Echo planar imaging

Echo planar imaging (EPI) is a magnetic resonance imaging (MRI) technique that is commonly used in Functional magnetic resonance imaging (fMRI) and diffusion-weighted imaging. EPI is a fast imaging method that allows for the rapid acquisition of multiple images in a short period of time, making it particularly useful for capturing dynamic processes in the body, such as blood flow and brain activity.

The key characteristic of EPI is its ability to acquire multiple images in a single echo train. This is achieved by repeatedly applying the same gradient and radiofrequency pulse sequences to generate a series of images. EPI is particularly well-suited for functional MRI studies, where it is used to capture changes in blood oxygenation levels associated with brain activity, allowing researchers to create maps of brain activation.

EPI has revolutionized the field of neuroimaging because it enables the collection of fMRI data with high temporal resolution, making it possible to study the dynamic aspects of brain function. It has also been employed in other areas of medical imaging and research, including diffusion-weighted imaging for studying tissue microstructure and perfusion imaging to assess blood flow.

In summary, echo planar imaging (EPI) is an MRI technique known for its rapid acquisition of multiple images, and it has had a significant impact on various fields of medical imaging and scientific research.

Echo planar imaging is performed using a pulse sequence in which multiple echoes of different phase steps are acquired using rephasing gradients instead of repeated 180 degree radio frequency pulses following the 90°/180° in a spin echo sequence. This is accomplished by rapidly reversing the readout or frequency- encoding gradient. This switching or reversal may also be done in a sinusoidal fashion. Echo planar sequences may use entirely gradient echoes or may combine a spin echo with the train of gradient echoes.

In a single-shot echo planar sequence, the entire range of phase encoding steps, usually up to 128, are acquired in one TR. In multi-shot echo planar imaging, the range of phase steps is equally divided into several “shots” or TR periods. For example an image with 256 phase steps could be divided into 4 shots of 64 steps each.

As a result an image can be acquired in 20-100 ms allowing excellent temporal resolution such as that required in cardiac imaging. Each subsequent echo results in a progressively T2-weighted signal.

DSC-MRI based on echo planar images (EPI) may possess severe geometric distortions from magnetic field inhomogeneities up to the order of centimeters. The aim of a study was to assess how much two readily available EPI-based geometric distortion correction methods, FSL TOPUP and EPIC, affect rCBV values from DSC-MRI in patients with confirmed glioblastoma.

Method: We used a combined single-shot 2D gradient-echo (T2*), spin-echo (T2) EPI sequence to estimate both T2* and T2-weighted rCBV from the same contrast agent injection. Effects of distortion correction on the positive phase-encoded T2- and T2*-images were assessed in healthy anatomical brain regions in terms of Wilcoxon signed rank tests on median rCBV change and on Dice coefficients, as well as in tumor lesions in terms of Wilcoxon signed rank tests on median rCBV change.

The results show that following distortion correction, both gradient-echo and spin-echo rCBV increased in cortical areas of the frontal, temporal and occipital lobe, including the posterior orbital gyri in the frontal lobe and middle frontal gyri ($p < 0.0008$). Similar, improved Dice coefficients were observed for gradient-echo EPI in temporal, occipital and frontal lobe. Only spin-echo rCBV in enhancing lesion increased with correction ($p = 0.0002$).

The study sheds light on the importance of performing geometric distortion correction on EPI-based MRI data before assessing functional information such as rCBV values. The findings may indicate that uncorrected rCBV values can be underestimated from positive phase-encoding EPI and that geometric distortion correction is warranted when comparing EPI-based data to conventional MRI [1].

1)

Hovden IT, Geier OM, Digernes I, Fuster-Garcia E, Løvland G, Vik-Mo E, Meling TR, Emblem KE. The impact of EPI-based distortion correction of dynamic susceptibility contrast MRI on cerebral blood volume estimation in patients with glioblastoma. Eur J Radiol. 2020 Sep 16;132:109278. doi: 10.1016/j.ejrad.2020.109278. Epub ahead of print. PMID: 33010685.