Hepatic MR imaging with 3D Gradient Echo: Linear Cartesian k-space ordering with partial scan along both slice and phase direction

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Introduction: 3D gradient echo (GRE) sequence is commonly used for T1-weighted MR imaging of liver. Conventional 3D GRE sequences utilize either one of centric-linear, radial or linear ordering of k-space with a fat suppression technique and partial scan technique along a slice direction. We introduce a enhanced 3D-GRE sequence, which adopted a linear ordering with half scan along both slice and phase directions, and matched turbo scan factor with the number of slices. We compared conventional and enhanced 3D T1-weighted GRE sequences in terms of image quality and conspicuity of liver lesions.

Methods: 39 consecutive patients suspected with liver lesions underwent hepatic MR examinations on 3.0-T system. Conventional 3D GRE sequence using radial ordering of k-space with partial scan along slice direction and 'enhanced' 3D GRE sequence using linear Carteisan k-space ordering and partial scan along both slice and phase direction were compared. In both sequence fat signal was suppressed using a spectral inversion recovery pulse. Conventional and enhanced 3D GRE images were obtained for precontrast images in 32 patients and for gadoxate disodium (EOB)-enhanced hepatobiliary phase images in 39 patients. For qualitative analysis, two reviewers jointly reviewed the conventional and enhanced 3D GRE images and recorded the grades of anatomic sharpness, overall contrast, homogeneity, and absence of artifacts in one of four scales (0-4) for both precontrast and postcontrast images. For quantitative analysis, one reviewer measured liver-to-lesion signal difference ratio (SDR) in one lesion in each patient who had lesions larger than 1 cm in diameter. Liver-to-spleen SDR was also measured for all patients. Interval values from qualitative analysis were compared by using paired sample Wilcoxon test. Liver-to-lesion and liver-to-spleen SDR were compared by using paired t-test.

Results: Compared to conventional 3D-GRE images, enhanced 3D-GRE images showed significantly higher liver-to-spleen SDR ($P=0.0464$) and liver-to-lesion SDR ($P=0.0004$) on EOB-enhanced images, but not on precontrast images. In qualitative analysis of the precontrast images, enhanced 3D-GRE images showed significantly better than conventional 3D-GRE images in terms of the anatomic sharpness, overall contrast, homogeneity, and absence of artifacts ($P<0.05$). In a comparison of EOB-enhanced MRI, enhanced 3D-GRE images showed better quality in terms of overall contrast, homogeneity and absence of artifacts ($p<0.05$).
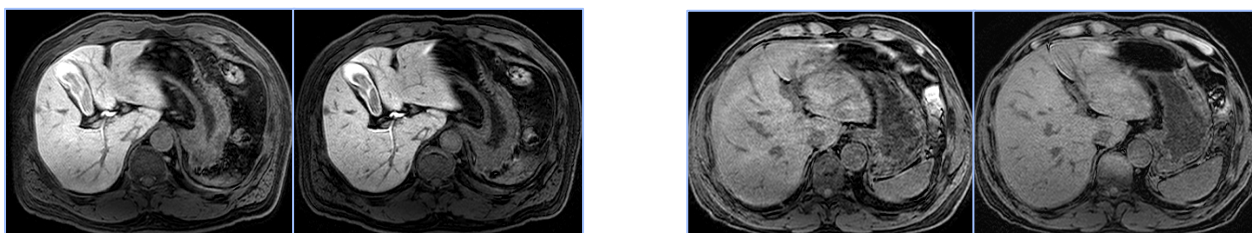

Fig 1. A small metastasis was more clearly visible on enhanced 3DFig 2. e-THRIVE image (left) showed better homogeneity GRE image (right) compared to conventional 3D-GRE image (left). and less artifacts than conventional 3D-GRE image (right).

Discussion and conclusion: Our study showed that enhanced 3D-GRE sequence provides better anatomic sharpness, contrast, improved homogeneity and decreased artifacts compared with conventional 3D GRE sequence as well as increased liver-to-spleen and liver-to-lesion contrast on delayed hepatobiliary phase images. In conclusion, enhanced 3D-GRE sequence provided better image quality and higher lesion contrast on both precontrast and postcontrast images, and can replace conventional 3D-GRE sequence.