3D Multi-Phase Contrast-Enhanced MR Imaging of Cirrhosis: 3.0 T versus 1.5 T

M. L. Lauzon[1,2], M. Breitling[2], R. Frayne[1,2], H. Mahallati[2,3]

[1]Radiology and Clinical Neurosciences, University of Calgary, Calgary, Alberta, Canada, [2]Seaman Family MR Research Centre, Foothills Medical Centre, Calgary Health Region, Calgary, Alberta, Canada, [3]Radiology, University of Calgary, Calgary, Alberta, Canada

Introduction: Cirrhosis of the liver is characterized by the architectural distortion of liver parenchyma leading to pathologic processes ranging from regenerative nodules and fibrosis to dysplastic nodules and primary malignancies (*e.g.*, hepatocellular carcinoma). Multi-phase contrast-enhanced MR acquisitions are considered critical in the diagnosis of these hepatic lesions, especially during the arterial phase [1-3]. MR imaging at 3.0 Tesla has many potential advantages compared to 1.5 Tesla [4]. Here, we compare (via signal-to-noise (SNR) and contrast-to-noise (CNR) ratios) pre-contrast and contrast-enhanced 3D gradient-echo (GRE) breath-hold T1-weighted multi-phase scans (arterial, portal venous and equilibrium phases) [5] for cirrhotic livers at 1.5 and 3.0 Tesla.

Methods: We selected nine confirmed cirrhotic patients from a gastroenterology clinic, all of whom had received a standard 1.5 Tesla clinical scan (Sonata; Siemens, Erlangen, Germany) and were undergoing treatment for their causative conditions. After obtaining informed written consent, and within 6 months of their 1.5 T assessment, these same patients were imaged on a 3.0 Tesla system (Signa VH/*i*; GE Healthcare, Waukesha, WI). The patients received 18 mL of Gd-DTPA (injected at 2 mL/s). The 3D GRE multi-phase sequence parameters were similar on both scanners: torso phased-array coil, axial orientation, minimum allowed TE (1.0-1.2 ms), minimum allowed TR (3.0-4.0 ms), 11° flip angle, 40x30 cm^2 FOV, 160x160 in-plane acquisition (reconstructed to 256x256), 40 slices per slab, 4.0 mm slice thickness (interpolated to 2.0 mm), fat and spatial (inferior and superior) saturation, both applied once per slice partition loop. Four sequential breath-hold phases (pre-contrast, arterial, portal venous, and equilibrium) were obtained. Region-of-interest (ROI) analysis was conducted for every patient on the eight images (four phases at two field strengths) in the liver (left and right lobes), spleen, pancreas parenchyma, and background. The means and standard deviations (SD) for all ROIs (homogeneous regions distant to intraparenchymal vessels) were recorded. The SNR was calculated as the mean in the tissue/organ ROI divided by the SD in the background ROI, while the CNR was calculated as the absolute difference in SNR between the two tissues of interest; a one-way analysis of variance (ANOVA; Microsoft Excel, Redmond, WA) was performed for the SNR and CNR measurements for each phase at 1.5 and 3.0 Tesla, and a *p*-value less than or equal to 0.05 was considered statistically significant.

Results: All patients tolerated their MR examinations and performed adequate breath holds at both field strengths. Qualitatively, the images appeared similar, with no visible artifacts. Due to changes in relaxation times [6], the 3.0 Tesla liver-to-spleen CNR was less than that at 1.5 Tesla. During the arterial and portal venous phases, the vessels were clearly visualized at both field strengths, and we observed similar enhancement patterns of the liver. The pre-contrast tissues had marginal or non-significant increases in SNR and CNR at 3.0 Tesla (see Table), whereas the contrast-enhanced comparisons showed a "trend" towards increased SNR and CNR (though not statistically significant). The spleen, however, displayed a significant increase in SNR for all phases at 3.0 Tesla.

Tissue	3.0 T SNR Mean ± SD	1.5 T SNR Mean ± SD	SNR *p*-value	TissueA *vs* TissueB	3.0 T CNR Mean ± SD	1.5 T CNR Mean ± SD	CNR *p*-value
Pre-Contrast				Pre-Contrast			
Liver-L	46.6 ± 13.0	34.2 ± 11.2	0.06	Liver-L *vs* spleen	17.2 ± 9.0	22.2 ± 9.2	0.29
Liver-R	38.4 ± 8.0	29.5 ± 8.2	0.05	Liver-R *vs* spleen	9.0 ± 4.3	17.6 ± 6.5	0.01
Spleen	29.4 ± 6.2	12.0 ± 4.2	< 0.001	Liver-L *vs* pancreas	7.8 ± 8.4	2.9 ± 2.9	0.16
Pancreas	43.0 ± 10.1	34.6 ± 9.8	0.12	Liver-R *vs* pancreas	8.6 ± 5.9	5.2 ± 4.0	0.21
Arterial Phase				Arterial Phase			
Liver-L	49.5 ± 13.6	41.5 ± 11.8	0.24	Liver-L *vs* pancreas	32.3 ± 19.2	25.5 ± 15.5	0.46
Liver-R	43.3 ± 14.0	32.7 ± 9.8	0.11	Liver-R *vs* pancreas	38.5 ± 20.8	33.6 ± 16.0	0.62
Pancreas	81.8 ± 29.8	66.3 ± 20.6	0.26				
Portal Venous				Portal Venous			
Liver-L	67.5 ± 21.7	66.6 ± 14.7	0.93	Liver-L *vs* spleen	16.0 ± 17.6	19.1 ± 12.2	0.69
Liver-R	67.2 ± 20.3	61.3 ± 18.7	0.56	Liver-R *vs* spleen	12.2 ± 12.6	17.3 ± 13.1	0.45
Spleen	77.5 ± 25.1	47.4 ± 5.9	0.01	Liver-L *vs* pancreas	9.3 ± 8.3	8.1 ± 4.5	0.72
Pancreas	73.2 ± 25.7	64.1 ± 9.5	0.39	Liver-R *vs* pancreas	9.3 ± 12.6	13.1 ± 7.5	0.50
Equilibrium				Equilibrium			
Liver-L	76.5 ± 19.8	67.3 ± 14.8	0.32	Liver-L *vs* spleen	12.6 ± 6.2	27.4 ± 13.6	0.01
Liver-R	67.5 ± 19.6	59.0 ± 15.6	0.36	Liver-R *vs* spleen	8.5 ± 7.2	19.2 ± 14.3	0.07
Spleen	70.0 ± 17.9	39.9 ± 5.6	< 0.001	Liver-L *vs* pancreas	12.1 ± 6.4	6.7 ± 8.1	0.16
Pancreas	68.6 ± 22.1	60.5 ± 8.5	0.38	Liver-R *vs* pancreas	11.9 ± 11.3	7.5 ± 6.4	0.38

Conclusions: We showed that 3D multi-phase contrast-enhanced GRE in cirrhotic patients at 3.0 Tesla offers clinically acceptable image quality, with signal-to-noise and contrast-noise characteristics comparable to 1.5 Tesla imaging. The lack of increase in SNR/CNR (except for spleen) using Gd-DTPA may be inherent to high field abdominal MRI since T1 remains somewhat constant at both field strengths, but the increased susceptibility losses offset the expected signal gains of the larger induced magnetization at 3.0 Tesla.

References: [1] JH Lim, *et al*. *Abdom Imaging* 2002; 27:117-128. [2] SM Hussain, *et al*. *MRI Clin N Am* 2002; 10:31-52. [3] BI Choi. *Liver Transpl* 2004; 10(2 Suppl-1): S20-S25. [4] R Frayne, *et al*. *Invest Radiol* 2003; 38: 385-402. [5] NM Rofsky, *et al*. *Radiology* 1999; 212:876-884. [6] CM de Bazelaire, *et al*. *Radiology* 2004; 230:652-659.