Microhemorrhage Detection with Segmented EPI SWI: Comparison to 3D GRE SWI in a Series of TBI Patients

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Introduction: Traumatic brain injury (TBI) is one of the major causes of morbidity and mortality worldwide. 3D gradient recalled-echo (GRE) susceptibility weighted imaging (SWI) is increasingly used for detection of intracranial microhemorrhage, the MR imaging hallmark of TBI (1). Because high resolution is needed, traditional 3D GRE has a relatively long imaging time. Acquisition of SWI can be greatly accelerated through the use of segmented echo-planar imaging EPI, with comparable image quality (2). In this study, we evaluated the performance of accelerated SWI using 3D segmented EPI (segEPI) GRE to see if it can substitute for traditional 3D GRE SWI for the detection of traumatic intracranial microhemorrhages in routine clinical use.

Materials and Methods: *Patients:* Forty-six patients enrolled in a natural history study of traumatic brain injury (clinical trials.gov identifier NCT01404494). *Sequence design:* The product 3D GRE sequence was modified to accommodate segmented EPI acquisition with variable echo train length (ETL). Acceleration using parallel imaging was not included in the sequence design. *MRI*: All patients were scanned on a 3T Siemens Biograph mMR system running version syngo MR B18P software. The product 3D GRE sequence (9m47s scan time) and the 3D segEPI sequence (1m 30 scan time) were performed sequentially. Contrast parameters for GRE: TR 64 ms TE 25 ms flip angle 20°, for segEPI TR 40 ms TE 25 ms FA 15°. Note that both used a TE of 25 ms to provide similar susceptibility contrast. Geometric parameters (same for both GRE and segEPI): matrix 448×343, in plane resolution 0.5×0.5 mm. 72 2 mm slices. Acceleration parameters for GRE: GRAPPA 2; for segEPI: ETL partial fourier in phase and slice directions of 6/8. *Analysis:* Magnitude and phase images were saved. The phase images were post-processed using a global phase unwrapping procedure followed by high pass filtering. Multiplication of the magnitude and filtered phase were used to increase contrast to produce "phase emphasized" images. *Review:* To minimize bias, the 46 pairs of data sets were reviewed in two separate sessions separated by at least two weeks. In session 1, microbleeds were counted by tagging them on a PACS workstation on either a GRE or a segEPI dataset from each patient. In session 2, the complementary data sets were tagged to complete. To assist in the identification of microbleeds, the magnitude, filtered phase, phase emphasized SWI and minimum intensity projections of any of these datasets could be reviewed. Standard statistical analyses were performed.

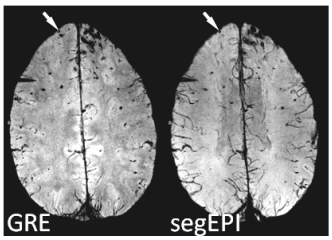

Figure 1: microbleeds are well seen with both 3D GRE and segEPI SWI minIP

		GRE +	GRE -
seg EPI	+	23	2
	-	5	16

Table 1: Concordance of microbleed detection in the 46 patients

Results: Image quality and hemorrhage was similar in both the GRE and segEPI datasets (Figure1). Arteries are better seen on the segEPI. Despite the use of a long ETL, distortions near the skull base on segEPI compared favorably with the GRE method and there is minimal obvious blurring. Similar lesion counts were obtained by both methods. Using the 3D GRE, the average number of microbleeds counted was 13.7 with a range 0-179 and a median of 1. Using the 3D segEPI the average number of microbleeds counted was 10.7 with a range 0-171 and a median of 1. The number of microbleeds counted by each method was highly correlated (Figure 2). An examples of a microbleeds identified by GRE and not by segEPI is indicated shown (Figure 1 *arrows*). Classification of patients into TBI or no TBI may be based on whether or not a microbleed is detected. The contingency table for the two methods is shown in table 1. Half (23) of the 46 TBI patients were positive by both methods, and 16/46 were negative. Discordance was present in 7 patients, all of whom had a relatively low lesion count.

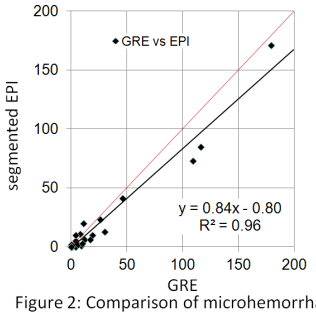

Figure 2: Comparison of microhemorrhage detection (n=46)

Discussion: Dramatic acceleration of SWI imaging can be obtained by incorporating segmented EPI into the traditional 3D GRE sequence. For the particular parameters chosen in this study, an over 6-fold acceleration was achieved allowing high resolution 0.5 × 0.5 × 2 mm voxel size covering the whole brain in 1½ minutes. Here we show that the ability to detect microbleeds is comparable to that obtained with the standard single echo 3D GRE method. Further analysis is needed to determine what factors account for the discordance between the two methods. Note that the basal forebrain and anterior temporal lobe are common sites of hemorrhagic contusions following TBI. Unfortunately, these are precisely the sites were image artifact and distortion from susceptibility effects are worst so that the ability to confidently detect hemorrhage in these regions is limited. Nevertheless, the high degree of image quality and the high level of concordance between the two methods indicate that segEPI can replace GRE for detection of microhemorrhage when time constraints are critical.

References:

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3. Zwanenburg JJ, Versluis MJ, Luijten PR, Petridou N. Fast high resolution whole brain T2* weighted imaging using echo planar imaging at 7T. Neuroimage 2011;56:1902-1907