Clinical Experience of HYPR FLOW

Y. Wu[1], K. M. Johnson[1], J. Velikina[1], P. Turski[2], and C. A. Mistretta[3]

[1]Medical Physics, University of Wisconsin, Madison, WI, United States, [2]Radiology Department, University of Wisconsin Medical School, Madison, WI, United States, [3]Radiology and Medical Physics, University of Wisconsin Medical School, Madison, WI, United States

INTRODUCTION

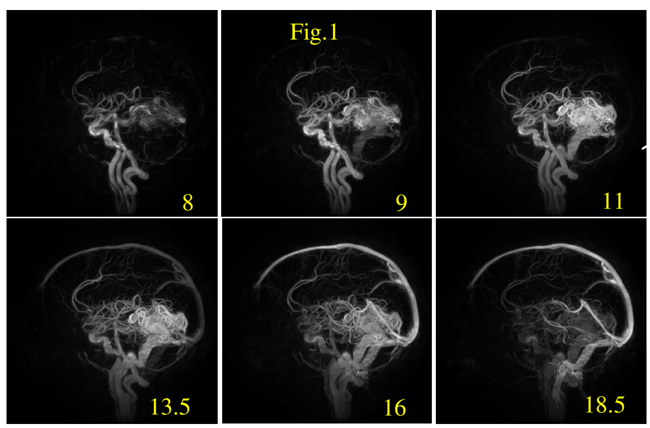
The recently introduced HighlY constrained back PRojection (HYPR) method allows reconstruction of serial images from highly undersampled data [1]. HYPR LR (Local Reconstruction) [2] permits the use of a longer composite window, resulting in increased SNR and quantitative reconstruction accuracy. Phase Contrast (PC) HYPR FLOW employs post contrast PC VIPR images as the composite and reconstructs the first pass Time Resolved Contrast Enhanced (TR-CE) VIPR acquisition using HYPR LR technique. HYPR FLOW decouples the temporal resolution, which is defined by TR-CE VIPR acquisition, from the spatial resolution and SNR, which depend on the PC VIPR acquisition, resulting in both high temporal resolution and isotropic spatial resolution with preserved SNR from the PC images. In addition, the phase contrast scan will add flow information to the CE-MRA time frames and provide velocity information suitable for the calculation of hemodynamic parameters such as pressure map and wall shear stress (WSS) which are potentially beneficial for understanding of the physiologic conditions behind diseases such as arterio-venous malformation (AVM). This abstract presents our clinical experience with HYPR FLOW including the contrast waveform fidelity, spatial resolution, SNR improvement over the VIPR method, and the physiological information beyond the contrast enhanced angiography.

METHODS

Following contrast injection, a CE-MRA examination of the head is performed using time resolved multi-echo VIPR (ME VIPR). Subsequently, PC VIPR acquisition is acquired and then used as a composite image for HYPR LR reconstruction. The imaging parameters for ME VIPR were: FOV = 26x26x26cm^3, TR/TE = 3.1/0.4 ms, BW = 125 kHz, read out points were 64 per echo covering between the center to the edge of the k-space, frame update time was 0.5 s. The scan parameters for the post contrast PC VIPR acquisition were: FOV = 20x20x20cm^3, TR/TE = 12.5/4.8 ms, BW = 62.5 kHz, 7000 projections. Scan time is about 5 minutes. The contrast material was injected at a rate of 2-3mL/s. The contrast dose was 0.1 mm/kg for each scan. The contrast enhanced dataset was processed by three reconstruction methods: conventional VIPR reconstruction method (VIPR) which regrids 3D radio projections into Cartesian grids followed by the Inverse Fourier Transform; HYPR VIPR reconstruction, which combines all the projections from the ME VIPR acquisition as the composite, and applies HYPR LR algorithm onto each time frame; and HYPR FLOW reconstruction, which uses the complex difference image obtained from the PC VIPR acquisition as the composite to apply HYPR LR algorithm onto each time frame. In order to compensate the signal variations due to the high undersampling, a tornado filter with 0.5 s at the central k-space and 0.75 s at the cutoff frequency of the HYPR LR local kernel was applied. Region of interest (ROI) were drawn in both arteries and veins with different vessel sizes and used for waveform and SNR analysis. Pressure and wall shear stress maps were calculated based on the flow information obtained from PC VIPR.

RESULTS AND DISCUSSION

Figure 1 shows an image series of an AVM patient obtained using the HYPR FLOW method. Contrast dynamics from feeding arteries to the nidus, drainage vein and to the sinus veins is clearly seen. The frame update time was 0.5 s and the reconstruction window was 0.75 s. Image comparison between VIPR, HYPR VIPR and HYPR FLOW was shown in Figure 2a, where images at 11 s after the injection were cropped from the axial plane. The spatial resolution was 2x2x2 mm^3 for VIPR and HYPR VIPR and 0.68x0.68x0.68 mm^3 for HYPR FLOW. SNR measurements from these three images were 8.8 for VIPR, 31.5 for HYPR VIPR, and 51.2 for HYPR FLOW. Distal vessels lost in VIPR and HYPR VIPR images are clearly shown in the HYPR FLOW image due to the improved spatial resolution and SNR. The contrast kinetics comparison in Figure 2b demonstrates that HYPR LR reconstruction is able to maintain the dynamic property of the VIPR dataset. Figure 3 shows the velocity information imposed to one frame of the HYPR FlOW images using color to indicate the direction of flow (left). The averaged wall shear stress map (right) indicates elevated WSS in the feeding arteries and reduced WSS at the AVM lesion. A major challenge of HYPR FLOW is the patient motion between two scans. In such case, a co-registration step (either auto or manual) can be applied between the VIPR composite and the PC composite. Alternatively, at the expense of slightly lengthened frame duration, the resolution of the ME VIPR can be increased. HYPR VIPR series can be used as the contrast enhanced series. PC VIPR would not need to register and still provide flow information.



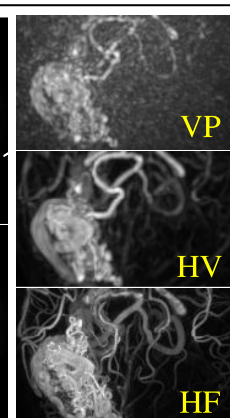


Fig.2a

Figure1 Image series of an AVM patient obtained using HYPR FLOW method. Numbers shown in the images are corresponding time (in seconds) after the injection.

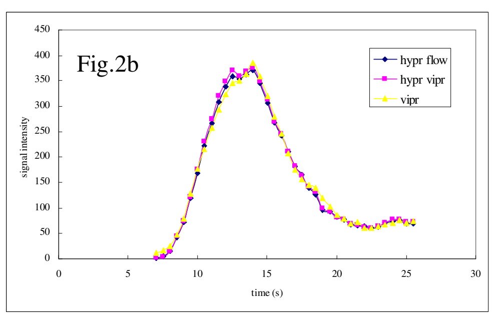


Figure 2.a Magnified axial plane images from the same patient reconstructed using VIPR (VP), HYPR VIPR (HV) and HYPR FLOW (HF) methods. Images were cropped from the whole FOV. HYPR FLOW image shows superior spatial resolution and SNR.
Figure 2b Contrast kinetics comparison of an ROI drawn from the carotid artery shows that HYPR FLOW and HYPR VIPR methods maintain the dynamic property in the VIPR dataset.

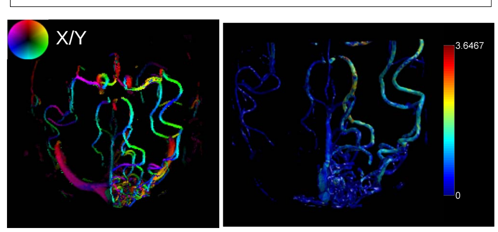


Figure 3. Color coded flow map (left) indicates the flow direction. The averaged wall shear stress map (right) indicates elevated WSS in the feeding arteries and reduced WSS at the AVM lesion.

CONCLUSIONS

HYPR FLOW is able to provide whole brain time-resolved contrast-enhanced MR angiograms with exceptional temporal resolution, isotropic spatial resolution and SNR with the benefit of flow information.

REFERENCES

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2. Johnson KM, et al, *Magn. Reson. Med.* In press.

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