Reduced Acquisition Window with Parallel Technique Improves Non Contrast 3D HASTE MRA Imaging

J. Xu[1], N. Oesingmann[1], A. Stemmer[2], K. McGorty[3], E. Hecht[3], R. P. Lim[3], Q. Chen[3], B. Stoeckel[1], V. S. Lee[3]

[1]Siemens Medical Solutions USA Inc., New York, NY, United States, [2]Siemens Medical Solutions, Erlangen, Germany, [3]New York University School of Medicine, New York, NY, United States

Introduction:

A non-contrast-enhanced MRA technique using 3D HASTE (Half Fourier Acquisition Single Shot Turbo Spin Echo) has been reported for various clinical conditions, such as arterial occlusion and venous malformation [1] [2]. This technique subtracts systolic 3D HASTE acquisitions from diastolic images to provide high resolution MRA without exogenous contrast agents. We have implemented a 3D HASTE sequence with iPAT (integrated Parallel Acquisition Technique) which reduces the number of acquired lines per image. By shortening the acquisition window, the defective signal attenuation is decreased and a narrower point spread function is achieved. Compared with conventional imaging techniques [3], the combination with iPAT demonstrates the visualization of a greater number of smaller vessels, and a better definition of vessel edges.

Materials and Methods:

As a single-shot technique, 3D HASTE collects all echoes after one excitation. Consequently, relatively short T_2 components show characteristic blurring in the phase-encode direction, so the signal amplitude is reduced due to an increasing full width at half-maximum in the point spread function. The later echoes have low signal intensity because of the T_2 decay, and the resulting image will be blurred. To minimize the blurring, it would be best to collect all of the echoes as quickly as possible using the shortest acquisition time. By applying parallel imaging methods additionally, fewer echoes are measured and the acquisition window becomes shorter, giving less blurring as well as better capturing of the desired period of systolic flow as compared to the conventional 3D HASTE. The relationship between the actual acquisition window and T_2 decay is schematically presented in Figures 1 and 2, respectively, demonstrating the actual acquisition window with and without acceleration factor 2. In Figure 2a, signal attenuation in a conventional single-shot image is shown with adjacent lines depicted as black and gray bars, in Figure 2b, the shorter echo train results in decreased signal attenuation during acquisition. Furthermore, signal attenuation for any given position in k-space is reduced by applying iPAT, which provides clearer delineation of arterial vessels with reduced flow artifacts, producing sharper T_2 images.

All experiments were performed with a 1.5 T Avanto system (Siemens, Erlangen, Germany), using a phased array coil. More than 20 volunteers and patients were imaged without and with acceleration factor AF=2, ECG triggering and a phased array coil were used for peripheral MRA. The following imaging parameters were selected for imaging the upper extremity part shown in Figure 3: FOV 500x500mm^2, slice thickness = 1.53mm, number of partitions=104, matrix = 320x240, AF=2, reference lines=24, total number of phase-encoding steps=108, BW=975Hz/pixel, TE = 49 ms, TR = 3 R-R intervals, TI = 170 ms, TD = 0/500 ms, total acquisition time 4:19min. For the hands, we used a phase array coil and ECG-gating with modified parameters: FOV 240mm x 240mm, slice thickness = 0.8mm, number of partitions =80, matrix = 320x180, AF = 2, reference lines=24,total number of phase-encoding steps=136, TD = 0/500 ms, TI = 170 ms, TR = 3 R-R intervals, TE = 54ms, BW = 975 Hz/pixel, total acquisition time 2:18min.

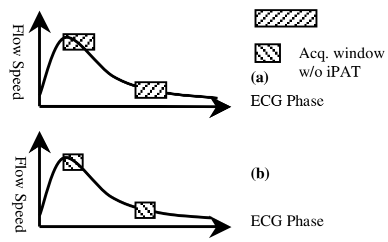

Figure 1: Different acquisition window covers different states of blood flow, and schematic display of the acquisition window with and without iPAT.

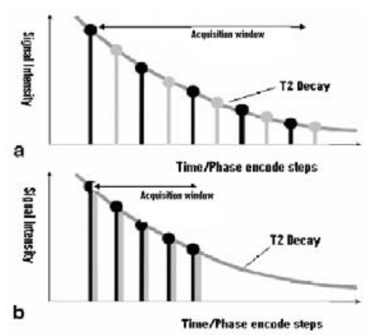

Figure 2:
Signal attenuation in different acquisition windows,
(a) Conventional single-shot HASTE without iPAT,
(b) Single shot HASTE with iPAT, acceleration factor 2.

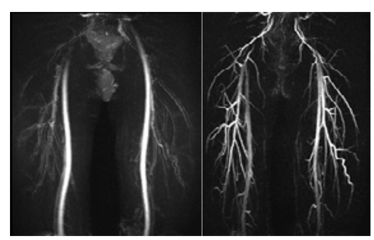

Figure 3: FOV 500x 500 mm^2, Slice thickness=1.53mm, Matrix=320x240, BW=975Hz/pixel, TE=49ms, TI=170ms, TR=3 R-R intervals, TD=0/500ms for systolic and diastolic phase (a) without iPAT (b) with AF = 2.

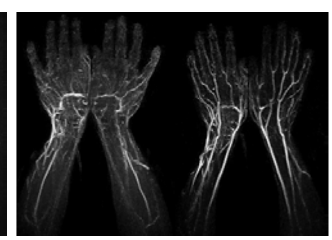

Figure 4: FOV 240X240 mm^2, slice thickness=0.8mm, TI=170ms, Matrix=320x180, TD=0/500ms, TE=54ms, TR=3 R-R intervals, BW=975Hz/pixel (a) without iPAT (b) with AF = 2.

Results:

Representative results are shown in Figures 3 and 4. Figure 3 demonstrates the marked reduction in image blurring and improved delineation of smaller vessels (profound branches) in the thighs of a healthy volunteer using iPAT (right) compared with no iPAT (left). Similar findings are demonstrated in Figure 4, where the addition of parallel imaging caused a substantial improvement in the image quality with better depiction of small vessels, including distal branches and less blurring of large vessels with sharper vessel edges.

Conclusion:

By applying parallel imaging to a non-contrast-enhanced 3D HASTE MRA sequence, the shorter acquisition window results in less blurring and the edges of vessels are visualized sharper. Moreover, the acquisition times are much shorter compared to a conventional 3D sequence. This fast 3D method allows coronal in-plane depiction of vessels without the application of exogenous contrast agents.

References:

1. Miyazaki M et al, Radiology 227:890-896 (2003);2. Miyazaki M et al, JMRI 12:776-783 (2000); 3. Griswold MA et al, MRM 41:1236-1245 (2002);