Peripheral Angiographic Applications of HYPR TRICKS

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INTRODUCTION

We applied the HighlY constrained back PRojection (HYPR) algorithm [1] to the PR-TRICKS MRA technique [2][3]. HYPR is a method that permits great improvements in temporal resolution in radial acquisitions by producing time frames using only a small subset of the total number of projections necessary to satisfy the Nyquist criterion. Streak artifacts that would ordinarily result from constructing images using a dramatically reduced number of projections are ameliorated by constraining the unfiltered back projected data to regions in which vessels are known to exist. In order to determine the location of the vessels, a vessel map is produced using data from multiple time frames. Because the data for each of the time frames is produced from projections that are acquired at slightly different angles, data from multiple time frames can be combined to produce high SNR, low artifact composite images (or vessel maps). Using the HYPR method, the temporal resolution can be improved by more than a factor of 80 as compared to a fully sampled multi-phase data set.

MATERIALS AND METHODS

Contrast-enhanced time-resolved images of the peripheral vessels were produced using the HYPR processing method applied to the PR TRICKs acquisition technique. PR-TRICKS is a 3D acquisition method in which k-space data in two dimensions are sampled radially, and data in the third dimension are sampled using a traditional slice encoding method. The ZIPR (kZ-encoding Inside PRojections) acquisition scheme [4] was used. A pre-contrast data set is acquired followed by a time-resolved series of data sets. For the HYPR implementation, the time-resolved data sets consist of as few as 10 projections (to produce a stack of 512 x 512 images), and the projections for each time-frame are rotated by a few degrees so that data for all frames in the set are unique. The pre-contrast data (mask) are subtracted (in k-space) from the remaining data to eliminate signal from non-enhancing tissues. Because the data from the time frames are unique, they can be combined to produce a high SNR, low artifact image including data acquired throughout the entire scan, or multiple images representing data acquired at various time points throughout the scan. The so-called composite images can be used as vessel maps to constrain the unfiltered back projection of the data from each of the highly undersampled time frames. In this way, images can be produced that have high temporal resolution dictated by the low number of projections per frame, and high SNR and low artifact properties as dictated by the characteristics of the composite image.

RESULTS AND DISCUSSION

To date, we have obtained peripheral exams in 7 healthy volunteers. Compared with conventional PR-TRICKS performed with very low numbers of projections, HYPR-TRICKS images have higher SNR and fewer artifacts. Compared with fully-sampled PR-TRICKS, the HYPR-TRICKS acquisition permits far better temporal resolution. We have achieved frame times of 0.94 sec using 10 projections/interleaf (512 samples/projection), 72 slices with a slice thickness of 1.5mm, a TR of 13.4ms, a TE of 5.4ms (to produce time frames composed of 512 x 512 x 72 spatially resolved data points), and a FOV of 38cm. Other frame rates have also been evaluated. Simulations and *in vivo* data demonstrate that the temporal characteristics of both veins and arteries are well represented using as few as 10 projections per time frame.

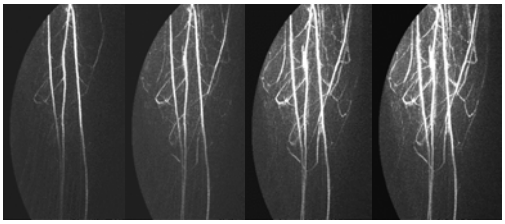

Figure 1: Coronal MIP images of four of 50 time frames of the lower extremities produced using the HYPR-TRICKS technique. The time/frame is 0.94 sec, and frames 5, 15, 25, and 45 are shown. The images are cropped. Each of the 50 full time frame image sets contains 512 x 512 pixels in each of 72 coronal slices. The injection rate was 2ml/sec, and the dose was 50 ml.

CONCLUSIONS

HYPR-TRICKS uses novel acquisition and reconstruction methods to yield high temporal resolution images. When applied to contrast-enhanced MRA of the lower extremities, HYPR-TRICKS permits dramatic increases in temporal resolution while maintaining good image quality and preservation of the temporal characteristics of the passage of the contrast agent from arteries to veins.

REFERENCES

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