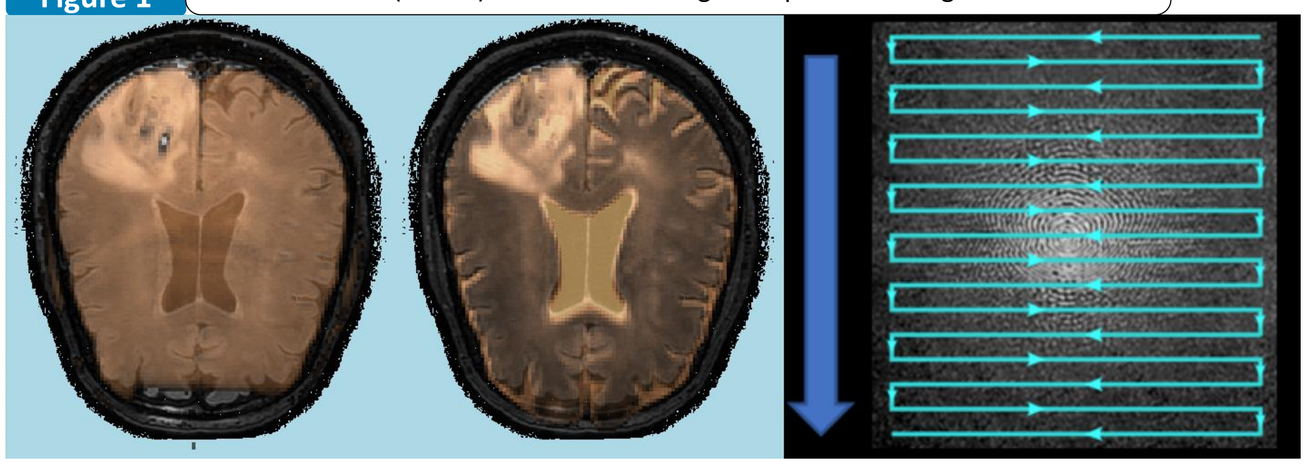
Purpose

MRI-based Echo Planar Images (EPIs) are sensitive to magnetic susceptibility induced geometric and intensity distortions (Figure 1), which we correct using two independent methods[1,3]. We evaluate the overall impact of the EPI distortion corrections by ranking 134 regions in Montreal Neurological Institute (MNI) space with decreasing rCBV change affected by the distortion corrections.

Figure 1 **Distortions in positive (and negative if animated) phase encoded EPIs example.** Left and middle (brown): GE and SE EPI. Right: k-space encoding.



Method

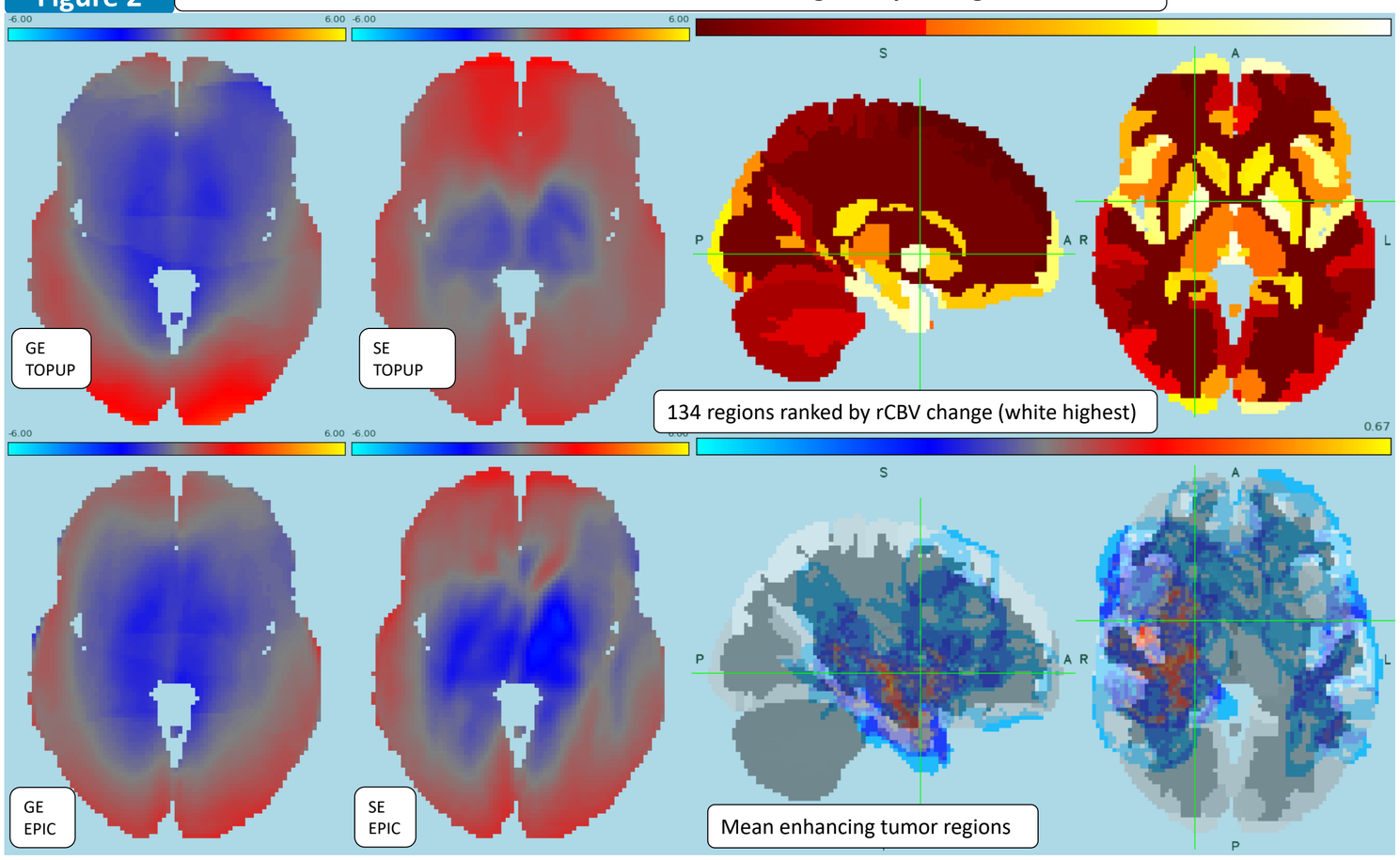
45 newly diagnosed glioblastoma patients of age 40-84

- **Dual** Gradient-echo (GE) - spin-echo (SE) negative and positive phase encoded EPI sequences (Figure 1). Contrast passage during **positive** phase encoded EPIs (DSC).
- Two correction methods (FSL **TOPUP**[1,2] and **EPIC**[3]) each use negative and positive phase encoded EPIs (Figure 1) to compute **deformation fields** (Figure 2). Deformation fields **used to correct DSC**.
- **Relative cerebral blood volume (rCBV)** from DSC[4] normalized to MNI space by **co-registrating** first dynamic DSC to 3D fluid attenuated inversion recovery (**FLAIR**) anatomical images[5].
- Assessment of correction effects in rCBV by **ranking** median Hellinger[6] and Wasserstein[7] histogram distances for **134** brain regions in MNI space[8] and looking at correspondence with **tumor** regions from a separate study[9].

Results and Discussion

- Major rCBV changes in and close to the basal forebrain (Figure 2 and 3).
- rCBV changes most pronounced in many of the same regions for GE rCBV and SE rCBV. Note that TOPUP and EPIC was made for SE EPIs and that GE rCBVs suffer from EPIs with additional signal loss and may also be less accurately co-registrated from the use of GE EPIs.
- Similar rCBV change across regions in left and right parts of the brain (Figure 2 upper right), opposed to locations of enhancing tumor (Figure 2 lower right).
- Differences in deformation fields across GE and SE EPIs.

Figure 2 **Left: Mean of deformation fields used for correction. Right: Impact regions + tumors.**



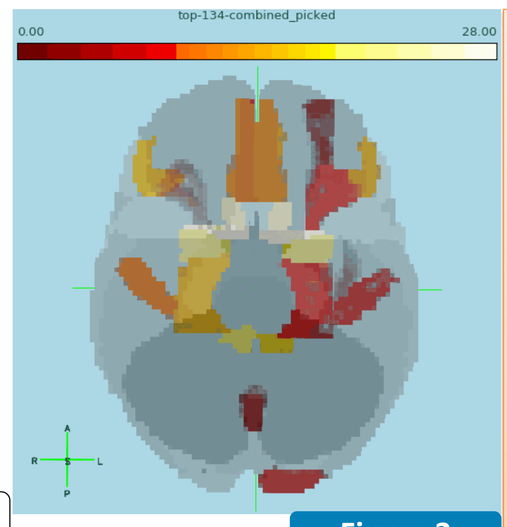


Figure 3 **2x14 regions with rCBV change ranked high (white, 1.)-low(red, 14.).**

Major rCBV change (MNI)

1. Left & right basal forebrain
2. Left & right accumbens area
3. Left & right amygdala
4. Left & right entorhinal area
5. Left & right Pallidum
6. Left & right postcentral gyrus medial segment
7. Left & right orbital part of the inferior frontal gyrus
8. Left & right medial frontal cortex
9. Left & right gyrus rectus
10. Left & right parahippocampal gyrus
11. Left & right transverse temporal gyrus
12. Left & right posterior orbital gyrus
13. Left & right occipital pole
14. Left anterior orbital gyrus

Conclusion

GE and SE rCBV will benefit from distortion correction especially in lateral regions close to and in the basal forebrain.

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