Time-resolved contrast enhanced neuro-angiography using HighlY constrained back PRojection (HYPR) with a hybrid radial/Cartesian acquisition (PR-TRICKS)

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INTRODUCTION

Currently available time-resolved MRA sequences such as TRICKS and those employing parallel imaging provide typical acceleration factors of three. We have recently developed a method called HighlY constrained back PRojection (HYPR) that exploits the idea of avoiding redundant k-space information in an angiographic time series [1,2,3]. This technique, when used in conjunction with a hybrid radial/Cartesian acquisition PR-TRICKS [4,5] provides relatively low artifact images with overall Nyquist undersampling factors of 200 or more. This provides the opportunity for substantial increases in temporal resolution, spatial resolution or volume coverage. HYPR has unique SNR properties that usually result in individual time frames having SNR determined by a running average of all or a substantial subset of the acquired data rather than the acquired data for each time frame. In this work we proposed to apply HYPR PR-TRICKS to generate time-resolved contrast enhanced neuro-angiography.

MATERIALS AND METHODS

A time series of interleaved undersampled radial acquisitions are obtained during the passage of contrast material. For each radial acquisition in the kx,ky plane, a series of TRICKS encoded kz acquisitions are acquired. For each kz region a composite image is formed from all or a substantial subset of the acquired projection sets. This composite image is relatively free of streak artifacts and has good SNR. Individual time frame projection information is backprojected using 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. This eliminates extravascular streak artifacts and greatly reduces intravascular streak artifacts. In the limit in which temporal behavior is spatially homogeneous, a single projection provides an exact reconstruction [6]. As temporal behavior becomes more heterogeneous, more projections per time frame are required to isolate local temporal behavior. For HYPR PR-TRICKS 10 projections are typically obtained for a 512 x 512 in-plane matrix normally requiring 800 projections for full Nyquist sampling, giving the Nyquist undersampling factors of 240 for 3D acquisition (80 in-plane by 3 through-plane).

HYPR TRICKS has been applied to angiography of the head. Acquisition parameters were: TR/TE/FA=8.5/1.5ms/30^o, BW=62.5, FOV/matrix/slices=24cm/512/48, 10 projections per time frame, 50 different sets of interleaves were applied, resulting in spatial resolution of 0.5x0.5x1.5 mm^3 with frame times of 0.5s. An injection of 20 ml of contrast injected at 2 ml/sec.

RESULTS AND DISCUSSION

Figure 1a shows eight of 126 acquired time frames in the coronal MIP. Figure 1b shows the axial MIP image at the peak frame. Arterial and venous phases are well separated with high spatial resolution and substantial spatial coverage.

Due to the use of integrated projection information in the composite image that constrains the reconstruction, motion blurring is a potential limitation of this method. In some instances it is advantageous to use less than the complete set of projections in a series of composite images that advance in time. For example, composite images may be retrospectively formed from temporal averages sliding along with the time frames. SNR gain, artifact reduction and temporal response depend on how large a temporal aperture can be used for the composite images.

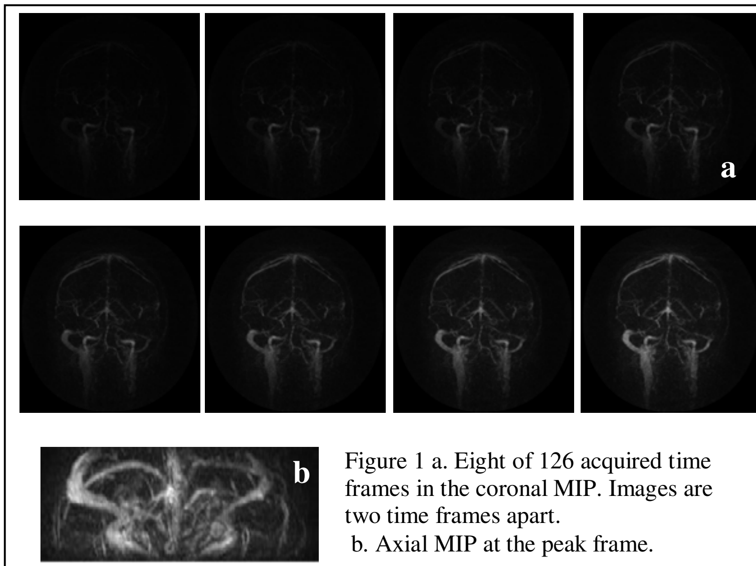

Figure 1 a. Eight of 126 acquired time frames in the coronal MIP. Images are two time frames apart.
b. Axial MIP at the peak frame.

CONCLUSIONS

HYPR PR-TRICKS can be used to acquire a series of 3D datasets using as few as 10 projections providing spatial resolution of 0.5x0.5x1.5 mm^3 with time frames as short as 500 ms. The unusual properties of HYPR result in far less decrease in SNR than would normally be associated with such large acceleration factors.

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