Accelated non-contrast-enhanced MR portography with undersampled k-space using compressed sensing reconstruction

Hiroyoshi Isoda[1], Koji Fujimoto[1], Shigeki Arizono: [1], Akihiro Furuta[1], Takayuki Yamamoto[1], Yasutaka Fushimi[1], Aki Kido[1], Kaori Togashi[1], and Naotaka Sakashita[2]
[1]Kyoto University Graduate School of Medicine, Kyoto, Kyoto, Japan, [2]Toshiba Medical Systems Corporation MRI Systems Division, Otawara, Tochigi, Japan

PURPOSE: The ability of non-contrast-enhanced MR portography has been demonstrated with the combined usage of a respiratory-triggered three-dimensional (3D) balanced steady-state free-precession (bSSFP) sequence and a time spatial labeling inversion pulse[1]. However, the acquisition is too long for clinical use. In addition, long acquisition may cause motion artifacts and lead to deterioration of image quality. Shortening of the acquisition time is feasible using compressed sensing (CS) which is a method of image reconstruction from undersampled data. In a recent study, CS was used in combination with a 3D bSSFP sequence for accelerating the acquisition of lower leg angiograms up to rates of 4[2]. The aim of this study was to compare and evaluate images of non-contrast-enhanced MR portography with two different methods, fully sampled k–space data and undersampled k-space using CS.

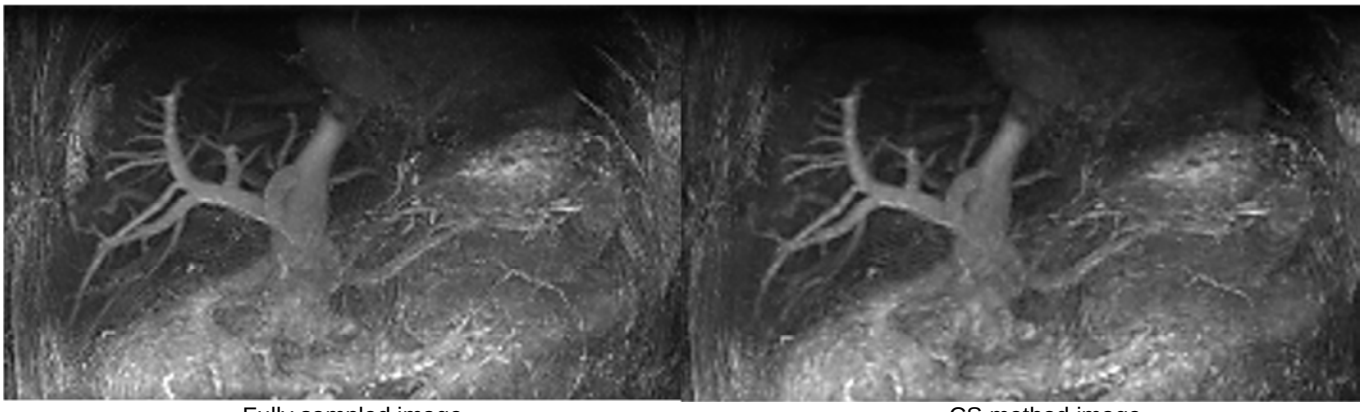
METHODS: Six healthy volunteers were examined using fully sampled respiratory-triggered 3D bSSFP with flow-out method at a 3T MR unit (Vantage, Toshiba Medical Systems Co, Otawara, Japan). A respiratory triggered 3D bSSFP imaging sequence with fat saturation was performed with the following parameters: TR/TE/FA=4.8msec/2.4msec/60°, slice thickness=3 mm, number of slices=30, acquisition time=1min48sec. No parallel imaging was used to facilitate retrospective undersampling for CS reconstruction. Application of the tagging pulse in the flow-out method was as follows: nonselective inversion recovery pulse inverts all magnetization in the region using TI=1,413 msec. The one tagging pulse was placed on the extrahepatic portal vein, splenic vein, and superior mesenteric vein trunk as much as possible and avoided the hepatic parenchyma. The thickness of this tagging pulse was 100 mm and the TI was 1400 ms. The k-space data were retrospectively randomly undersampled by a factor of 3.7 and then reconstructed using CS methods. Images were reconstructed by an in-house software based on the FCSA algorithm: min 1/2|y-Ax|_2^2 + alpha*|psi(x)|_1 * beta*TV(x), where psi and TV represents Wavelet transform and total variation, respectively[3]. Alpha and beta were regularization parameters and optimized beforehand. The fully sampled and reconstructed images were evaluated by two blinded readers in consensus. Visualization quality was scored on a four-point scale for assessments of the right portal vein (RPV), left portal vein (LHA), portal branch of segment 8 (P8), and portal branch of segment 4 (P4).

	Fully sampled images	CS images
Visualization scores		
RPV	4.0 ± 0.0	4.0 ± 0.0
LPV	3.8 ± 0.4	3.8 ± 0.4
P8	3.7 ± 0.5	3.5 ± 0.8
P4	2.8 ± 1.2	2.7 ± 1.4

Table Qualitative results in two methods

RESULTS: Table showed qualitative results. CS method at undersampling a factor of 3.7 resulted in image quality scores similar to the fully sampled reference images.

CONCLUSIONS: Shortening the acquisition time for portal vein visualization was feasible without deterioration of the image quality by CS method at undersampling a factor of 3.7. It will facilitate using non-contrast-enhanced MR porography with CS method in clinical practice



Fully sampled image CS method image

Fig. Non–contrast-enhanced MR portography on MIP images from fully sampled k–space data as well as undersampled k-space with undersampling factors of 3.7 using distributed CS.

REREFENCE

1. Furuta A, Isoda H, Yamashita R et al. Non-contrast-enhanced MR portography with balanced steady-state free-precession sequence and time-spatial labeling Inversion pulses: comparison of imaging with flow-In and flow-out methods JMRI 40:583–587, 2014.
2. Cukur T, Lustig M, Nishimura DG. Improving non-contrast-enhanced steady-state free precession angiography with compressed sensing. Magn Reson Med 61:1122–1131, 2009.
3. Junzhou H, Shaoting, Dimitris M. Efficient MR image reconstruction for compressed MR imaging. Medical Image Analysis 15:670–679, 2011.