Aorta and lower extremities bolus chasing MRA: Evaluation of background signal reduction techniques

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Introduction

In lower extremities bolus chasing MRA, a low infusion rate is used to facilitate delayed venous enhancement despite a relatively long imaging time. As a result, blood T1 values are not decreased to values where good contrast between arteries and fat can be achieved. To overcome this limitation, background tissues reduction methods are required. Most of the proposed methods use image subtraction. However, this increased the examination time and is subject to image misregistration between the mask and the angiogram. It has been hypothesized that image subtraction may be supplanted by fat suppression techniques, thus eliminating the need for an unenhanced imaging. The purpose of this study was to determine the background signal reduction technique that best enhances the visibility of the vascular segments from the abdominal aorta through the iliac arteries.

Material and methods

All imaging was performed with a 1.5 T unit (Signa Horizon, GE Medical Systems, Milwaukee). The body coil was used for signal transmission and reception. Fast multistation 3D gradient echo sequence with table translation allows complete assessment of the peripheral vasculature within the pulse sequence (1, 2). The 3D angiographic slab was prescribed in the coronal plane for three consecutive volumes (abdomen, upper leg, lower leg). The patient's legs were positioned horizontally to limit the anterior to posterior extent of the imaging volume. 3D gadolinium-enhanced MR angiography with fat suppression and automated breath detection. - The commercially available Smart Prep pulse sequence (GEMS) with contrast encoding detects the contrast bolus arrival and automatically synchronizes the 3D acquisition. Integrated automated table motion algorithm provides table motion to the next scanning region. 100 consecutive patients referred for MR examination of the aorta and lower extremities (83 male and 17 female patients with a mean age range 30-83 years) received a 40 mL dose of gadodiamide (Omniscan, Nycomed, Oslo, Norway) by using a power injector (Spectris, MedRad, Pittsburgh, PA), at a rate of 0.5-0.6 mL/s, followed by a saline flush. Each patient was instructed to hold his breath at end inspiration immediately before triggering the 3D acquisition at the abdominal level.

Image acquisition parameters were TR 5.1-7 ms, TE 1.5 ms, TI 20-22 ms (Spectral inversion of lipids), 25-35° flip angle, 0.5 NEX, 62.5 kHz bandwidth, rectangular FOV 33-38 x 42-46 cm, matrix 256x192, 100-130 mm thick slab, 29-32 partitions of 3.6-4 mm, total acquisition time 80-85 s. Zero-filling was used to interpolate the slice thickness to 1.8-2 mm and the matrix to 512 in image reconstruction.

Standard 3D multistation gadolinium enhanced MR angiography with mask subtraction. - A similar population of 110 patients underwent contrast-enhanced MR angiography with prior acquisition of subtraction mask. Patient movement between mask and contrast scan was minimized by proper fixation of the legs and feet; accurate registration of unprocessed contrast-enhanced image sets was performed by electronically registered table position and motor driven rapid table movement. The standard 3D FGR multistation technique (2) uses a sequential view order, TR 4.2-7 ms, TE 1.4-1.8 ms, 35 to 45° flip angle, 62.5 kHz bandwidth, 42-46x32-36 rectangular FOV, 256x384x152-224 matrix, 3D slab thickness of 12-14 cm with 32-36 partitions, actual partition thickness of 3.5-4 mm, interpolated section thickness 1.8-2 mm, leading to a total imaging time of about 95-105 s. The same 40 mL dose and injection scheme were used. Data acquisition was initiated approximately 35 seconds after the infusion starts.

Evaluation. Postprocessing (subtraction, volume projection) was performed on an independent computer workstation. MR angiograms were independently analysed by two radiologists (HF, FL) experienced in vascular imaging on a segment by segment basis with consideration of hard copy films of the full-slab maximum intensity projection (MIP) volume images, available in different oblique projection angles, image degradation as a result of overlay from unenhanced high intensity fat tissue or motion artifacts was rated on a three-point scale: grade 0 = none, grade 1 = mild, diagnostic image quality; grade 2 = substantial, (not diagnostic image quality). Distribution arising from semiquantitative scores, were compared between the two populations with a nonparametric two by k chi-square test (Arcus Quickstat software for Windows).

Results

In 83 of the 100 fast suppressed cases at the abdominal level, the overall result was considered high quality, defined as a grade 0, and diagnostic quality in 95% (grade 0 and 1). In comparison for the patients in the subtraction group, the respective ratios were only 62% and 97% (significance level of difference: p < 0.001). The subtraction method received a better grading for the lower leg segments. Image quality was considered diagnostic in 90% (grade 0 and 1) of the patients, with 52% grade 0 in the delineation of the run-off vessels. The respective frequencies in the fast suppressed group were 59% (grade 0 and 1) and only 15% grade 0 (significance level of difference: p < 0.001). At the upper leg level both methods lead to diagnostic quality (90 and 93%), with superior high quality images when using subtraction technique (52% versus 46.5% grade 0, p < 0.02).

Conclusion

Significant improvement in vessel discrimination was observed at the abdominal level when using fat suppression technique. Associated centric encoding scheme provided additional immunity to incomplete stream-tail Gross patient motion can be restricted in the lower extremities and much of the undesired overlying fat tissue can be suppressed with subtraction technique. This provided superior diagnostic image quality at the lower leg level. Further background reduction would be achieved at the upper leg level with combined tissue suppression techniques. This study raises potential interest for an interactive user-selected suppression mode for better delineation of the vessels when imaging the different segments.

References
