Coherent Steady State Flow Quantification at 1.5 and 3 Tesla

J. W. Grinstead[1], S. Sinha[1], Y-L. Nien[1], S. Tateshima[1], F. Vinuela[1]
[1]University of California, Los Angeles, Los Angeles, CA, United States

Introduction

Recently, a fast, high-SNR method for thru-plane phase-contrast flow quantification based on balanced steady state free precession imaging, termed PC-SSFP, was developed and tested on flow phantoms and the aortic valve of normal volunteers [1]. The present work applies this technique to human and animal carotids at 1.5 and 3T, and evaluates the feasibility of using the scheme for in-plane flow encoding.

Materials and Methods

PC-SSFP achieves flow quantification by inverting the slice select gradients to create a change in the first moment which can be used for flow quantification instead of adding traditional flow encoding lobes which increase the TR, making the sequence more susceptible to off-resonance artifacts [1]. Here, the method is implemented and tested on an *in vivo* porcine common carotid-jugular fistula model at 1.5T and 3T. Also, as suggested in [1], the feasibility of extending the method to encode in-plane flow by inverting the balanced readout gradients was implemented and tested on ¼" tube flow phantom with sinusoidal velocity waveform of amplitude 50 cm/s and 2 sec period.

Scan parameters for PC-SSFP were 3.5mm slice thickness, 220x220 mm field of view, TR/TE= 3.56/1.78ms, FA=60° at 1.5T and 38° at 3T (reduced FA due to increased SAR), 256x256 matrix with 930 Hz/pixel, 2 avg, gated, 60 sec scan, effective v_{enc}=200 cm/s. To achieve steady state, dummy pulses were used over one ECG interval after gradient inversion. Subtraction of phase images was done offline. Standard FLASH PC-FQ was done for comparison with TR/TE = 37/4.9 ms at 3T, 57/5.1 ms at 1.5T, 3-4min scan time, 3 avg, FA=30, 2.5mm slice thickness, 384x312 matrix, v_{enc} =120 cm/s.

Results and Conclusions

A comparison of thru-plane FLASH-PC and PC-SSFP in the swine fistula model 2 weeks post surgery is shown in **Fig 1**, giving similar results for both and demonstrating flow inversion superior to the pressure sink caused by the fistula (the upper curve is incomplete due to an image artifact). Regions 1 & 2 are arteries, 3 & 4 are veins. The SNR was significantly higher using PC-SSFQ (**Fig 2**, showing vessel locations), although it is difficult to quantify because of the saturation of static background tissue in the FLASH-PC. In general, the limiting factor with PC-SSFP was the resolution achievable while maintaining a reasonable TR (less than 4ms), which was approximately 0.8 mm (vessel diameters were 3-5mm). Results of thru-plane flow encoding at 1.5T of the carotid artery showed the average velocity in both carotids had similar variation over the cardiac cycle, and had a strong pulsatile component as expected compared to the venous curve.

There was significant phase shading over the image using in-plane PC-SSFP in the flow phantom in the readout direction which prevents absolute velocity quantification, believed to be caused by the fact that the change in 1st moment varies over the echo. However, point-by-point changes in velocity was seen, and a comparison to FLASH-PC in **Fig. 3** for a small ROI is promising.Additional experiments to characterize the effective flow encoding over the echo are required.

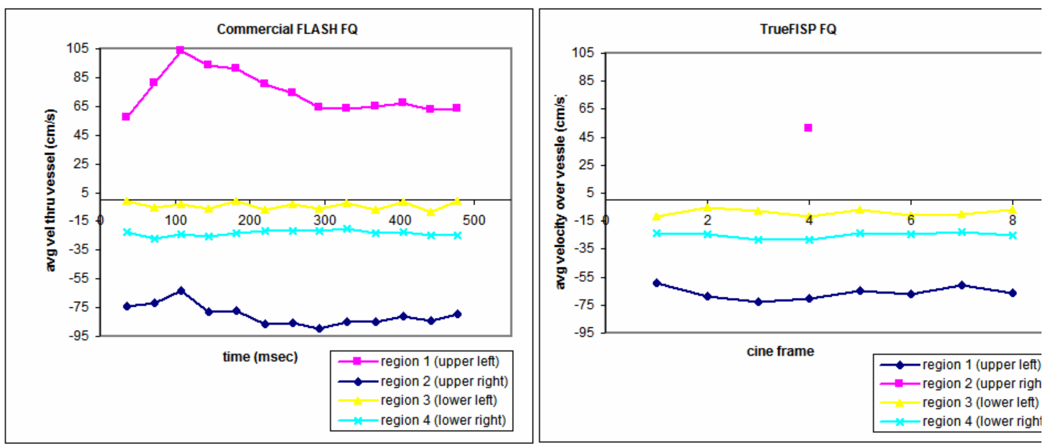
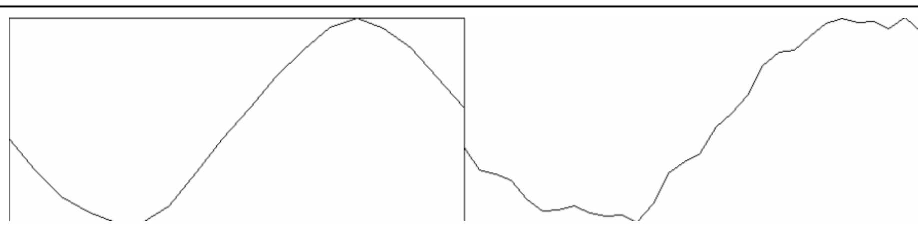


fig.1

Reference

[1] Markl M, MRM 2003 49(5);945-52



FLASH-PC

PC-SSFP (in plane)

Fig. 3

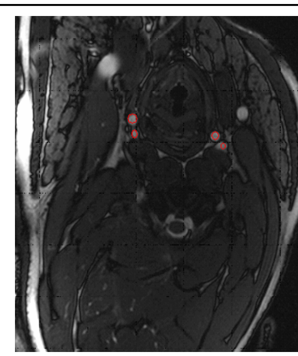


fig.2