Motion-resistant XDGRASP for free-breathing liver MRI: qualitative comparison with standard breath-hold hepatobiliary phase imaging

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Synopsis

Breath-hold post contrast T1-weighted liver MRI is limited by the patient's ability to cooperate with breathing instructions. Free-breathing radial imaging and compressed sensing-based motion-resolved image reconstruction (XDGRASP) has been specifically developed to resolve motion artifacts over standard cartesian techniques. In this work, we apply XDGRASP to enable free-breathing MRI in the hepatobiliary liver phase, a clinically relevant problem. We demonstrate that the image quality of free-breathing XDGRASP is equal to or superior to the one using standard breath hold acquisitions.

Introduction

Contrast-enhanced MRI using a hepatobiliary specific agent (Gd-EOB-DTPA) is essential for the assessment of a variety of liver pathologies[1]. Post-contrast hepatobiliary phase images are currently obtained on the GE platform using a Cartesian T1-weighted Liver Advanced Volumetric Assessment (LAVA) sequence, which is routinely acquired during a breath-hold. Image quality can often be degraded by respiratory motion as patients may be unable to cooperate with or to complete breath hold (BH) instructions[2]. XDGRASP uses a combination of radial acquisition and motion-resolved compressed sensing reconstruction to resolve motion artifacts over standard cartesian techniques[3]. We have recently demonstrated that the quality of XDGRASP reconstructions on delayed-phase post-contrast (Gadobutrol) images were equivalent to, and in some cases superior to conventional delayed phase BH LAVA acquisitions[4]. In this study, we aim to compare the image quality of XDGRASP imaging at the hepatobiliary phase against those acquired with the conventional BH LAVA.

Methods

Patient selection: HIPAA compliant, institutional review board approved prospective single center study. Five patients who were undergoing routine outpatient liver MRI with Gd-EOB-DTPA were recruited and informed consent was obtained.
Data Acquisition: Datasets were acquired on a 3T MRI scanner (MR750w, GE Healthcare, Waukesha, WI) after contrast injection during the hepatobiliary phase. Breath-held Cartesian LAVA (BHLAVA) was performed during a breath-hold of 20 seconds with a spatial resolution of 1.25x1.25x3mm^3. Free-breathing golden angle radial data was acquired using 600 spokes with similar spatial resolution of 1.25x1.25x3mm^3 and scan time of 60 seconds.
Image reconstruction: BHLAVA data were reconstructed online on the scanner. Free-breathing radial data were reconstruction using the XDGRASP algorithm[3], where a respiratory signal was extracted directly from the data and used to sort the acquired data into 4 under sampled respiratory states and temporal compressed sensing reconstruction was performed on the 4 dimensional data (3D image + respiratory dimension).
Image comparison and assessment: Non labelled, reconstructed images were assessed by two abdominal radiologists blinded to clinical data with 10 and 1 years' experience respectively. Assessment included numerically grading the overall quality of the images, liver edge sharpness, bile duct sharpness and motion artifact from 1 (non diagnostic) to 5 (excellent). If lesions were present further scoring of lesion conspicuity and lesion edge sharpness were recorded.

Results

In 4 out of 5 patients, both radiologists graded XDGRASP overall image quality, liver edge sharpness, bile duct edge sharpness and motion artifact as good or excellent. In the same 4 cases, XDGRASP was graded equal to or superior to the standard Breath Hold LAVA images. Liver lesions were present in 4 cases; in all these cases lesion conspicuity and lesion edge conspicuity were graded as good or excellent and in 3 of the 4cases this was equal to or superior to the BH LAVA images. In one case, XDGRASP was graded by both radiologists equal to the BH-LAVA images for motion artifact, however it was graded inferior in the categories of overall image quality, liver edge sharpness and bile duct sharpness. In the same case, one reader also scored XDGRASP inferior to BH LAVA in lesion conspicuity and lesion edge sharpness.

Discussion

We have demonstrated in a small cohort of outpatients the feasibility of generating free-breathing XDGRASP hepatobiliary phase images, which are in most cases equal to or superior to standard Breath Hold LAVA acquisitions. These results are promising and future studies will focus to validation in a larger prospective cohort.

Acknowledgements

No acknowledgement found.

References

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Figures

		Overall image quality		Liver edge sharpness		Bile duct sharpness		Motion artifact		Lesion conspicuity		Lesion edge sharpness	
		R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
Patient 1	BH-LAVA	5	4	5	4	5	4	5	4	5	5	5	4
	XDGRASP	5	5	5	5	5	5	5	5	5	5	5	5
Patient 2	BH-LAVA	4	4	4	4	5	4	4	5	NA	NA	NA	NA
	XDGRASP	4	4	5	5	5	5	5	5	NA	NA	NA	NA
Patient 3	BH-LAVA	4	4	4	4	4	5	4	4	5	5	5	4
	XDGRASP	5	5	5	4	5	5	5	4	5	5	5	4
Patient 4	BH-LAVA	4	4	5	5	4	5	4	4	5	5	5	5
	XDGRASP	3	3	4	4	3	4	4	4	5	4	5	4
Patient 5	BH-LAVA	5	5	5	5	5	5	5	5	5	5	5	5
	XDGRASP	5	5	5	5	5	5	5	5	5	5	5	5

Table 1: Numerical grading (1-5) of breath-hold LAVA (BH-LAVA) and free-breathing XDGRASP. 1 (non diagnostic), 2 (poor), 3 (acceptable), 4 (good), 5 (excellent). R1 = Reader 1, R2 = Reader 2.

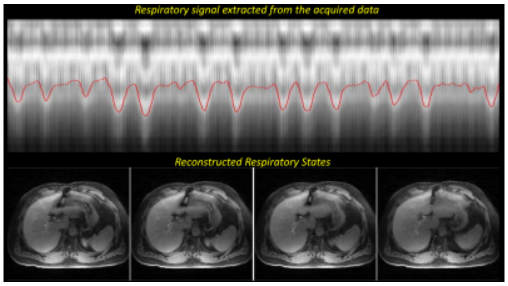

Figure 1: XDGRASP reconstruction: The respiratory motion signal is directly extracted from the data and data are sorted and reconstructed into 4 different respiratory states.

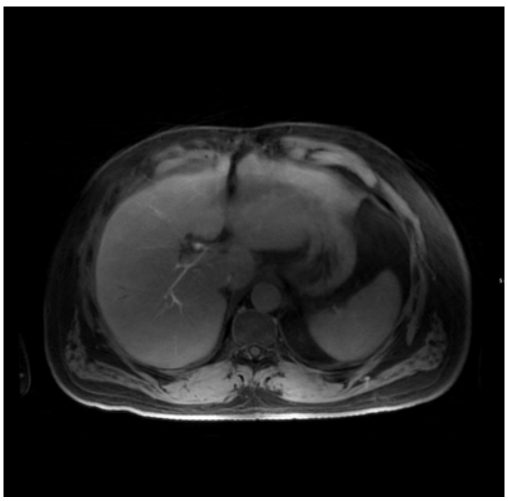

Figure 2: Comparison of free-breathing XDGRASP (left) and breath-held LAVA (right) on patient 1, where XDGRASP was graded by reader 1 as equal to BH-LAVA across all assessment categories. Reader 2 graded the XDGRASP superior to BH LAVA in most assessment categories.

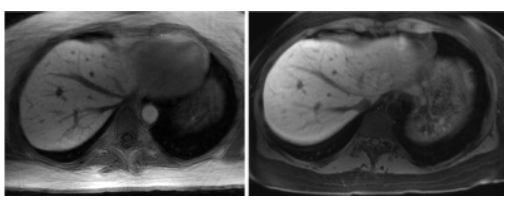

Figure 3: Comparison of free-breathing XDGRASP (left) and breath-held LAVA (right) on patient 3, where XDGRASP overall image quality was graded superior to BH-LAVA by both readers.