Non-contrast Enhanced Renal MR Angiography using NATIVE TrueFISP – Initial Experience for Clinical Imaging of Patients with Renovascular Disease

S. J. Gandy[1], P. Guntur Ramkumar[2], S. A. Waugh[1], R. S. Nicholas[1], A. W. Taylor[2], X. Bi[3], P. Weale[3], and J. G. Houston[2]

[1]NHS Tayside Medical Physics, Ninewells Hospital, Dundee, Angus, United Kingdom, [2]NHS Tayside Clinical Radiology, Ninewells Hospital, Dundee, Angus, United Kingdom, [3]Cardiovascular Research and Development, Siemens Medical Solutions, Chicago, Illinois, United States

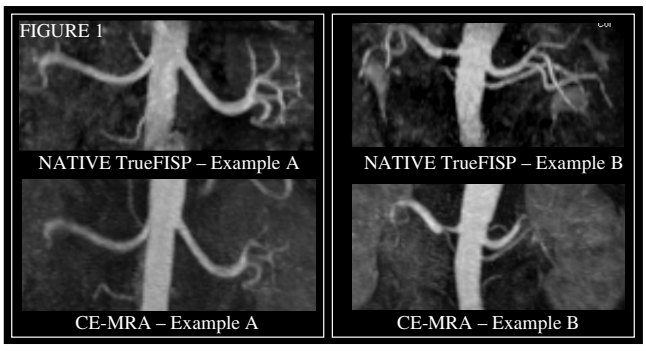
Introduction and Aims: Non-contrast MR angiography (NCE-MRA) using fast steady-state gradient echo imaging can provide an alternative method to the established technique of contrast enhanced MR angiography (CE-MRA) [1-3]. Non-contrast acquisitions are of particular use for imaging the renal arteries, since they can potentially circumvent the need for contrast agent administration in patients with higher risk of developing Nephrogenic Systemic Fibrosis (NSF). The aim of this study was to compare the use of a new non-contrast method against CE-MRA in a cohort of clinical patient volunteers. The newly implemented method, NATIVE TrueFISP (Siemens Healthcare, Erlangen, Germany), consists of a spatially selective inversion preparation applied over the imaging volume, which suppresses static tissue and slowly flowing blood in order to enhance the visualisation of non-inverted blood which arrives in the imaging volume during the inversion time.

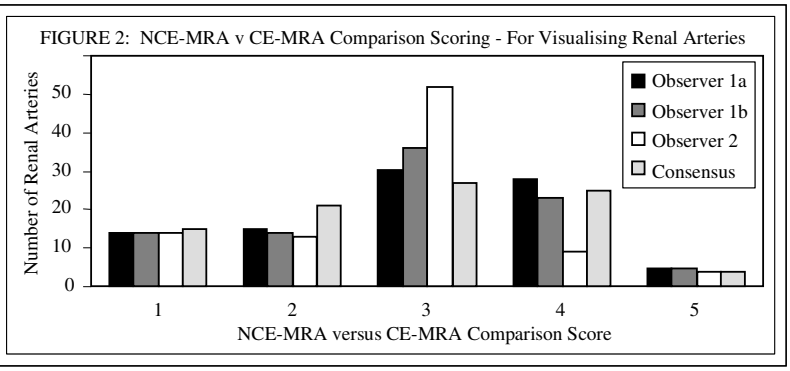
Methods: Fifty consecutive consenting patient volunteers (24 males and 26 females, mean age 71 years, age range 20-91 years) were recruited for imaging, with all patients requiring routine clinical renal MR angiography on the basis of suspected hypertension or known previous renovascular disease.

All imaging was performed on a Siemens 1.5T Magnetom Avanto scanner using a combination of body matrix and spine array coils. The imaging parameters for the navigator-gated, prospectively ECG-gated NATIVE 3D TrueFISP sequence were mean TR = 928ms (range 335-1300ms), TE = 1.6ms, mean TI = 830ms (range 250-1200ms) and 90° flip angle. A block of 72 contiguous fat-suppressed axial slices, each 1mm thick, were acquired over the defined imaging volume with field of view 242x340, 216x304 in-plane pixel resolution and parallel imaging (GRAPPA) factor 2, resulting in an average scan time of 4min 20sec. Following the NATIVE sequence, each patient underwent a standard CE-MRA examination consisting of a pre-contrast mask acquisition, followed by arterial phase data collection after appropriate bolus timing. Bolus timing was derived from a standard 'test bolus' technique, and each CE-MR angiogram was acquired following administration of a 20ml bolus of gadoteric acid ('Dotarem', Guerbet, Paris, France) using a Spectris Solaris power injector (Medrad inc, Pennsylvania, USA) delivered at 2.5ml per sec, followed by a 20ml saline flush delivered at the same rate. The imaging parameters for the pre- and post-contrast CE-MRA acquisitions were TR 3.5ms, TE 1.2ms and 25° flip angle. A block of 72 contiguous coronal slices, each mean 1.2mm (range 1.1-1.5mm) thick were acquired over a (patient size dependent) field of view of 400-500mm, 227x384 in-plane pixel resolution and parallel imaging (GRAPPA) factor 2, resulting in an average scan time of 13 sec.

Coronal MIP images were derived for each of the NATIVE and arterial-mask subtracted CE-MRA datasets, and displayed side-by-side. The renal arteries of each MIP image were examined by two independent observers, one an MR physicist (observer 1) and the other a radiologist (observer 2). Relative comparison scoring (CS), (i.e. a direct side-by-side comparison of each technique) was performed using a qualitative 5-point scale, detailed in the table below. Observer 1 scored the images twice technically on the basis of perceived image quality, with the primary emphasis being signal-to-noise ratio (SNR), relative contrast and ability to visualise proximal and distal renal artery architecture. Observer 2 scored the images once from a clinical perspective, with the primary emphasis being the perceived ability of each technique for detection of renal artery stenoses. A consensus score was also derived after discussion between each observer of the relative technical and clinical merits of both imaging techniques. Finally, observer 2 compared the source images and MIP reconstructions of each method for evidence of RAS, and stenoses that were deemed clinically significant were categorised as moderate (30-60%), or severe (>60%), if present. Statistics were derived using SPSS 16.0 (Chicago, Illinois, USA).

Score	Description	Score	Description	Score	Description	Score	Description	Score	Description
1	CE-MRA superior to NCE-MRA (latter non-diagnostic)	2	CE-MRA superior to NCE-MRA (latter deemed useful)	3	CE-MRA and NCE-MRA deemed equivocal	4	NCE-MRA superior to CE-MRA (latter deemed useful)	5	NCE-MRA superior to CE-MRA (latter non-diagnostic)





Results and Discussion: Of the 50 patients enrolled, CE-MRA data were acquired successfully in all cases, whilst NATIVE data were acquired successfully in all but 2 cases where technical positioning of the imaging volume was incorrect. Qualitative comparison of each technique was therefore subsequently performed on the cohort of 48 patient volunteers where both examinations had proved technically successful. Additionally there were four patients who had only one kidney present, resulting in a total of 92 arteries available for comparative analysis.

Example MIP images are displayed in figure 1, and qualitative comparison scoring is presented in figure 2. Of the 92 arteries analysed, 14-15 were identified as CS 1 and 4-5 were identified as CS 5. The most common comparison scores were CS 3 (obtained for 27-52 arteries) and CS 4 (obtained for 9-28 arteries). The mean comparison scores obtained for all 92 arteries were 2.95 +/- 1.14 (observer 1a), 2.90 +/- 1.11 (observer 1b), 2.74 +/- 0.98 (observer 2), and 2.80 +/- 1.14 (consensus analysis). Calculation of inter-rater agreement statistics yielded Cohen's kappa coefficients of 0.91 (observer 1a v 1b), 0.66 (observer 1a v 2), and 0.70 (observer 1b v 2). Finally, of the 12 clinically significant renal artery stenoses detected, 9 were visible using both MRA methods, whilst 3 were visible using CE-MRA only.

This study has shown that MIP analysis of NATIVE TrueFISP versus CE-MRA for renal artery imaging results in virtually equivalent data, with CE-MRA marginally more successful than the non-contrast technique. Whilst this study has not compared the source images in detail (which is a recognised prerequisite for robust MR assessment of renovascular disease), the results are encouraging and have demonstrated that the mean NATIVE v CE-MRA comparison scores are very similar, irrespective of whether the data are analysed from a technical perspective (observer 1) or a clinical perspective (observer 2).

Conclusion: This study has demonstrated that the NATIVE TrueFisp NCE-MRA technique for visualisation of renal arteries is reliable and virtually equivalent to the commonly used technique of CE-MRA. This non-contrast technique is believed to provide a suitable and useful alternative examination for those patients where the CE-MRA method is either not possible or inappropriate for clinical reasons.

References: [1] Katoh M. *et al*. Kidney Int 2004; 66: 1272-78, [2] Maki JH. *et al*. JMRI 2007; 26: 966-73, [3] Krishnam MS. *et al*. Invest Radiol 2008; 43: 411-20.