Time-Resolved Magnetic Resonance Fistulography with TREAT and GRAPPA for Surveillance of Hemodialysis Arteriovenous Fistulae

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INTRODUCTION

Arteriovenous (AV) fistulae are the most commonly used access in patients requiring long term hemodialysis. Fistula dysfunction often occurs necessitating frequent graft monitoring with possible intervention. Currently, x-ray fistulography is the gold standard imaging modality used for surveillance of diseased hemodialysis AV fistulae; however, it is an invasive procedure with exposure to ionizing radiation and nephrotoxic contrast material. Contrast enhanced magnetic resonance angiography (CEMRA) is now routinely used as a first-line imaging tool for evaluating the vasculature, and has also previously been utilized for assessment of hemodialysis AV fistulae [1, 2]. Because of the rapid flow through AV dialysis fistulae, a time-resolved approach would more optimally separate the arterial inflow from venous outflow and also give information about flow dynamics. In general, in order to improve temporal resolution with CEMRA, spatial resolution must be sacrificed resulting in a reduction in image quality. A number of new acceleration techniques, i.e. parallel imaging and TREAT (time-resolved echo-shared angiographic technique), have recently become available resulting in up to four fold increases in imaging speed. When these are used in combination, it may be possible to achieve substantial improvements in temporal resolution while maintaining spatial resolution.

PURPOSE

To evaluate a novel time resolved CEMRA technique, which combines parallel imaging (GRAPPA) with TREAT, for assessment of hemodialysis AV fistulae and compare it with conventional x-ray fistulography. The details of this new pulse sequence will also be presented.

METHODS AND MATERIALS

10 patients with hemodialysis AV fistulas were evaluated by MRA using a 1.5T Siemens Sonata. 7 patients had correlative x-ray fistulography within 4 weeks of the MRA. Three patients received MRA imaging after attempts at achieving x-ray fistulography had failed. Patients were positioned supine on the scan table with arms by their side. Multi-element array coils were wrapped around upper and lower arms. A 3D gradient echo FLASH pulse sequence (TR/TE: 2.8/1.2; flip angle: 200; 512 readout; 50-70 partitions; 1.2x0.7x1.3mm^3 voxels) was used for imaging. This was combined with GRAPPA (acceleration factor 2) and TREAT to reduce the acquisition time to approximately 4-5 seconds per frame. Data sets were subtracted inline and there was automatic maximum intensity projection (MIP) post-processing. This yielded a series of MIP images at 4-second time points. The forearm and upper arm were imaged in two separate stations. 20 cc of Gadolinium was injected at 2cc/sec for each station via an 18G intravenous cannula placed in the contralateral upper extremity.

For image analysis, the vascular tree was divided into nine evaluable segments: superior vena cava, brachiocephalic vein, subclavian vein, axillary vein, arterial inflow, arterial outflow, arteriovenous anastamosis, venous outflow below elbow, and venous outflow above elbow The images were evaluated by 2 independent observers and the presence of occlusions, stenoses, and pseudo aneurysms were noted for each vascular segment. MRA findings were correlated with findings on x-ray fistulography. Image quality for each vascular segment with both techniques was also rated by each observer as excellent, good, fair, poor, or non-diagnostic.

RESULTS

Time-resolved MRA depicted dynamic filling and draining of AV dialysis fistulas with 4-second time resolution in all cases. A total of seventy-one vascular segments were obtained by MRA, and fifty-four vascular segments were obtained by conventional x-ray fistulography. Three patients were unable to undergo conventional x-ray fistulography due to failure to “cannulate” their fistulas. Fifty vascular segments visualized by MRA were analyzed against their x-ray fistulography counterparts. Conventional x-ray fistulography showed five stenoses. MRA depicted all five stenoses and three false positive findings, resulting in a sensitivity of 100% and a specificity of 92%. X-ray fistulography showed 5 pseudoaneurysms. MRA depicted all five pseudo aneurysms and three false positive findings, resulting in a sensitivity of 100% and a specificity of 92%. Overall, time-resolved MRA accurately demonstrated disease within AV fistulas when compared to fistulography with 100% sensitivity and 83% specificity. Arterial inflow was better visualized on MRA with image quality considered to be excellent in 90% of MRA segments compared to only 13% of x-ray fistulography segments. Overall, image quality with MRA was considered excellent 63% of the time versus only 30% of the time with x-ray fistulography.

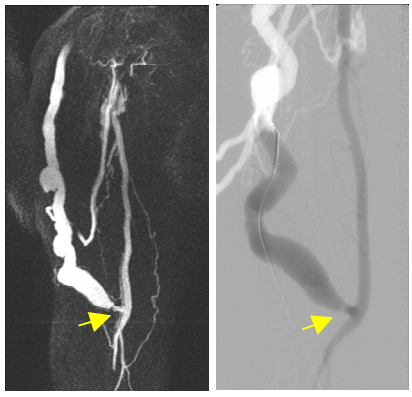

Fig 1. Hemodialysis AV fistula in 54 y/o AA female. Contrast Enhanced MRA (left) with corresponding DSA (right) demonstrating a stenosis at the arterial anastamosis of the fistula (arrows).

CONCLUSION

Time resolved CEMRA using GRAPPA and TREAT can produce detailed images of the vasculature with high temporal resolution. This novel MRA technique is accurate at detecting disease in hemodialysis AV fistulas and has the potential to replace x-ray fistulography as a screening tool in these patients.

REFERENCES

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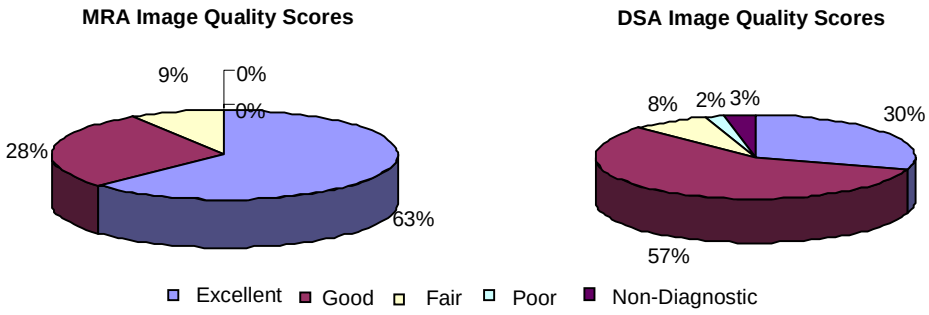

Fig 2. Image quality score results for MRA versus DSA studies.