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

Samantha J Holdsworth[1], Stefan Skare[2], Kristen Yeom[1], Michael U. Antonucci[1], Jalal B Andre[3], Jarrett Rosenberg[1], Matus Straka[1], Nancy J Fischbein[1], Greg Zaharchuk[1], and Roland Bammer[1]

[1]Department of Radiology, Stanford University, Palo Alto, CA, United States, [2]Karolinska Institute, Clinical Neuroscience, Stockholm, Sweden, [3]Department of Radiology, University of Washington, Seattle, WA, United States

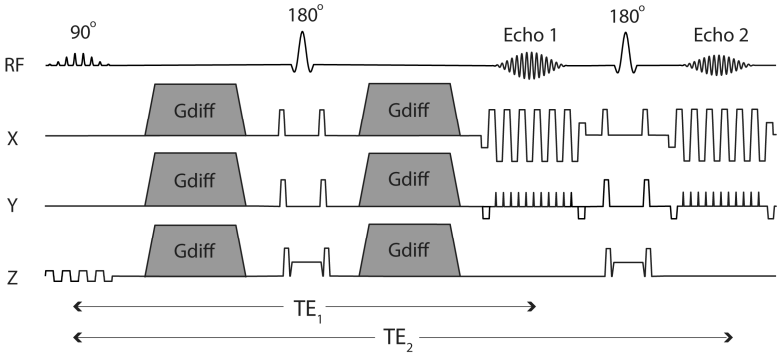

Fig. 1: The dual-echo EPI sequence, with GRAPPA factor = interleaves = 3, FOV = 24cm, matrix = 192², slthk/gap = 5mm/1.5mm, 24 partial Fourier overscans, TE_1/TE_2 = 48/105ms, 1b0/4directions, b=1000s/mm², TR=3s, scan time 2:30min. With the set of imaging parameters used here, this approach does not increase the scan time compared to the single echo alternative since Echo 2 fills in the sequence dead-time.

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

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–standard, 5–above average, 6–very good, 7–outstanding. R_2 maps calculated from the two echoes were evaluated for potential complementary information. Tests for differences in ratings between Echo 1 and Echo 2 were done with a two-tailed Wilcoxon signed-rank test.

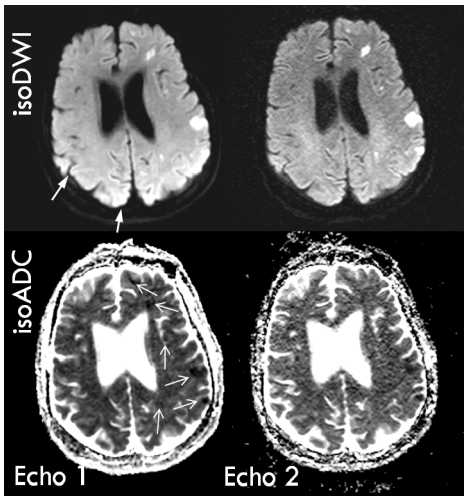

Fig. 2: Dual echo DWI and ADC images of a 66yr old embolic stroke patient.

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**).

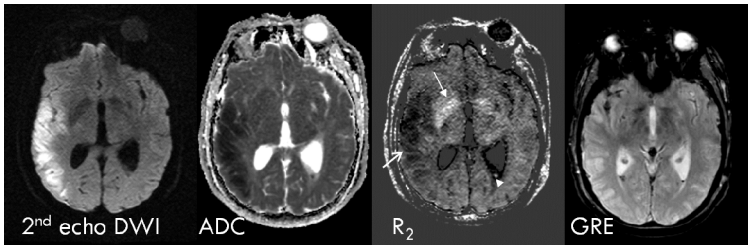

Fig 3: 69yr patient with vasospasm. The R_2 map brings out the hypointense signal associated with infarct (open arrow) as well as areas of hyperintense signal correlating with intraventricular hemorrhage(arrowhead) and basal ganglia calcification (closed arrow).

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.

Conclusion: 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 T2-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 , 5RO1 EB008706, 5R01 EB01165402-02), the Center of Advanced MR Technology at Stanford (P41 EB015891), Lucas Foundation, Oak Foundation.