Dual-echo diffusion-weighted EPI for better sensitivity to acute stroke

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**Introduction:** Many diffusion-restricting lesions also have a prolonged \(T_2\) value compared to the surrounding tissue. We hypothesize that one may improve lesion conspicuity in acute stroke patients with the use of a longer TE than in conventional practice by means of an accelerated dual-echo diffusion-weighted (DW)-EPI approach (Fig. 1). Echo 1 provides a high SNR image used to calculate the apparent diffusion coefficient (ADC), while Echo 2 can be used for enhanced conspicuity. Furthermore, relaxivity \(R_2\) maps can be calculated from the dual echo images to potentially reveal an additional source of image contrast. This study investigated the applicability of such a dual-echo sequence in the setting of acute stroke.

**Methods:** Dual-echo DWI data were acquired on 50 patients suspected of stroke using a 1.5T GE scanner and 8-ch head coil. Three radiologists reviewed the echoes using the routine vendor-supplied DWI as a reference. Images were graded on lesion conspicuity and diagnostic confidence on the following Likert scale: 1–nondiagnostic, 2–poor, 3–acceptable, 4–good, 5–above average, 6–very good, 7–outstanding. Results: Echo 2 was unanimously favored over Echo 1 for the evaluation of acute infarcts. Lesion conspicuity and diagnostic confidence were rated better for Echo 2 over Echo 1 (mean values of 6.5/4.9 and 5.9/5.4, respectively \(p<0.0001\)). **72 more lesions were found on Echo 2 across 34 patients diagnosed with acute stroke than on Echo 1.** 93% of these were deemed as acute infarct on ADC, 4% were too small to assess, and 3% were non-restricting chronic lesions. Echo 2 was predicted to have changed the overall radiological impression in 20% of cases; and to have impacted stroke workup in 16% of cases, and potentially influenced 32% of cases. As shown in Fig. 3, while the DWI of Echo 2 has higher lesion sensitivity, the ADC of Echo 1 is the best candidate for confirming acute lesions. Echo 2 was also favored for ruling out stroke from regions of heightened coil sensitivity (closed arrows). The \(R_2\) maps were also useful for detecting ischemic infarct, subarachnoid hemorrhage and basal ganglia calcification (Fig. 3).

**Discussion:** Longer TEs than those typically used can increase the diagnostic sensitivity of DWI. Given that the DWI from Echo 2 was more useful for lesion delineation and detection, we recommend that the TE should be exploited to draw attention to lesions, and that the accelerated dual-echo EPI DWI approach is a good candidate.

**Conclusions:** Contradicting the common teaching to use short echo times to avoid \(T_2\)-shine through, the long TE of Echo 2 gives rise to DW images with superior conspicuity of diffusion lesions compared to DW images acquired at a shorter TE or conventional \(T_2\)-weighted imaging alone: Echo 1 provides high SNR ADC maps for specificity in acute stroke, and the information from both echoes is a potential source of complementary information for the assessment of blood and mineralization products. In conclusion, using the minimum TE to achieve maximum SNR and avoid \(T_2\)-shine through may result in increased identification of stroke-related lesions on DWI, and a dual-echo approach should be considered when protocoling DWI scans in stroke patients. **Acknowledgements:** NIH (2R01 EB00271108-A1 , 5R01 EB008706, 5R01 EB01165402-02), the Center of Advanced MR Technology at Stanford (P41 EB015891), Lucas Foundation, Oak Foundation.

**Fig. 1:** The dual-echo EPI sequence, with GRAPPA factor = interleaves = 3, FOV = 24cm, matrix = 192\(^2\), slice/bandgap = 5mm/1.5mm, 24 partial Fourier overscans, \(T_E/T_E^2\) = 48/105ms, 160/4 directions, \(b=1000\)s/mm\(^2\), TR=3s, scan time 2:30min. With the set of imaging parameters used here, this approach does not increase the scan time compared to the single echo alternative since Echo 2 fills in the sequence dead-time.

**Fig. 2:** Dual echo DWI and ADC images of a 66yr old embolic stroke patient.

**Fig. 3:** 69yr patient with vasospasm. The \(R_2\) map brings out the hypointense signal associated with infarct (open arrow) as well as areas of hyperintense signal correlating with intraventricular hemorrhage (arrowhead) and basal ganglia calcification (closed arrow).

**Target audience:** Practitioners interested in improving diffusion lesion conspicuity in the setting of acute stroke.

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