AV ratio and SNR tradeoffs for composite image selection in application of HYPR PR-TRICKS on contrast enhanced cerebrovascular MRA

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INTRODUCTION

HYPR PR-TRICKS (1) combines radial undersampling, Cartesian TRICKS and HighlY Constrained backProjection Reconstruction to achieve a significant Nyquist undersampling with reduced streak artifacts and preserved signal to noise ratio (SNR). HYPR PR-TRICKS can be potentially applied to contrast enhanced MRA and perfusion studies to improve the temporal resolution, spatial resolution and volume coverage. HYPR employs composite image(s) to define the backprojection constraint. The undersampling streak artifacts level and SNR depend primarily on the composite image(s) rather than the projections which are used for backprojection to determine the current dynamic information. The composite image(s) should be chosen such that the temporal behavior is determined by the projections at current time frame, while preserving as much SNR as possible through use of a long composite. There are several different ways to build the composite image(s) for different applications. In this study, six different sets of composite images were evaluated for the time resolved contrast enhanced cerebrovascular MRA application. Artery-vein separation and SNR were compared through fourteen subjects using the two-tailed paired t-test.

METHODS

HYPR PR TRICKS exams were obtained in fourteen adult volunteer subjects following an approved Investigation Review Board protocol. Typical image parameters for HYPR PR TRICKS used in this study are: TE=0.8 ms TR=6.6 ms MATIX=512x512 without zero filling FOV=24cm, Slice-thickness =2mm, 10 projections were acquired at each time frame, giving a frame time of 0.26 s. The contrast material (Omniscan - gadodiamide) was injected at a rate of 2-3mL/sec followed by a saline flush for a dose of 0.1 mm/kg for each scan. For each subject the composite images were generated from sliding window sums centered at the current target time frame with durations of 1) 2.8 s; 2) 5.5 s; 3) 8 s; 4) 11.0 s; 5) a progressive composite window created by progressively adding together time frames ending with the target time frame and 6) a fixed composite image incorporating the entire acquisition. Individual time frame images were obtained by backprojecting the current frame projections with the constraint that information is non-iteratively deposited in the vessel locations defined by the composite images and with weighting provided by the composite images. In order to assess arterial and venous separation the maximum A/V ratio was calculated using signal intensity measurements from the internal carotid artery and the sagittal sinus. SNR was calculated using signal intensity measurements from the internal carotid artery and the background close to the ROI at the peak arterial frame. A two-tailed paired t-test was applied to any two of the six composite methods for both the maximum A/V ratio and SNR.

RESULTS AND DISCUSSION

Figure 1 shows a typical time series of contrast enhanced cerebrovascular MRA using HYPR PR-TRICKS with eight second sliding window composite images. Images are shown every 10 frames. Arterial and venous phases are well separated with good SNR supporting the image quality. Figure 2 shows the variation in the peak A/V ratio for sliding window composite images of 2.8s, 5.5s, 8.0s, 11.0s, a progressive composite and a fixed composite through the entire examination. The peak A/V ratios from any two of the six composite methods were used to perform a two-tailed paired t-test. The corresponding P values were shown in table 1. HYPR images using 5.5 s and 8 s sliding window composites had highest A/V ratio, whereas the fixed composite gives the lowest A/V ratio. The differences are statistically significant (P<0.05). However the A/V ratios are not significantly different between 5.5 s and 8 s sliding window composite methods (P=0.207). The signal to noise ratio with the six composite methods are compared in figure 3. The SNR is highest for the fixed composite. The SNR with intermediate (8s, 11s) length sliding window methods is significantly higher (P<0.05) than the short (2.8s, 5.5s) length sliding window and the progressive composite methods. Note that there is no significant difference between the SNR with 8s and 11s sliding window composite methods (p=0.94). This is probably because that the 11 sec composite window includes enhancement to the background tissue, causing more fluctuation to the background.

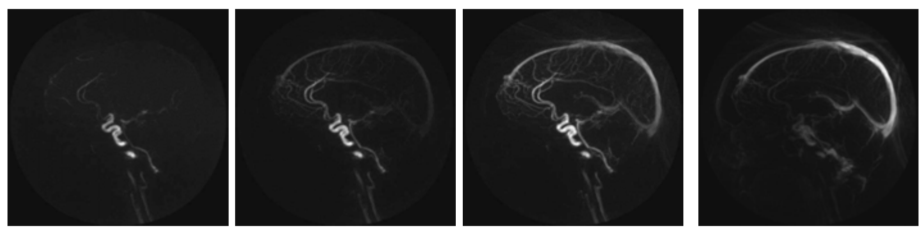

Figure1 A typical time series of contrast enhanced cerebrovascular MRA using HYPR PR-TRICKS with eight seconds sliding window composite images. Images were shown every 10 frames. Arterial and venous phases are well separated with good SNR supporting the image quality.

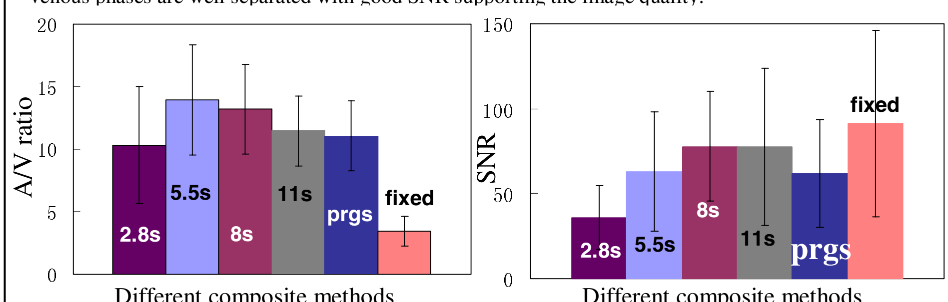

Figure 2&3. Comparison of A/V ratio (left) and SNR (right) for the six composite methods.

	2.8s	5.5s	8s	11s	prgs	fixed
2.8s		**0.005**	**0.012**	**0.265**	**0.57**	**6.3E-5**
5.5s	**0.004**		**0.207**	**0.011**	**0.004**	**1.9E-7**
8s	**0.0001**	**0.001**		**0.0008**	**0.004**	**2.4E-8**
11s	**0.002**	**0.025**	**0.94**		**0.51**	**1.6E-8**
prgs	**0.009**	**0.77**	**0.01**	**0.033**		**3.6E-8**
fixed	**0.004**	**0.019**	**0.1**	**0.035**	**0.008**	

Table 1&2. The t-test of the A/V ratio (red) and SNR (black) for any two out of six composite methods

CONCLUSIONS

HYPR PR-TRICKS provides both high spatial and temporal resolution using a large undersampling factor with preserved SNR. The intermediate sliding window method provides optimal A/V separation and SNR for the contrast enhanced cerebrovascular MRA application. Although there are many other factors for this particular application that might affect the length of the composite window, such as fast flow rate in the AVM patients, this study provides a guide line for the implementation of HYPR PR-TRICKS for contrast enhanced cerebrovascular MRA.

REFERENCES

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