Comparison of HYPR Stack-of-Stars and HYPR VIPR to TRICKS in Peripheral CE MRA

Y. Wu[1], K. Johnson[1], O. Wieben[1], J. velikina[1], A. Carrillo[2], S. Kecskemeti[1], C. A. Mistretta[1], and F. R. Korosec[1]

[1]Medical Physics, University of Wisconsin-Madison, Madison, WI, United States, [2]GE Healthcare, Evanston, IL, United States

Introduction

HYPR [1] is a reconstruction algorithm that enables rapid frame update rates while providing high SNR, spatial resolution, and temporal accuracy and minimal artifacts [2,3]. In this study, three time-resolved imaging methods were compared, a hybrid radial acquisition method (stack-of-stars) with HYPR reconstruction, a true 3D radial acquisition method (VIPR) with HYPR reconstruction, and a commercially-available 3D Cartesian TRICKs method. The three methods were used to acquire contrast-enhanced MR angiograms of the peripheral vessels in healthy human volunteers.

Methods

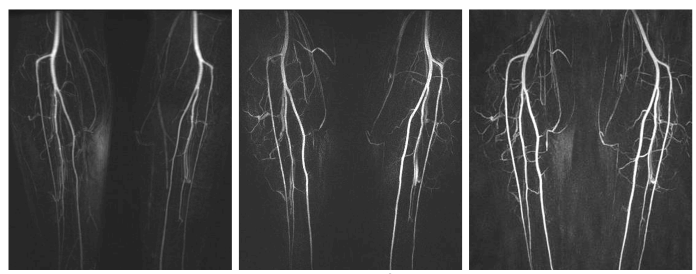
In the stack-of-stars [4] method, a cylindrical volume is imaged by using radial sampling in two dimensions (in-plane), and conventional phase-encoding in the third dimension (through-plane). In VIPR [5], a spherical volume is imaged by using radial sampling in all three dimensions. The sampling trajectory used in VIPR is such that the endpoints of the radial k-space lines trace out, on the surface of the sphere, a spiral pattern originating at the equator and ending at one of the poles.

We have obtained contrast-enhanced MR angiograms of the peripheral vessels in 7 healthy human volunteers using HYPR stack-of-stars, HYPR VIPR, and Cartesian TRICKS. Gadolinium-based contrast material (MultiHance, Bracco Diagnostics Inc, Princeton, NJ, USA) was injected into a vein in the antecubital fossa at a rate of 2 cc/sec using an MR-compatible power injector (Medrad, Indianola, PA). The volume of contrast material was equally divided among the three scans for a total dose of 0.3 mmol/kg of body weight. The order of the scans was randomized. All imaging was performed on a 3T MRI scanner (GE Healthcare, Waukesha, WI). Two types of imaging protocols were evaluated. In one, the spatial resolution of the methods was matched; in the other, the frame update rates were matched. The relevant parameters of the protocol in which the frame update rates were matched are listed in Table 1.

	Cartesian TRICKs	HYPR Stack-of-Stars	HYPR VIPR
FOV:	44 cm x 36 cm	44 cm x 44 cm	44 cm x 44 cm
Matrix:	320 x 180	512 x 512	448 x 448
Slices:	32 (ZIP to 64)	64 (ZIP to 128)	448
Thickness:	3.2/1.6 mm	1.6/0.8 mm	1.0 mm
Resolution:	1.4 x 2.0 x 3.2 mm	0.9 x 0.9 x 1.6 mm	1.0 x 1.0 x 1.0 mm
Voxel Volume:	9 mm^3	1.3 mm^3	1 mm^3
Lines per Frame:	45 views & 32 sl	16 proj & 64 sl	750 proj
Update Time:	6.9 sec	6.0 sec	4.6 sec
Temporal Window:	41 sec	6.0 sec	4.6 sec
Composite Width:	41 sec	97 sec	74 sec
Data Fraction per Frame Update:	$1/4^{th}$ = 45/180	$1/50^{th}$ = 16/804	$1/420^{th}$ = 750/315,265

Table 1

Results and Discussion



TRICKS **HYPR stack-of-stars** **HYPR VIPR**

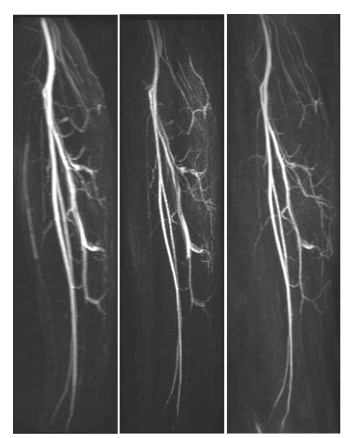
Figure 1: Coronal MIP images

Figures 1 and 2 show coronal and sagittal MIP images of a single frame of a time-resolved series of images obtained from the calves of one volunteer acquired using the parameters in Table 1. (Note, a gradient non-linearity correction was not applied in the HYPR VIPR reconstruction). When the frame update rates are nearly matched, the voxel volumes of the HYPR stack-of-stars and HYPR VIPR methods are 6.9 and 9 times smaller than the voxel volume achieved with TRICKs. Also note that although the frame update rates are nearly equal, the temporal reconstruction window of the TRICKs method is 6.8 and 8.9 times longer than that of the stack-of-stars and VIPR methods, respectively. Combining the enhancements in spatial and temporal resolution, the "enhancement factor" of the HYPR stack-of-stars and HYPR VIPR methods relative to TRICKs are 47 and 80, respectively. Signal versus time curves measured from ROIs placed in vessels confirm that the HYPR methods provide a more rapid temporal response than TRICKs, and the waveforms match closely with those obtained using a high temporal resolution 2D multi-phase Cartesian acquisition [3].

In comparing the HYPR methods, the stack-of-stars method offers a better geometric fit to the anatomy (with the slice-encoding along the shallow anterior-posterior dimension), and is well suited for accommodating readily-available, well-developed parallel imaging algorithms in the slice-encoding dimension, whereas the VIPR method, with its true 3D radial sampling, better tolerates greater undersampling factors, which translates into better spatial and temporal resolution. Additional gains have recently been realized by modifying the angular distribution of the radial sampling lines in the stack-of-stars method to image elliptical cylindrical volumes and in the VIPR method to image ellipsoidal volumes [6].

Conclusions

In this study of contrast-enhanced MRA of the peripheral vessels, both HYPR methods provide better spatial and temporal resolution (or a combination of both) than TRICKs. In comparing the HYPR methods, VIPR permits higher undersampling factors (better spatial or temporal resolution), whereas HYPR stack-of-stars is more geometrically suited, and the parallel imaging algorithms applicable to the slice-encoding dimension of the stack-of-stars method are readily available and further developed that those applicable to non-Cartesian trajectories. Benefits and limitations of the two HYPR acquisition trajectories are still under investigation.



TRICKS **HYPR stack-of-stars** **HYPR VIPR**

Figure 2: Sagittal MIP images

References

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Acknowledgements

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