Autocalibrated Phase-Contrast Imaging

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Introduction: In phase-contrast MRI (PC-MRI), the full field of view is not needed for flow quantitation, as outer tissue such as the chest wall is irrelevant to the flow measurement. The full field of view is commonly aliased in order to maximize the spatial resolution. It has been reported that SENSE [1] may pose as a problem in correctly unaliasing the tissue due to coil sensitivity maps that do not match that of the aliased tissue in the full field of view [2]. The reconstructed images will have artifacts that may compromise the accuracy of a flow experiment. We apply an autocalibrating sequence to PC-MRI (fig. 1) for both aortic and pulmonary flow. We reconstruct the data using the GRAPPA [3] method and then compare our measurements with SENSE. Through Bland-Altman statistical analysis, we will show that autocalibrating sequences will have closer agreement than SENSE to conventional PC-MRI.

Methods: Data was acquired with 5 normal volunteers using conventional PC-MRI, SENSE PC-MRI, and autocalibrated PC-MRI. GRAPPA was used to reconstruct the autocalibrated PC-MRI. Reduction factor of 2 was used for the undersampling (R=2 for SENSE, ORF=2 for GRAPPA). For autocalibrated PC-MRI, 32 central fully-sampled phase encodes (ACS) were acquired. Volunteers were scanned on a 1.5T TwinSpeed MRI Scanner (GE Medical Systems, Waukesha, WI) with 150 T/m/sec maximum slew rate and 40 mT/m gradient strength. Institutional review board approval was obtained for the study protocol, and consent was obtained from all volunteers. Flow from the aorta and pulmonary artery was measured. Bland-Altman analysis was used.
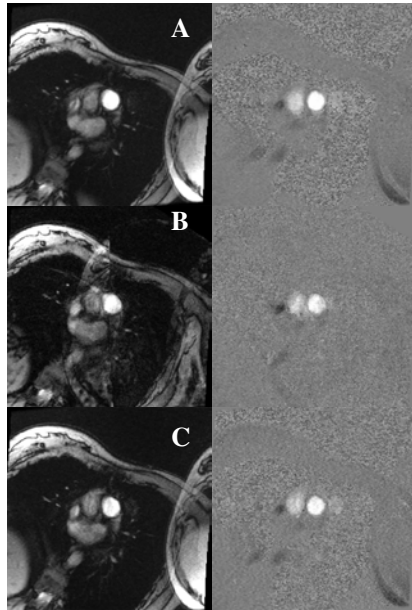

Figure 1. Autocalibrating PC-MRI

Results: Figure 2 shows magnitude and magnitude-weighted velocity images of the pulmonary artery. The aliased full field-of-view artifact is still present in the SENSE reconstruction. The GRAPPA reconstruction does not have this artifact. Figure 3 shows the flow profiles. Figure 4 shows the Bland-Altman statistics, comparing aortic flow with SENSE to conventional PC-MRI, aortic flow with GRAPPA to conventional PC-MRI, pulmonary artery flow with SENSE to conventional PC-MRI, and pulmonary artery flow with GRAPPA to conventional PC-MRI. The mean differences are smaller for GRAPPA than that of SENSE.

Discussion: A practical autocalibrating PC-MRI sequence is demonstrated. Measured flow from a GRAPPA reconstruction shows closer agreement to flow from conventional PC-MRI than that from SENSE PC-MRI. The aortic flow measurements seemed to benefit more from GRAPPA than the pulmonary artery flow measurements because the aliased signal is stronger in the aorta cases.

References: 1. Pruessman, K.P, et al. MRM 1999,42:952-962. 2. Griswold MA, et al, MRM 2004;52:1118-1126. 3. Griswold, MA, et al, MRM 2002;47:1202-1210.

Figure 2. Magnitude and Magnitude-weighted Velocity Images for A) reference B) SENSE C) GRAPPA

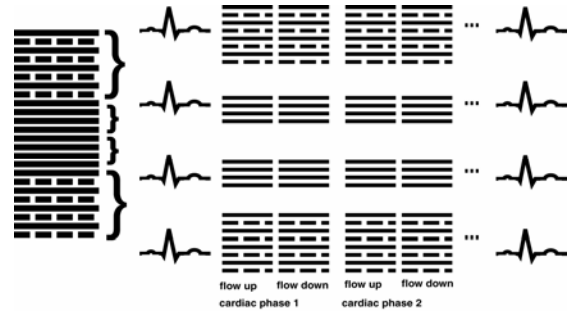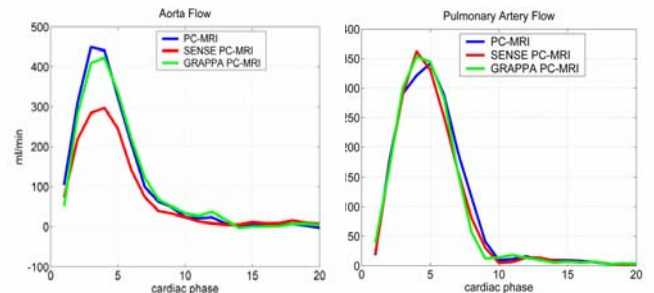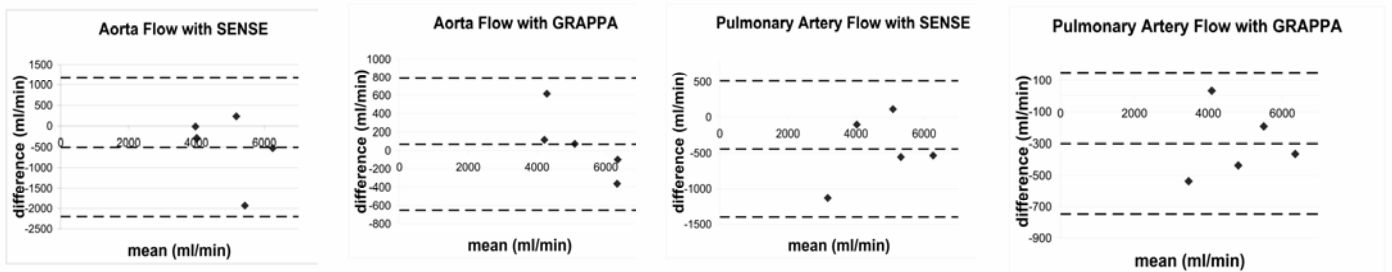**Figure 3. Flow Profiles**

Figure 4. Bland-Altman Statistics