Initial Clinical Experience with High Resolution 4D Magnetic Resonance Angiography utilizing VIPR-ME

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INTRODUCTION:

Contrast enhanced MR angiography has evolved to become a premiere technique for the non-invasive evaluation of vascular pathology. However MRA typically does not provide dynamic information in a similar fashion to conventional angiography. Time resolved images can provide information about the physiology of various vascular structures, which may be important for patient management, but these methods generally sacrifice spatial resolution to obtain the temporal information. We present a technique using 4D Vastly-Undersampled Isotropic Projection Reconstruction (VIPR) to acquire large volume high-resolution time resolved MRA images in a series of patients.

MATERIALS and METHODS:

7 Patients (6:1) mean age 56, Range: 23-80 were recruited following routine MRA examination. Informed consent was obtained and the study was approved by our IRB. Imaging was performed using a GE Signa 1.5T CV/i scanner (General Electric Co., Milwaukee, WI) equipped with gradients supporting 40mT/m magnitude, 150T/m/s slew rate and 4 - 8 channel torso phased array coils. We developed a T-1 weighted Vastly-Undersampled Isotropic Projection Reconstruction technique with Multiple half Echoes (VIPR-ME) (TR/TE/Flip/BW; 4.4/0.3/30degrees/125, FOV; 44cm x 44cm, matrix 256 x 256 x 256, 20 time frames were reconstructed at 2 second intervals). A spatial-frequency dependent filter was applied to reconstruct the time-resolved phases. The speed-up factor attributed to the filter was 45 at the center of k-space, while the speed-up factor at the periphery of k-space was 3 due to VIPR under-sampling. The total scan length was 30 seconds for breath-held applications, and 60 seconds for applications that did not require breath holding. Gadodiamide 25-40 cc (Omniscan, Amersham, Health Inc., Princeton, NJ) was infused at 4-5cc/second and then flushed with 20cc saline at 2cc/second. Patients were asked to breath-hold as long as possible. Scanning was inititiated several seconds after contrast injection and no timing bolus was utilized. The images were then reviewed on a 4D capable workstation and analyzed for quality of vascular images and temporal resolution.

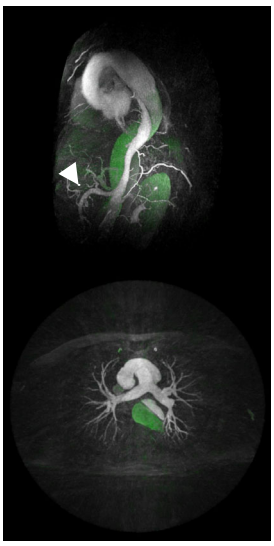

Figure 1: Time resolved images of thoracic aortic dissection with color shading of true (white) and false (green) lumens as a function of time to enhancement. Note the clear demonstration of the SMA arising form the true lumen.

RESULTS:

VIPR-ME provided high quality 4D image data sets in all cases. Spatial resolution was 256 x 256 x 256 and temporal resolution was on the order of 2 seconds. This degree of temporal resolution allowed clear separation of the arterial and venous phases in all patients including demanding applications like the resolution of pulmonary artery/veins and in the intracranial circulation. Time resolution was also sufficient to delineate the filling of the true and false lumen of aortic dissection channels over time. The time-resolved images could also be interrogated for the presence of respiratory motion, and data could be excluded from the reconstruction after the patient could no longer hold his or her breath. Data sets could be viewed in cine mode in a fashion similar to conventional digital subtraction angiography. The technique negated the need for timing contrast arrival. True isotropic resolution of the images allow for high quality post processing of the images with both MIP and VR techniques.

CONCLUSION:

4D MRA utilizing VIPR-ME provided clinically useful, 256 x 256 x 256 isotropic, time-resolved images of multiple vascular structures during a single breath hold and contrast injection.

REFERENCES:

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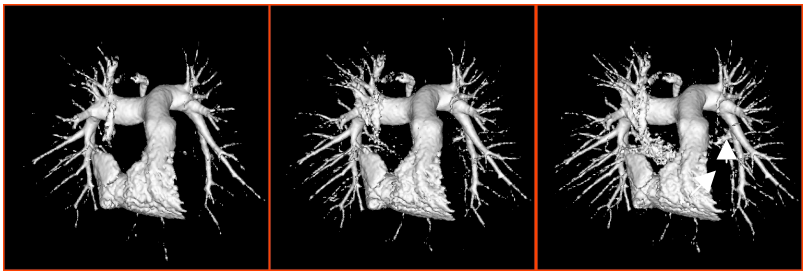

(a) **(b)** **(c)**

Figure 2: Volume rendered time resolved series of the pulmonary vessels demonstrating pure arterial and early venous phases. Note in (c) the late appearance of the pulmonary veins (arrow).