Correction of signal loss in HYPR FLOW reconstruction

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INTRODUCTION

We have previously reported HYPR FLOW technique in which a separately acquired phase contrast image is used as a spatial constraint for HYPR processing of undersampled time frames acquired during the first pass of injected contrast [1,2]. With VIPR acquisition, this technique was able to provide 0.69 mm isotropic (.33mm³) spatial resolution with 0.5s frame rate and a 0.75s temporal window for time-resolved contrast-enhanced information with flow information and flow derived quantities from the phase contrast scan. However, the spatially constraining image (PC VIPR) is susceptible to signal loss due to dephasing from complex flow or saturation of slow flow, which in turn will degrade the final images. We present here a reconstruction method called IMAC HYPR FLOW, which combines both the magnitude image (MAG) and the complex difference image (CD) as the spatial constraint and utilizes the iterative HYPR (I-HYPR) to generate each individual time frame, such that the signal loss due to the complex/slow flow can be greatly recovered in the time-resolved contrast-enhanced time frames.

METHODS

From the phase contrast acquisition, both the magnitude (MAG) and complex difference (CD) images can be generated. Regular HYPR FLOW reconstruction utilizes the complex difference image as the spatial constraint due to its excellent angiographic contrast and near-zero background signals. However, it is sensitive to flow and could result in signal loss in the time-resolved contrast-enhanced time frames. The magnitude image has good signal depiction in regions with complex/slow flow, but the prominent background signal could be passed to the HYPR images and degrade the image quality. Proposed reconstruction scheme (IMAC HYPR FLOW), as shown in Figure 1, includes two steps: first step is to generate a new constraining image which not only has good angiographic contrast, but also has good signal depiction at flow sensitive regions. This can be achieved by linearly combining two HYPR images obtained by using MAG and CD as the spatial constraint respectively, where \(0≤α≤1\) is a weighting factor and was set to 0.5 for simple implementation. Second step is to reconstruct the final time frame image by using this linearly combined HYPR images as the spatial constraint. The algorithm was tested on two aneurysm patients’ data, where there were significant signal drop-offs within the aneurysms in the CD images.

RESULTS AND DISCUSSION

Signal drop-offs have been significantly improved for both data sets. Figure 2 shows the results from one of the aneurysm patients, where the aneurysm has been treated with detachable coil. Fig.2a is one of the original low resolution time frames reconstructed using gridding technique. After the regular HYPR FLOW reconstruction, although the spatial resolution and SNR has been greatly improved, substantial signal drop-off/blur can be observed (Fig.2b) due to the fact that the spatial constraint (CD) was not able to depict the residual aneurysm lumen where the flow was extremely slow. Signal has been significantly recovered in IMAC HYPR FLOW image (Fig.2c). Detailed comparison is shown in the magnified images Fig.2d, e and f, respectively. Compared to the regular HYPR FLOW image, there is slightly background shading around the vessels, especially around the large vessels in the IMAC HYPR FLOW image. This is due to the import of the background signals from the magnitude weighting. Parameter \(α\) can be adjusted for optimizing the background suppression and signal recovery.

CONCLUSIONS

IMAC HYPR FLOW is able to recover the signal drop-offs from the regular HYPR FLOW reconstruction due to the flow related artifacts in the spatial constraint.

REFERENCES


Funded in part by 1R21EB006393-01. We gratefully acknowledge GE Healthcare for their assistance.